Planning
the
Built
Environment
Planning the Built Environment

Larz T. Anderson
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Acknowledgements

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In the 1970s, Professor Gerckens taught a series of “Elements” courses in Ohio State’s graduate program in City and Regional Planning. These were intended to develop the basic skills necessary for the practice of urban planning. For these courses Professor Gerckens developed several course manuals, a number of data sheets, and a series of student exercises. His students found his teaching to be stimulating and his course materials valuable.

When Professor Gerckens was promoted up the academic administrative ladder, I was privileged to continue teaching several of his “Elements” courses, using the course outlines and materials he had developed.

As time passed, I edited and updated his work, dropped some of it, and added to it here and there. Later on I taught similar “Elements” courses in the graduate planning program at Virginia Tech¹ based on the course materials Gerckens and I had developed at Ohio State.

The text that follows owes its genesis to Professor Gerckens. He should not, however, be held responsible for any errors of omission, commission, or distortions of fact.

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Note

¹ Formally known as Virginia Polytechnic Institute and State University.
This book, as suggested by its title, is about planning the physical components that constitute much of our built environment.

The term “planning” refers primarily to the design of the functional, rather than the aesthetic, aspects of those physical components.

The term “built environment” refers to the structures and facilities that we build in urban and suburban areas, as a part of the physical pattern we use in our current civilization. These include roads, utility systems, schools, subdivisions, housing, and some accompanying physical features.

This built environment can be considered to be composed of a number of subcategories, which include:

- the natural environment
- the built environment
- the social environment
- the economic environment

Those who are involved with designing various aspects of urban areas realize that all of these environments are interrelated; that actions taken in one category of environment usually impact other parts of the total environment. This book will, however, consider primarily the built (or physical) environment, because to do justice to a comprehensive review of the totality of our urban environment might well call for a team of experts to work for decades, and produce a large and complex tome.

The professionals who are most often involved with designing the physical components in our urban areas are (in alphabetical order): architects, civil engineers, landscape architects, traffic engineers, and urban planners.

It is the author’s observation that, for the design of components of the built environment, there are many assignments which one person (or a team) qualified in one profession can often undertake and complete satisfactorily (perhaps brilliantly) without the participation of people from other professions. These assignments are often small in scale and have few, but well-defined, objectives (for example, a single structure that is to be built for a specific use, and in accordance with established, clearly defined development regulations).

There are also many assignments where, although they could be satisfactorily done by members of one profession, the quality of the resulting design would probably be substantially improved if it were undertaken by a team which has representation from several of the design professions (for example, a small subdivision).

There are still more assignments where it is absolutely essential that professionals from a variety of fields work together if a truly satisfactory design is to be produced. These jobs are often large in scale, involve a number of topics, and have multiple objectives which are often conflicting (for example, the development of a section of an urban area, in order to create a large, “planned-unit development” which has a variety of land uses).

The purpose of this book is to acquaint students (and to reacquaint experienced professionals) in one of the design fields with some of the basic procedures used by professionals in other design fields. For example: If you are now (or want to be) an urban planner, it would be helpful for you to know something about water and sewer systems, traffic gener-
ation, and site planning. This is not to imply that you should become a civil engineer, a traffic engineer, and a landscape architect. On the other hand, you should know enough about these other fields so that the work you do will be compatible with the work they will do, and that you know enough about their vocabulary and design constraints in order to communicate and work effectively with them.

Many chapters in this book conclude with lists of “Recommended Reading” and “Sources of Further Information.” The “Recommended Reading” lists are important sources that augment this text; readers are strongly urged to review them if they are available. (They should be considered “required reading” if this book is used as a classroom text.) The “Sources of Further Information” are provided for those readers who wish to delve further into the topic under discussion; they should not be considered as “required reading.”

A number of exercises are provided in Appendix A that are directly related to many of the topics discussed in this book. These exercises have proven to be valuable learning experiences for students, and to be a far more effective teaching technique than lecturing or assigning readings; they are what some educators refer to as “experiential learning.”

In writing this book, consideration of how to use computer programs in the design process has been consciously omitted. There are many excellent and affordable computer programs that are very useful to design professionals. However, to the inexperienced, computers may be considered to be beige boxes that, when some numbers are typed in, will print out other numbers that they assume are valid and need not be questioned. It is hoped that those who read this book will understand which factors should be considered when designing segments of the built environment, and will learn how to make appropriate calculations concerning them. Only when we understand the analysis and design processes should we rely on computer programs; only then should they be used to take over what is often complex, time-consuming, and tedious work.
PART

I

Land
CHAPTER 1

Landforms

DEFINITