HILLSIDE DEVELOPMENT

The subdivision of hilly areas is a growing problem. Hills once bypassed as too costly to build on except by owner-builders are now prime residential areas for subdividers for the very reason that they were bypassed and are closer to the metropolitan center than the nearest vacant flat land.

Unfortunately, hillsides are difficult and costly to subdivide. Developers -- to help reduce costs -- have appealed to planners to write subdivision controls that have lower standards for hillside areas than flat land. But the problems peculiar to hillside subdivision often require controls that increase development costs. Experience shows, however, that if the controls written for flat lands are not modified for hillside use, subdividers will simply level the hills.

Unstable cuts and fills because of grading, erosion, streets, storm water drainage, sewage disposal, water supply, access for fire fighting, and disposition of unusable land are problems of hillside areas that cities are attempting to solve. But there are so many problems that no single approach solves them all; indeed no one community has yet met and solved even its own. Attempts have been made, however, and this report brings together some of the attempts -- provisions from zoning ordinances, as well as provisions from subdivision ordinances especially written for hillside areas.

Zoning problems are considered first in the report; then the changes needed in flat land subdivision controls to adapt them to hillside uses; third, the interrelationship of density and street standards; fourth, grading controls; and finally, other problems.

Little has been written on the problems of hillside development, and consequently Planning Advisory Service has drawn heavily on those few reports and articles available. The National Association of Home Builders recommends solutions to some of the problems in its Home Builders Manual for Land Development. George C. Bestor, civil engineer in the San Francisco Bay area, and David D. Bohannon, widely known California developer, have both written articles for Urban Land based on their experiences in hillside work.

The Los Angeles County Regional Planning Commission, the Tucson Rite, County Planning Commission, and the development firm of John W. Murphy, Tucson, gave Planning Advisory Service considerable information.

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PLANNING ADVISORY SERVICE gives full credit to the authors of the articles and reports from which it has drawn for the ideas on hillside development and regulation they contributed. Each new idea and approach is valuable, especially when a growing problem is in its early stages.

ZONING AND DENSITY

Common sense points to low densities for all steep, hilly areas, although low densities do not necessarily mean large lots.

Lot sizes may be quite different for houses built on a slope from what they are for those built on the flat top of hillside ridges or in valley flat lands. For instance, in western Pennsylvania the ridges or knobs of the hills -- actually flat land -- offer ideal sites for single-family houses on small lots or for apartment buildings. In the foothills of California, however, houses are frequently built on the actual slope. The "flat" site may accommodate a house on a half-acre, while the "slope" site may require a three-acre lot; and in either case some areas of a site may be completely unsuitable for construction.

Certainly the developer who claims that rigid minimum lot size zoning for hillside areas is costly and wasteful of land does so with some justification. Mr. Bestor says1:

... If all hillsides were uniform, area zoning would be a perfect solution, but such is not the case. Often a hillside is so steep and has so many ravines that one building site per two or three acres is necessary, yet nearby there may be delightful benches or ridge-tops that are flat.

A developer should be held to averages in lot size, with a more lenient minimum when justified, rather than to so-called averages which become minimum. If he has some two-acre lots, the developer may need a few half-acre lots to come out economically.

Although it is not the planning agency's responsibility to see that a developer makes a profit, standards for hillside subdivisions must reflect consideration of the problem.

The Marin County, California planning commission has a policy that relates slope to required lot area2:

Lot Slope Policy is applied on a lot-by-lot basis at the time of preliminary subdivision design. Each individual lot is

1George C. Bestor, "Design and Development of Hillside, Large Lot and Resort Subdivisions," Urban Land, March 1958. (All statements in this report attributed to Mr. Bestor are taken from this article in Urban Land.)

2Marin County Planning Commissioner. Tiburon Peninsula Section of Marin County Master Plan. (San Rafael, California: Marin County Planning Commission, 1956.)
Landslides wreck another two Los Angeles homes

Two-thirds of the new homes in the City of Los Angeles are now being built on hillside lots -- and all of them are potential victims of destruction by landslides.

So says General Manager Gilbert E. Morris of the city building department. For the two $50,000 homes in Pacific Palisades pictured above, the odds ran out in August. Their sudden nocturnal collapse was variously blamed on water seepage and on grading for hillside home sites lower down.

"The only way to avoid home damage from slides is to quit building and subdividing on hills," says Morris. "Southern California rests on thousands of earthquake faults."

Moreover, the hills fringing Los Angeles are composed of stratified earth and rock, interleaved with shale layers. These are firm if dry, but slippery when wet. Homebuilding in the heights, with subsequent seepage of lawn water and septic tank fluids, turns the shale layers into lubricants for strata above -- which are often tilted seaward.

Despite the danger, Californians still like hill sites and lenders are happy to finance them. Morris notes that less risk is involved since the city adopted its unique 1955 grading ordinance. This requires all cuts and fills be made according to code specifications aimed at preventing slides. Since its adoption, says Morris, only two or three of nearly 50,000 new home sites have suffered slide damage.

Worst slide in the LA area came in 1956 at Portuguese Bend near San Pedro. It gradually destroyed 145 homes, has resulted in more than $20 million in law suits. Homeowners who built on leased sites are suing the developer. The developer and other homeowners are suing the county. They contend the slide resulted from a road building project.

There is no legal precedent for such suits in California. But this year in Pittsburg 11 homeowners whose backyards slid away have won $150,000 from Builders Felice Perri & Sons. The court held that fill was improperly dumped in the yards. As a result it slipped.

Story from House & Home, October 1959, reprinted with permission

sized according to the terrain the lot falls on with the objective of obtaining the best lot design and consequently, in most cases, the best house site for that type of terrain.

Under the Marin County lot slope policy, the minimum size for hillside lots increases as the slope increases. (The largest lot required under the zoning ordinance is 9,000 square feet.)
The Marin County policy is a policy -- not an ordinance provision -- carried out in administration of the zoning ordinance, but it might be desirable to make the requirements and chart (see Figure 1) part of an ordinance.

The result of the Marin County policy is that a hillside development does not have a per lot or per acre density, but does have an average density per acre for the entire development. The Tiburon Peninsula master plan report says:

The entire hillside area is expected to average approximately two homes to the acre. This over-all density figure does not indicate any particular density for any particular parcel of land: in other words, "lot slope policy," as applied to each individual building site, is the governing device in subdivision design . . .

In hillside subdivisions in which "lot size averaging" is used instead of conventional minimum lot size, the major problem is on what basis improvements should be required. It is not feasible to require improvements according to lot sizes that vary so much. That method could result in 36-foot pavement for a half-acre lot and 24-foot pavement for an adjoining one-acre lot, for instance. Instead, improvements must be required on the basis of anticipated over-all density.

But determining the anticipated over-all holding capacity is the difficulty. It cannot be done on a lot-density formula basis, as it can be for flat land subdivisions. Instead, the number of lots in any single hillside development must be determined on the basis of a "lot slope policy" and the holding capacity for the entire subdivision figured from the number of lots. Public facilities and services must be planned accordingly.

Actually estimating the basis for public utilities and services is not as complex as might first appear. Moreover, improvement requirements especially for hillside projects might be included in the subdivision ordinance.

As it is pointed out in the Tiburon Peninsula master plan, the number of lots in a hillside area will be determined to some degree by the layout of the roads. Experience has shown that the use of the lot slope system plus the best possible street layout and the best lot design will usually give the subdivider the maximum number of good building sites.

The Marin County approach to densities and lot sizes for hillside subdivisions has much to recommend it. Once the planning agency has a rough idea of the number of families and the number of people an area can accommodate, it can set a minimum lot size. Many of the lots will be considerably larger than the minimum and some part of the site will be unsuitable for development, but the developer will have a great deal of flexibility in lot sizes and at the same time the planning agency can maintain high development standards.

The real point of control over hillside developments then becomes the subdivision review process.
EXAMPLE: FOR A LOT WHOSE NATURAL GROUND SLOPE IS 25%, THE INDICATED AREA IS 20,000 SQUARE FEET AND THE INDICATED AVERAGE WIDTH IS 115 FEET.

APPLIES TO UPLAND AREA OF THE UNINCORPORATED PORTION OF THE MAIN TIBURON PENINSULA.
SUBDIVISION REGULATIONS

Some planners think hillside subdivisions should be subject to the same subdivision regulations that govern flat land developments of the same density -- an approach subject to strong attack by developers, who argue that it is inflexible. Flat land requirements applied to steep terrain, they say, lead to tremendous earth moving operations, total transformation of the site, and problems of compaction of fill areas. Hillsides do not lend themselves to the mass production type of residential development for which most subdivision regulations were written.

Variations by lot size

Greater flexibility in subdivision controls has been achieved in some California cities by relating subdivision standards to the lot size provisions of the zoning ordinance.

For example, in the Redding, California subdivision ordinance (1956) hillside areas are defined and four types of "hillside area" subdivisions are set up. Apparently the four types are based on lot size requirements for "combining districts," under the zoning ordinance, not on the slope standards in the subdivision ordinance.

"Hillside Areas." A hillside area, as referred to herein is defined as one with an average slope of 15 per cent or more. The standards under 1394.15 apply to all hillside areas with the added provision that areas with a cross slope of 40 per cent or greater are considered to be extremely rugged and the development of this terrain is limited to lot size types III and IV as defined below:

(a) Type I -- Lot area 6,000 to 10,000 square feet. A type I subdivision is one in which the lot size is between 6,000 and 10,000 square feet with all of the lots having an area of not less than 6,000 square feet. It could be defined as all subdivisions other than those described in II, III and IV below.

(b) Type II -- Lot area 10,000 square feet to 20,000 square feet. In this classification are subdivisions in which all lots have an area in excess of 10,000 square feet.

(c) Type III -- Lot area 20,000 square feet to one acre. In this classification are subdivisions in which 80 per cent of all lots have an area of 20,000 square feet or over, and the average area of all lots is 20,000 square feet or over.

(d) Type IV -- Lot area one acre or over. Eighty per cent of the lots in this classification shall be one acre or over and the average area of all lots in the subdivision shall be one acre or over.

Improvements required, varying with lot size, are also in the subdivision ordinance:
<table>
<thead>
<tr>
<th>Lots</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area, average minimum</td>
<td>6,000 sq.'</td>
<td>10,000 sq.'</td>
<td>20,000 sq.'</td>
<td>40,000 sq.'</td>
</tr>
<tr>
<td>Frontage minimum*</td>
<td>60' except 30' at end of cul-de-sac</td>
<td>80' except 40' at end of cul-de-sac</td>
<td>100' except 50' at end of cul-de-sac</td>
<td>150' except 75' at end of cul-de-sac</td>
</tr>
<tr>
<td>Width, average minimum</td>
<td>50 feet</td>
<td>80 feet</td>
<td>90 feet</td>
<td>100 feet</td>
</tr>
<tr>
<td>Street design</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.O.W. width</td>
<td>60' minimum</td>
<td>60' minimum</td>
<td>50' minimum</td>
<td>50' minimum</td>
</tr>
<tr>
<td>Pavement width</td>
<td>40' or two 20'</td>
<td>40' or two 18'</td>
<td>26' or two 18'</td>
<td>25'</td>
</tr>
<tr>
<td>Cui-de-sac or loop street</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R.O.W. width</td>
<td>50' or 56'</td>
<td>50'</td>
<td>50'</td>
<td>40'</td>
</tr>
<tr>
<td>Pavement width</td>
<td>36'</td>
<td>32'</td>
<td>26'</td>
<td>24'</td>
</tr>
<tr>
<td>Curb &amp; gutter</td>
<td>Roll Concrete curb &amp; gutter, except corners</td>
<td>Roll Concrete curb &amp; gutter, except std.curb at corners</td>
<td>Concrete curb &amp; gutter</td>
<td>Concrete curb &amp; gutter</td>
</tr>
<tr>
<td>Sidewalks</td>
<td>4' both sides on lots up to 75' wide</td>
<td>4' min.graded area lots 75' to 100' wide both sides</td>
<td>3' graded area</td>
<td>3' graded area</td>
</tr>
<tr>
<td>Slope</td>
<td>Maximum cross** slope on which this slope is permitted</td>
<td>Up to 20%</td>
<td>Up to 25%</td>
<td>Up to 30% over on approval of P. C.</td>
</tr>
</tbody>
</table>

* 20 per cent of the lots in any hillside subdivision (not including lots at end of culs-de-sac) may have a reduced frontage, provided that such reduction is not below the requirements of the next least restrictive type or classification of subdivision.

** Grading restrictions, not more than 10 per cent of area lot to be left in slope steeper than original ground or steeper than 25 per cent whichever is greater.
The subdivision provisions for lot sizes are presumably based on the zoning ordinance provisions for lot sizes, as they appear in the "combining districts." For example, the Type II lot as it appears in the "hillside areas" definition of the subdivision ordinance is a lot with an area between 10,000 square feet and 20,000 square feet. The "combining district" provision of the zoning ordinance provides for a "B"-1 lot of 10,000 square feet. Obviously, the Type II lot is defined so as to fall within the lot size class of the "B"-1" combining district. The "combining district" provision appears below:

The following regulations shall apply in lieu of building site area, yard and lot width requirements in the respective R-1, R-2, R-3, R-4 Districts where such districts are combined with the "B" District* and shall be subject to the provisions of Section 1312. All other provisions of the respective districts shall apply.

<table>
<thead>
<tr>
<th>Combining designation</th>
<th>Minimum building site area</th>
<th>Minimum lot width</th>
<th>Minimum lot length</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;B&quot; - 1&quot;</td>
<td>10,000 sq. ft.</td>
<td>80 ft.</td>
<td>120 ft.</td>
</tr>
<tr>
<td>&quot;B&quot; - 2&quot;</td>
<td>20,000 sq. ft.</td>
<td>100 ft.</td>
<td>175 ft.</td>
</tr>
<tr>
<td>&quot;B&quot; - 3&quot;</td>
<td>40,000 sq. ft.</td>
<td>150 ft.</td>
<td>200 ft.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Combining designation</th>
<th>Minimum front yard depth</th>
<th>Minimum side yard widths</th>
<th>Maximum lot length</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;B&quot; - 1&quot;</td>
<td>25 ft.</td>
<td>10 ft.</td>
<td>2½ times the width</td>
</tr>
<tr>
<td>&quot;B&quot; - 2&quot;</td>
<td>30 ft.</td>
<td>15 ft.</td>
<td></td>
</tr>
<tr>
<td>&quot;B&quot; - 3&quot;</td>
<td>30 ft.</td>
<td>20 ft.</td>
<td></td>
</tr>
</tbody>
</table>

On any land graded or benched for building sites not more than 10 per cent of area of the lot is to be left in slope steeper than original ground or steeper than 25 per cent, whichever is greater, unless approval is obtained from the Planning Commission prior to obtaining a building permit.

*Editor's note: "B" is the combining district symbol.

The approach used in Redding is also used in San Mateo, California, where the idea apparently originated with the planning agency, and in San Carlos, California.

Adoption of this technique -- classification by lot size and varying requirements -- should get around the problem that arises if special provisions lowering standards for all kinds of improvements in hillside or other large-lot, low-density subdivisions are written into a subdivision ordinance. The reduced standards for hillsides, many planners have feared, would become the standards for all subdivisions. Requirements that vary with varying situations is a common device used in zoning ordinances that can be adapted to subdivision regulations with success.
The "classification by lot size" approach with varying standards for improvements cannot, however, be combined with a "lot slope policy," since under it lot sizes vary widely within any single subdivision.

**Use of variances**

Some communities have tried to handle hillside development by permitting variances from the flat land requirements of the subdivision ordinance. If there are no standards for hillside developments to guide the administrator, however, the variance procedure becomes a game of bargaining for concessions between the administrator and the subdivider -- a game out of which many abuses can arise.

The San Mateo planning commission, in *Subdivision Standards for Hillside Areas* (1953) comments on the problem:

> ... The subdivider buying land must know what standards he must conform to in order to estimate his development costs accurately. The city administration must be in a position to refer to established standards in order to properly and fairly review the plans submitted for approval.

It is apparent, also, that a policy of varying requirements to meet the situation on each particular job is certain to result in time-consuming negotiations and misunderstandings, as well as in an inconsistent and broken street pattern.

**Special provisions**

In the majority of communities, regulation of hillside development through subdivision controls has taken the form of amendments to the basic ordinance -- amendments aimed at particular problems. Los Angeles County has made a number of studies of hillside development problems, all leading to subdivision ordinance amendments.

Some communities have also supplemented such amendments with a grading ordinance since grading and cut-and-fill operations have been the biggest problems and the point at which controls can be of the greatest value. (For examples of grading ordinances, see *Land Development Ordinances, Planning Advisory Service Information Report No. 86, May 1956*.)

In communities in which amendments for hillside problems have been adopted, perhaps supplemented by a grading ordinance, the principal point of control has been design review. Without modifications in improvement standards, the average flat land subdivision ordinance can only be adapted for use on hillside areas by careful control of subdivision design.

Another method of putting hillside regulations into effect is by preparation and adoption of a master plan for the entire hillside area. This method has been used by Marin County, for instance, for the Tiburon Peninsula, referred to earlier. It has also been employed by the Tucson-Pima County Planning
Commission in the development of the Catalina Foothills, a 5,000-acre area about a mile north of Tucson. Under the plan, major rights-of-way are mapped and the property owners grant to the county a deed of easement for the right-of-way. When an acceptable subdivision plat has been recorded, the area described by the plat is zoned from SR (suburban ranch) to CR-1 (single residence).

In addition, the developers impose private restrictions, an unusual feature of which is a prohibition against the destruction or removal of any "native growth" (including cacti and Palo Verde trees) except that in the way of construction. The intention is to preserve as far as possible the plant life, rock deposits, and wildlife that contribute to the desirability of the area for residential use.

Which of the approaches outlined above is the best? The planning agency working on hillside problems may want to use a little of each. It may want to vary regulations by classes; in unusual situations it may believe that variances are justified. It will certainly want to make amendments to the subdivision ordinance and will often suggest adoption of a grading ordinance. All of the approaches merit consideration.

STREETS

Streets are the most crucial factor in adjusting flat land design and improvement standards to hillside areas. A whole series of related problems center around them -- paving and right-of-way widths, layout, curbs and gutters, sidewalks, vertical and horizontal curves, grades, use of private means of access to lots, on-street and off-street parking, and setbacks.

Traffic engineers and planners think that street standards must be related to the kinds and amounts of traffic the streets will carry. The hierarchy of street types -- minor street, collector street, arterial street, and expressway -- is familiar to all. In hillside areas minor and collector streets are dealt with almost exclusively.

The functions of a street in a new hillside subdivision can only be determined and the street classified when it is considered in relation to the entire street pattern of the area; and the differences in function, by types, should be made clear in the street pattern. Moreover, the pattern should be determined for an area large enough to enable an accurate estimate of the traffic, both for the immediately proposed subdivision and later developments in the area. Obviously, it is not possible to plan a good street pattern for an entire area if only one small piece is considered at a time.

The function of the street -- its type -- is directly related to expected traffic volume. And traffic volume in turn is related to the traffic pattern and the number of traffic generators along a street. In a residential area, traffic generation can be derived from population density. Once the

density factors -- lot size and residence type -- have been determined, as well as the proposed street pattern, traffic volume is predictable and street types can be designated as needed to serve the area.

The basic physical differences between the street types are in cross-section -- width of right-of-way, width of paving (based on number and width of moving and parking lanes), median strips, and sidewalks. The tables in the Redding ordinance illustrate how these features can be varied. The major element of concern, however, is the number and width of moving and parking lanes.

Elimination of on-street parking lanes

Developers of hillside areas have directed most of their protests of "excessive" street improvement standards at the paving widths required for minor and collector streets. They claim it is possible to eliminate parking lanes from minor and collector streets in hillside areas with savings in paving costs and grading because the narrower the paved area is, the less grading is needed.

Aesthetics is also a reason given by planners and developers for reducing the width of hillside streets. Mr. Bestor says: "Wide streets destroy trees and natural land formations and heavy lot grading often eliminates what is left of the natural beauties of the original hillside." Although the scars of grading may heal with time, streets and houses should be blended into hillsides as well as possible.

Planners are not sure that parking lanes can be eliminated. However, Mr. Bestor advocates an alternative -- parking bays. He makes the point that "As long as one or both sides of a street serve as elongated parking- lots, the pavement cannot be materially narrowed."

Mr. Bestor notes that in flat land developments driveways can be used for off-street parking, but that in hillside areas many driveways are so short that they cannot. To assure adequate parking spaces, he suggests that an estimate of the over-all parking requirements be made and that "the deed restriction . . . call for a certain number of developed and surfaced on-lot parking spaces per building site." He points out that the amount of parking necessary varies with the income level of residents and the type of development.

To provide for other parking needs, such as the car with the flat tire, he suggests that the developer "provide parking bays outside the flowline of gutter, and these should be suitably surfaced at the time of street construction." Parking bays are not suitable, however, in areas in which the lots have relatively short frontages because the frontage becomes almost a continuous strip of driveways and bays. But as lot frontage increases, the savings in road building should become evident.

Mr. Bestor explains:

... A narrow street could wind among the trees and avoid local steep spots, whereas a 35 or 40 foot pavement could
only be "blasted through." The use of parking bays, instead of adding uniformly to the street width for parking, permitted the total graded surface "tight" spots to be narrowed to around 30 feet. Good trees could be left in place within 20 feet of the road centerline and, as mentioned, (the street) could be detoured around an especially fine oak. In breaks between trees, or where cross slopes ease, bays could be introduced on one or both sides of the street.

Mr. Bestor goes on to say that public officials should not oppose narrower streets and consequent elimination of some on-street parking because of the possibility that emergency vehicles might have trouble when some one has a big party. "It is always possible for traffic minded doubters to imagine great concentrations of parked cars which would make every solution impossible except a large parking lot for each house, on hillsides or anywhere else." Even on standard-width streets, there is considerable trouble when peak on-street parking demands coincide with an emergency.

The parking bay merits consideration by planning agencies. There may be difficulties in engineering street drainage and providing gutters and curbs but these problems should be solvable. Provision of parking bays may justify narrower than standard streets. Ninety degree parking in bays might be a desirable solution on steep streets, Mr. Bestor suggests.

**Special standards for hillside streets**

Some planning agencies have adopted special standards for cross-sections of streets in hillside areas. Sometimes the hillside street is defined as a special class in the definitions section of the subdivision ordinance, as minor, collector, or arterial streets are. In other cases, special hillside streets are allowed in areas considered suitable by the reviewing authority.

The primary purpose of having a hillside street classification is to allow a reduced cross-section -- both right-of-way and paving width. For example, the Tulare County, California, subdivision regulations (1959) say:

> In mountainous areas standards for road right-of-way width and paving width for minor streets and cul-de-sacs may be reduced to forty feet (40') and twenty-six feet (26') respectively.

Minor streets in flat areas in Tulare County must have 50-foot rights-of-way and 36-foot paving. Mountainous areas are defined as those "above 1,500 feet elevation according to United States Geological Survey datum."

In the Santa Barbara, California subdivision ordinance (1956), steep hillside streets are defined as a special class:

"Street, Steep Hillside" is a street where the cross slope of existing ground is in excess of ten percent (10%) and where the center-line slope of the street is in excess of ten percent (10%).
Right-of-way and paving widths required for steep hillsides are only slightly less than those required for a minor street, however.

Under the Burbank, California municipal code, the reviewing authority determines in what cases reduced cross-section streets are permissible:

The width of streets on hillside or mountainous land shall be determined by future traffic needs and topographical conditions. All mountainous highways which form a part of primary or secondary traffic routes shall have a minimum [pavement] width of forty (40) feet, but shall be made wider where the topography will permit. Other mountainous roads of more than frontage importance shall have a minimum width of twenty-six (26) feet. These widths shall be approved only where the City Planning Commission, in the exercise of reasonable discretion, determines that the cross slope will not permit a greater width.

Hillside and mountainous areas are not defined in the Burbank code, so the planning agency presumably grants variances as each case comes up.

As the foregoing examples show, the reduction in standards for hillside streets are often not sufficient to meet the problems of excessive grading and paving. If the goal is to reduce the amount of land that is scarred in the course of street construction, planning agencies should consider using rights-of-way widths as narrow as 40 feet and paving widths as narrow as 18 to 20 feet.

Cross-sections varying with lot size

Other subdivision ordinances follow the technique of varying pavement requirements by lot size. The Contra Costa County, California subdivision ordinance (1953), for example, allows a minor street to have a paved width of 20 feet if the lot is more than 40,000 square feet and the lot frontage is greater than 120 feet.

The Santa Barbara County subdivision ordinance (1958) permits a 24-foot paved road in a "rural type" subdivision. A "rural type" subdivision is defined as a "subdivision in which the parcels average at least 120 feet in width and have an average lot area of 30,000 square feet or more, exclusive of roads."

There are two classes of subdivisions defined in the Richmond, California, subdivision ordinance (1956). The class B subdivision is an area within which 80 per cent of the lots have an area of 20,000 square feet or more and in which the average size of all lots is 20,000 square feet or more. In a class B subdivision, a type III street -- paved width of 22 feet, paved valley gutters (no curb), and no sidewalks -- is permitted.

Drafters of the Fremont, California subdivision ordinance (1957) saw the need for special provisions for hillside subdivisions:

In the case of subdivisions or portions thereof having an
average slope of not less than 8 per cent, the commission, in
the exercise of its discretion, may modify the foregoing re-
quirements of this ordinance in a manner that will result in
the best possible utilization of the land to be subdivided,
giving consideration to the topography of the land and the
general character of the proposed subdivision.

The ordinance provides that the basis for requirements for street and road-
way widths and design in hillside areas are the topography of the land and
the density of development in terms of the proposed number of dwellings to
be served by the street or roadway. It provides that in subdivisions or
sections of a subdivision in which all lots have an area of a half acre or
more: (1) street grades for minor residential streets may be increased to
20 per cent; (2) the dedicated width of a two-way street may be reduced to
40 feet, with a minimum pavement width of 26 feet; (3) the dedicated width
of a one-way street can be reduced to 30 feet, with a minimum pavement width
of 20 feet; (4) integral sidewalks and curbs may be permitted.

The special standards for streets in hillside subdivisions in the Fremont
ordinance seem to avoid the familiar problem that arises when standards for
variances and special exceptions are not written into the ordinance. Fur-
thermore, by permitting the reviewing authority to consider each street on
the basis of topography and the number of dwellings served, it should be
possible to serve the public interest and at the same time allow the devel-
oper to vary from flat land street standards.

From the standpoint of ease of administration, the best approach is probably
to set a single, recognized standard, permitting a narrower-than-usual width
for minor and collector streets. On the other hand, if the planning agency
establishes hillside zoning with rigid but different minimum lot sizes for
different zones, the use of street standards varying with lot size is prob-
ably more appropriate.

The preceding examples indicate the direction in which planning agencies
are moving in modifying improvement requirements for hillside areas and
other large-lot subdivisions. In some cities, pavement width requirements
for minor streets have been reduced to as little as 20 feet for hillside
and large-lot subdivisions. If parking can be successfully handled through
such devices as parking bays, minor streets with only two narrow moving lanes
seem reasonable.

Elements other than street width that can vary

Design standards and improvement requirements for horizontal and vertical
street curves, grades, curbs, and sidewalks may also be modified in hillside
areas. Because of the winding nature of hillside roads, it is probably de-
sirable to allow sharper horizontal curves there than on minor streets in
flat land subdivisions -- possibly as short as a 75-foot radius. Grades,
too, may be allowed to depart from normal limits; they may be steeper, but
only for short, straight stretches.

Requirements for curbs and gutters should also be checked. Although it may
be feasible to omit straight curbs in flat land, large-lot developments
(substituting either rolled curbs or paved valley gutters), straight curbs are absolutely necessary on hillside streets if parking is even a possibility. To hold a car on a steep grade, drivers must be able to park their cars with tires against a straight curb. The Contra Costa County ordinance requires straight curbs in any block in which the grade is more than 6 percent. Curbs are also an important means of controlling street drainage; erosion of the roadside on steep hills is a major problem.

The value of curbs in control of erosion is noted by David Bohannon:

... Unless you do put a curb on one side of the street, you will have a problem of controlling the concentrated, rapid surface water run-off in steep terrain. So a properly designed curb will act as a water gutter and will carry that water to a proper point where it can be picked up in a manhole and culvert and carried on to a lower level until it finally reaches the main storm water drainage course for the area. This is an important consideration or you will accelerate erosion on your downslope sites and you will have no end to difficulty from that type of water run-off.

Sidewalks are another improvement around which controversy frequently centers. Although the subject is discussed in Land Development Ordinances, Planning Advisory Service Information Report No. 86 for May 1956, there are additional factors that should be considered for hillside areas.

In areas in which sidewalks are not required, the graded shoulders of the road are often used for walking, despite the obvious hazards. Under some ordinances in which narrow paving is permitted, a four- or five-foot graded shoulder is specified, at least partially to protect pedestrians. Developers say that omission of sidewalks preserves the "natural" appearance of hillside areas, but this argument may not always hold true.

Where sidewalks are required, they are often required only on one side of the road. The Home Builders Manual for Land Development suggests that "On hillside streets or in rough topography considerable savings may be realized by keeping the sidewalk on the up-hill side above the grade of the roadway. This avoids excessive cut required for a flat section."

Lot access—public or private?

Perhaps the thorniest street layout problem in hillside developments arises from the request of developers to substitute private streets, trails, and group driveways for dedicated streets, primarily to save space and costs.

Writing from the developer's viewpoint, Mr. Bestor says:

4David D. Bohannon, "Hillside Development," Urban Land, January 1959. (All statements in this report attributed to Mr. Bohannon are from this article in Urban Land.)

Variations often prohibited in general subdivision ordinances, such as "panhandle" lots or lots reached by easements, are sometimes necessary in the special subdivisions under consideration. It is often impractical to extend a public road to each one, two or three building sites in some hillside pocket. A full-width road may use up all of the flat land, or the length of road may be such as to make the lots uneconomical to develop. If an isolated area such as this is thrown in with an adjoining lot fronting on the street, the developer loses one or more good building sites. More important, such "lost" sites constitute potential problems for the future. The area might be resubdivided. It is better to reach sites of this type with a carefully designed "panhandle" than lose them. When driveway easements used by two or three owners are necessary, they can be worked out by the developer, approved by the governing body, and made a recorded obligation on all future owners. If arrangements are thought out in advance, there need be no worry on the part of the public officials that the easement may become a maintenance obligation.

Mr. Bohannon reports in the article referred to earlier that he made an arrangement with the city of San Mateo that permits "us to use a so-called type of trail, dedicated, if you please, and accepted on an official map. Had we not been able to do that it would be difficult to finance a house because a mortgagor insists upon having access to a dedicated street. At any rate, we have installed that type of little lane leading to interior lots with parking area provided at street level."

Considering the almost universal distaste of municipal authorities for private streets and access easements, it is probably desirable to require public dedication of such streets and easements if they are used in hillside areas.

Driveways

Driveways are, in effect, part of the parking problem. On level or fairly level lots, conventional driveways and garages can be used for parking. However, as the slope steepens, other solutions are necessary. On lots where the slope permits driveways -- leading either uphill or downhill, as the case may be -- at an acute angle to the street the driveway may be used to reach a garage or other off-street parking space. Mr. Bestor's suggestion that "panhandle" lots be platted to accommodate angled driveways requires some variation from provisions of the usual subdivision ordinance. Most subdivision ordinances require side lot lines to be substantially at right angles to street lines. The "panhandle" shape does considerable violence to this regulation.

For very steep slopes, Mr. Bohannon says that ". . . it is necessary to modify the front yard setbacks because of topography to permit the garages to be placed at street level and within five feet of the property line. This will permit the construction of garages as the upper portion of the residential structure on property below street grade and garages placed in the cut bank where the property is above street grade."
Such variations in setbacks or front yard requirements are probably reasonable in steep hillside developments. If variations are allowed, however, developers should be required to show building placement on plats, and projections into the right-of-way should be forbidden under the zoning ordinance. The Berkeley, California, zoning ordinance (1959) allows variations from the yard requirements in "H" districts (combining districts for hillsides) if a use permit is secured in each case.

Provision of roadside parking bays is particularly important in a development in which garages are built on or near the property line because there are few if any driveways in which visitors can park cars.

There may also be a problem in backing out of street-grade garages and having sufficient distance to turn if the street pavement is narrow. The three driveway-garage schemes mentioned above -- conventional driveways, angled driveways, and street grade garages -- are illustrated in an article, "When You Build on a Hillside, Build a Hillside House," in House & Home magazine for June 1958 (pages 90-99).

GRADING CONTROLS

Many cities are requiring, under the subdivision ordinance, submittal of grading plans and are controlling grading to a greater degree than formerly. Grading ordinances used in several cities are discussed in Land Development Ordinances, Planning Advisory Service Information Report No. 86 For May 1956. Los Angeles County, which has an outstanding grading ordinance, has made additions to its subdivision ordinance to cover grading operations in subdivisions. The following amendment to the subdivision ordinance was adopted in 1959:

Matters Required: The approximate lot layout and the approximate dimensions of each lot and of each building site. Where pads or benches are utilized or proposed for building sites, engineering data shall show the existing topography and the approximate finish grading (such grading to conform to Grading Ordinance 2225) as well as the location and the size of each building site.

"Building site" and "pad" are defined in the amendment:

"Building site" means that portion of the lot or parcel of land upon which the building and appurtenances are to be placed, or are already existing, including adequate areas for sewage disposal, clearances, proper drainage, appropriate easements, and, if applicable, the requirements of other ordinances.

"Pad" means a building site prepared by artificial means, including grading, excavation, or filling, or any combination thereof.

It is not only necessary to tie together provisions for grading plans but
also to establish standards for finished slopes, setbacks from the foot and top of cuts and fills, and usable open space.

Large grading operations can be avoided in steep areas by fitting the house to the site. Mr. Bohannon, in the *Urban Land* article, remarks:

... Obviously, there is an economical breaking point where it would be advisable to design the residential structures in such a way that the house may be built on a lot left in its natural state rather than go to the expense of the extra grading operations required to provide level, house building sites upon which a conventional foundation may be located.

Several ways of fitting the house to hillside sites are shown in the article in the June 1958 issue of *House & Home*.

**Contour maps and grading plans**

There are many possible approaches to regulation of grading through the subdivision ordinance. In a discussion of how to avoid grading problems, the *Home Builders Manual* says: "Contour intervals should vary with the type of property encountered. Where the site contains grades which average 3 per cent or less, use contours with a one-foot interval. A greater interval will be of little value on flat topography. Where slopes are up to 15 per cent, a two-foot contour interval should be used with a five-foot interval for slopes of 15 per cent and over."

Subdivision regulations commonly require that contour lines be shown on the tentative map.

Contour lines at five-foot intervals where average slopes exceed 6% and at two-foot intervals where average slope is less than 6%. Datum for elevations shall be indicated on the map. (Santa Barbara County, California)

* * * * *

Contours at five-foot intervals if average slope greater than ten per cent. Contours at two-foot intervals if average slope less than ten per cent. (City of Santa Barbara)

* * * * *

Topography with contours such that (a) contour intervals of one foot (1') or less shall be used where the ground slope is three per cent (3%). (Richmond, California)

The presence of hilly terrain may indicate that a grading plan should be required to accompany the tentative plan.

The subdivider shall file, with the tentative maps, accurate contour maps showing the contour at reasonable intervals.
Where the grade of the tract or parts of it exceed 5%, the subdivider shall also submit an over-all grading plan of the tract showing features of the land adjacent to the tract within a reasonable distance therefrom which tend to affect the subdivision. In those cases in which a grading plan is required, the grading plan will show how positive runoff of surface waters from individual lots will be achieved and the means by which ultimate disposal of the subdivision surface waters will be accomplished. (Santa Clara County, California)

* * * * *

Where slopes in excess of 10% occur within the area to be subdivided, a preliminary grading plan, indicating the general location and magnitude of cuts and fills may be required by the Planning Director. (Santa Barbara County)

* * * * *

If, in the opinion of the Public Works Director, hillside or irregular topography warrants special grading studies, a preliminary grading plan shall be submitted and shall show surrounding topography if same has bearing on drainage of area. (City of Santa Barbara)

Richmond, California requires an improvement plan, including a "map and report showing all earth fills of twelve inches (12") or more," and a development plan showing finished grading and the "relationship of shape and size of each house to shape, size and finished contours of its lot."

In some places a finished grading plan as well as a rough grading plan must accompany the tentative map.

Submission of a final grading plan showing the finish grade of all building pad areas, the depth, extent and slope of all cuts and fills and the finish grades of streets prior to consideration of the final or record of survey map. (Santa Barbara County)

* * * * *

Final grading map may be required by the Public Works Director. (City of Santa Barbara)

The subdivision ordinance provisions quoted above indicate to the subdivider only those situations in which grading plans are required. They do not give specifications for grading or regulate it in detail. Specifications and regulations should be put into a grading ordinance.

Restrictions on slopes

Perhaps the most that should be included in the subdivision ordinance to regulate grading are restrictions on the angles of cuts and fills.
Some examples:

No existing slope or proposed cut slope shall be steeper than one and one-half (1 1/2) horizontal to one (1) vertical, except as hereinafter provided.

No fill slopes, existing or proposed, shall be steeper than two (2) horizontal to one (1) vertical, except as hereinafter provided.

Slopes exceeding the foregoing requirements may be approved by the City Council upon the recommendation of a competent soils engineer acceptable to the Public Works Department.

(City of Santa Barbara)

* * * * *

No land shall be graded, cut or filled so as to create a slope exceeding a vertical rise of one foot for each two feet of horizontal distance between abutting lots, and may do so within a lot only where a stone retaining wall of sufficient height and thickness is provided to retain the graded bank.

Major cuts, excavation, grading, and filling, where the same materially changes the site and its relationship with surrounding areas or materially affects such areas, shall not be permitted if such excavation, grading, and filling will result in a slope exceeding a vertical rise of one foot (1') for each two feet (2') of horizontal distance between abutting lots or between adjoining tracts of land, except where adequate provision is made to prevent slides and erosion by cribbing and retaining walls. (Model subdivision ordinance, Institute of Local Government, University of Pittsburgh, 1958)

**Maintenance easements**

The responsibility for maintaining slopes resulting from grading for street construction is on the city after the streets are accepted. In many cases, cuts and fill are outside the right-of-way lines and it is, therefore, necessary for the city to have an easement to maintain the slopes.

Mr. Bestor comments on the problem of slope maintenance as follows:

... I have heard the argument that rights-of-way on hills should be wider, not narrower, than on the flat, so that city or county crews can have access to slopes when they erode. I believe this can be handled, when necessary, by maintenance easements.

Subdivision ordinance provisions dealing with the easement problem include:

Excessive fill and cut slopes when necessary in the opinion
of the City Engineer shall have an easement equal to the cut
or fill distance plus ten feet (10'). (Richmond, California)

* * * * *

Where a cut or fill road slope is outside the normal right-
of-way of the street, then a slope easement shall be provided
of sufficient width to permit maintenance of the slopes by
the county. (Marin County, California)

Setbacks from cuts and fills

In a paper presented at the 1958 conference of the League of California
Cities, John A. Lambie, county engineer for Los Angeles County, said:

Building setbacks from the top of a fill should be carefully
watched, as we find quite frequently that tension cracks form
in this area. To provide a safety factor against tension
ruptured foundations, floors and walls, it is generally con-
sidered good practice to locate structures a minimum distance
of five feet from the crest of fills up to twenty feet in
height. This distance should be increased proportionally for
higher fills. On cuts, a building should be set back a minimum
distance of three feet from the base of the slope. This will
make space for loose material to accumulate and provide access
for its removal.

Ordinance provisions that protect the public against tension cracks logically
should be in the building code. However, the general provisions section of
the zoning ordinance may also include such a provision.

Retaining walls

In some hillside subdivisions there is extensive use of retaining walls to
create terraces or benches for building sites. Retaining walls are costly,
however, as is pointed out in the article in House & Home and it is recom-
manded that they not be used. Mr. Bohannon says:

In hillside lot development I've attempted to terrace resi-
dential sites. I have found it exceedingly costly for retain-
ing walls and for drainage techniques.

Wherever retaining walls are used or needed, regulation is necessary. In
some subdivision ordinances retaining walls are included in the list of im-
provements that may be required.

Retaining walls may be required whenever topographic condi-
tions warrant or where necessary to retain fill or cut slopes
within the rights-of-way or slope easement. (Marin County)

* * * * *

Support of cut and fill slopes by adequate retaining walls of
concrete or masonry or other material approved by the County Public Works Department may be required. (Santa Barbara County)

Developers presumably avoid the use of retaining walls as much as possible because of cost.

Compaction of fill

Compaction of fill is one of the major parts of the grading operation. "The principle that deep fills must be adequately compacted also finds wide agreement," Mr. Bestor says in his Urban Land article.

Mr. Lambie said in his talk before the League of California Cities:

Generally, all sloping building sites end up with some kind of a fill, if only to get rid of the material that was cut from the higher side of the lot. The question is then asked, "Should all fills be compacted, or is it possible to use some uncompacte material resulting in a savings in cost?" Com- pacted material should be used in any location where a building is to rest on the fill. In other cases, it will depend upon the type of material and use of the land.

For example, when the paving of terraces on a fill is necessary to prevent the saturation of the fill below, soil compaction is essential to prevent settling and the cracking of the surfacing material.

In general, the density of fills should be maintained at about ninety per cent. This is not difficult to obtain in most soils and is satisfactory in residential developments where the foundation loads are light, resulting in small soil pres- sures.

Mr. Bohannon says: "Just to push the dirt over the hillside and let it go at that is the thing which gets everybody into trouble. . . . you should have a compaction of not less than 90 per cent on your finished treatment."

Compaction of fills should be required in the grading ordinance.

GEOLOGICAL HAZARDS

The problems of developing sites suitable for building and of constructing roads in hillside areas are not limited to earth moving or grading. Success- ful handling of grading problems depends on a knowledge of geological and soil conditions. A Los Angeles County interdepartmental committee -- planning, engineering, forestry, and other officials -- studying hillside development had this to say:

Geological considerations relative to the establishment and
maintenance of building sites and the location of geologically hazardous areas in the foothills and mountains of Los Angeles County are of utmost importance. Until recently, most of the land used for residences has been relatively free of damage from existing or potential geological hazards; however, the increasing population and hence the ever increasing demands for building sites in Los Angeles County will accelerate the development of the available foothill and mountain slopes for residential living. On much of this terrain, geological hazards are inherent and their effects have to be neutralized or eliminated if extensive damage to public and private property is to be avoided. The consequence of continuing an approach to building site problems wherein geological and soil considerations are overlooked could be disastrous. Therefore, it is essential in the interest of public welfare, that the County secure and utilize the information and data geology can provide regarding those natural factors necessary to insure sound development, and incorporate requirements for geological surveys and reports into its procedures, policies, and laws.

Geological hazards are defined in the report as "those . . . inherent in the crust of the earth (land slides, soil slump, ground subsidence, rock failure, mud avalanche, and similar conditions)."

The committee recommended that the county create a qualification board for geologists and soil engineers who offer geological studies in support of subdivision applications. The subdivision ordinance was amended to read as follows:

If the advisory agency finds that a geological report is necessary to determine whether the property to be subdivided is subject to an existing or potential geological hazard, a written report stating how the geological conditions will affect the proposed development may be required. The report shall be prepared by a geologist experienced in engineering matters and qualified by the County Geological Qualification Board.

The committee also recommended that the county be given authority to require a note on the final map directing attention to any portions of the land within the subdivision that was subject to an existing or potential geological hazard.

The requirement that a geological report be submitted is apparently not completely acceptable to developers. Mr. Bestor notes "... arguments arise to what extent soil engineers and erosion control experts must be employed by the subdivider." However, Mr. Sohannon remarks:

Where heavy grading operations are indicated to change the natural ground surface to provide more level lots for residential use, many conditions may be encountered which often greatly affect the finished lot cost. Before undertaking such an operation a proper soil investigation should be made by a
qualified soil engineer and the grading operations should proceed under his control.

Prohibiting development in hazardous areas

Many subdivision ordinances include a provision giving the reviewing authority the power to reject the development of subdivisions in hazardous areas. A few of these provisions mention hillside areas as those that might be unsuitable.

Areas known to be dangerous by reason of geological conditions, unstable subsurface conditions, ground-water or seepage conditions, flood hazard, inundation or erosion by the ocean or any other dangerous condition shall not be subdivided or divided except under restrictions as to the use of all or any part thereof. (Orange County, California, 1957)

* * * * *

Land subject to flooding, land with excessive slope, and land deemed by the Planning Commission to be undesirable for development shall not be platted for residential occupancy, nor for such other uses as may involve danger to health, life or property or aggravate the flood hazard. Such land shall be set aside for compatible uses. (Model subdivision ordinance, Institute of Local Government, University of Pittsburgh)

* * * * *

Areas subject to slides or other similar hazards to public safety shall not be subdivided. (Tulare County)

* * * * *

The following, among others, shall be cause for disapproval of a tentative map:

Excessive depth or slope of cuts or fills. (Santa Barbara County)

* * * * *

If any portion of the land within the boundaries shown on a tentative map, or maps, of a subdivision or approved record of survey is subject to flood hazard, inundation, or geological hazard and the probable use of the property will require structures thereon, the advisory agency may disapprove the map, or maps, or that portion of the map, or maps, so affected, and require protective improvements to be constructed as a condition precedent to approval of the map or maps. (Los Angeles County)
Other provisions prohibiting subdivision of land unsuitable for development are given in Subdivision Design -- Some New Developments, Planning Advisory Service Information Report No. 102 for September 1957. The preservation of natural features such as rock formations, which are common in hillside developments, is also discussed in the report.

DRAINAGE

Leroy L. Little, former assistant director of the Allegheny County, Pennsylvania planning department, in a report to a 1957 local government conference on subdivision control at the University of Pittsburgh, commented on drainage problems in filled land:

The problems created by rearranging land are many, and by adding paved areas -- streets, sidewalks, driveways, roofs and patios -- the drainage run-off is increased. Particular attention must be given to the protection of filled land. Inadequate or poor grading, uncompacted fill, rubbish fill and ponded water result in potential subsidence. Our geologic formations in Allegheny County lead to particular problems such as slippage and collapse. The infiltration of water in filled land may create a lubricated plane, and we have seen in recent weeks many such problems which have resulted in severe damage because of such failures. Additional damage has occurred to municipal facilities in broken sewer and water lines and destroyed drainage structures.

There are differences of opinion, Mr. Bestor points out, "as to how far a subdivider should be forced to take care of every possible future drainage problem." At any rate, subdivision controls should spell out what is expected of the subdivider.

Perhaps the best example of comprehensive provisions for drainage are those in the Contra Costa County and Richmond, California ordinances. Such general but inclusive provisions are adequate to regulate drainage from hillside areas.

There are other problems, however: provision of on-lot drainage channels and control of erosion on slopes.

On-lot drainage channels may be needed in addition to the usual lot grading, according to the Home Builders Manual. Although lots should be graded so that water drains away from buildings, on hillside lots water often drains toward them. A drainage channel or swale may be needed to carry away surface water.

Erosion control is another problem -- one Mr. Lambie discussed at the conference mentioned earlier. He said:

Cuts, in general, do not create a major problem, as they are normally quite stable and basically are subject only to erosion. In turn, an erosion problem can be reduced by picking up the water at the top of the slope and carrying it by means of a trough to a channel or natural drainage course. On long slopes, an accumulation of water on the surface may create an erosion problem. This may be solved by cutting one or more terraces in the face of the cut which will pick up this surface water and carry it away in a similar manner.

A word of caution on terraces -- in some formations they are extremely detrimental. An example is in the case of shale layers where the water may percolate downward rapidly along the planes of the shale. A pressure head is built up by water in the shale, tending to separate the shale layers. Then depending on the slope of the strata, there may be a failure of the material, resulting in the upper portion falling or sliding down, over and on top of the lower material. This has been one of the major causes of slides in our Southern California area.

* * * * *

Since we have had the grading ordinance in the County, the primary complaint involves the erosion of material from a cut or fill onto the property below. . . . Some of the basic requirements [for erosion control] are:

1. To have a dense surface,
2. To remove any accumulation of water, and
3. To slow down the velocity before it can scour or cut into the surface.

In many instances, the soil cannot be compacted to provide a hard surface, so planting is used to reduce the velocity of the water to prevent scouring.

In certain soils a dense ground cover may be detrimental, as it will permit the water to soak into the ground and cause a sloughing off of the material. Successful planting depends on many factors. Two important ones are the fertility of the soil and the means of watering the plants, particularly where natural rains will not maintain the growth. The type of plants themselves are significant, for we must get a ground cover immediately.

Some subdivision regulations include erosion control planting as an improvement. The Santa Barbara County ordinance requires:

Erosion control planting and structures, with provision for the maintenance of planting until growth is established.

The city of Santa Barbara has a similar provision.
It may be as necessary to prohibit development of hillside areas because of bad drainage conditions as it is because of geological hazards. Floods are a major hazard, but the usual provision in a subdivision ordinance that requires submission of drainage plans should make it possible for the subdivider and the reviewing authority to determine which areas of a site are subject to floods. Buildings should be located to avoid damage from overflowing streams and so that they do not disrupt drainage paths.

SEWAGE DISPOSAL

Sewage disposal is more closely related to drainage problems in hillside areas than it is in other areas. Mr. Lambie notes that septic tanks may cause saturation of the soil with resulting geological problems, such as landslides.

Of special importance is the sewage disposal problem. I realize that some cities are completely sewered but in our County and many incorporated areas there are large mountainous regions that will not be provided with sewers for many years to come. This disposal problem should be included in the original subdivision planning, but quite often little is done other than increasing the size of the lot area, to provide space for the septic tanks and the necessary leaching lines or seepage pits. In this instance, it is of prime importance to know what type of material may be below the surface, for it is essential to dispose of the effluent from the system without creating a ground slippage or sinking hazard. This goes somewhat into the geology in the area, such as the type of material, slope of strata and similar items. When a proper investigation has not been made, the seepage waters may pass through the upper soils and stay on top of an impervious layer below. This water saturates the top soils and may result in a rapid lateral movement of the material. This takes place in natural soils or even fills and creates quite a problem, especially when the movement is onto the neighbors' property.

The use of septic tanks in hillside areas has apparently proved to be possible only under certain circumstances. Mr. Bestor notes:

... Where lot size and soil characteristics permit, septic tanks are sometimes allowed. There are fewer instances of this practice than previously and many existing septic-tank subdivisions are being sewered today through the cumbersome means of the improvement district.

Mr. Bohannon's experience may also furnish a guide to when septic tanks can be used in hillside areas:

We don't advocate septic tanks on sites of less than one acre. We like to see lots average two to two-and-a-half or three acres where septic tanks are used. I have one development with lots which average about two and a quarter acres. We do use septic tanks /there/, but we have an excellent soil con-
dition for the effluent. There is ample evaporation and there is no problem.

To rule successfully and fairly on whether septic tanks can be permitted in a hillside development, the reviewing authority must have the power to decide which lots are suitable for septic tanks. A subdivision ordinance provision that requires consideration of grading, geological, and percolation studies is helpful.

The Los Angeles County subdivision ordinance was amended to require consideration of all three factors. That part of the amendment dealing with grading is on page 17 of this report, that on geological factors on page 23, and the part requiring percolation tests follows.

Matters required. Proposed method of sewage disposal. Where public sewers are not available and where private sewage disposal systems will be utilized, the results of a percolation test shall be submitted in accordance with the recommendations of the health officer.

Lot design. Area and width. Where public sewers are not available and private sewage disposal is to be used, every lot or parcel or building site shall be of sufficient size to provide for satisfactory sewage disposal for the land use intended.

If septic tanks are not a feasible solution and trunk sewers are not available, developers should consider the use of group disposal or "package" plants.

A private sewer system in a subdivision should be planned so that it can be connected with a public system when it is available. The House & Home article on hillside houses in the June 1958 issue (referred to previously) includes a diagram of several solutions to the problem of locating sewer lines for downhill houses.

"LEFT-OVER" LAND

A basic problem in hillside subdivisions is what to do with left-over land -- land that cannot be, or was not, subdivided into lots -- and how to get to it for fire fighting, for instance. Some of the land can be subdivided if the developer is permitted to use a substandard means of access -- such as public trails, driveways, and private streets. Access by "substandard streets" is also a way to eliminate future resubdivision -- even if a questionable way.

There will, however, undoubtedly be land that cannot be developed. It may, of course, be possible to add the land to lots next to it. It is claimed by Mr. Bestor, with some justification, that excessively large lots are

\[\text{For examples of group disposal plants, see "There's a Community Treatment Plant to Fit Your Needs," House & Home, February 1958.}\]
not an unmitigated asset. Unless wooded or otherwise attractive in the wild state, they can become an eyesore if not kept up." In Los Angeles County it was suggested that such left-over land be acquired for public use -- fire protection and watershed purposes, for instance.

Richmond, California handles the problem through its subdivision ordinance:

No subdivision shall be accepted which leaves unsubdivided islands, strips, or parcels of property unsuited for subdividing and not accepted by the City of Richmond for appropriate use, and all lots must be buildable.

Most subdivision ordinances have similar provisions that empower the reviewing authority to prevent unsubdivided property being left in the developer's hands, even though it may be difficult to decide what should be done with the land.

Another common provision -- requiring resubdivision of larger-than-building lots -- illustrates the difficulty of applying flat land subdivision ordinances to hillside areas. Harold W. Lautner, head of the Department of Urban Planning and Landscape Architecture at Michigan State University, in his book on subdivision practices, quotes a provision from the Riverside, California ordinance that rather neatly resolves the problem by exempting hillside subdivisions from the resubdivision provisions. The provision says: "A subdivision that contains any lots one-half acre or more in area or more than one hundred sixty-five (165) feet in any dimension . . . shall have a plan for resubdivision prepared for it. The provision does not apply to . . . residential subdivisions of hillside land, arroyo edges or other places where the topography of the land is such that no further street or extension of any street through such subdivision will be possible or desirable."

### ACCESS FOR EMERGENCIES

Access for fire fighting and to handle other emergencies involves not only the lot pattern but also street length and width. In a letter to Planning Advisory Service, John Malone, chief of subdivision administration for Los Angeles County, says: "Many subdivisions begin development at the foothills and travel up the canyons and ridges for as much as two miles without any other outlet or entrance. These roads of excessive length, in this type of mountains, have caused considerable trouble."

The Los Angeles County engineering department noted in a report that "In the event of an emergency the failure to provide access to hillside areas from more than one entrance street greatly endangers public safety, making it difficult to evacuate the area and to dispatch emergency vehicles to the scene."

As a result of the Los Angeles County studies of hillside development, the
following amendments to the subdivision ordinance, dealing with access for fire fighting, were adopted:

Dead-end streets in mountainous areas. In areas where, in the opinion of the Forester and Fire Warden, there will be a fire hazard to the watershed or any other properties, a cul-de-sac or dead-end street in excess of 500' in length shall have a pavement width of 36' within a minimum right-of-way width of 42'.

Fire fighting access easements. In areas where, in the opinion of the Forester and Fire Warden, there will be a fire hazard to the watershed or any other properties, unobstructed fire protection equipment access easements, not less than fifteen feet wide shall be dedicated from the public street to the subdivision boundary. The Forester and Fire Warden shall recommend to the advisory agency regarding the location, design and grading of such easements. Such location, design and grading shall be as found necessary by the advisory agency.

County officials thought that any street serving as the only means of access to a development should be relatively wide, perhaps classified as a collector street.

An adequate water supply for fire fighting is also a problem in hillside areas. Advance public works planning may be needed to assure availability.

This report was prepared by Robert A. Clark, Planning Advisory Service.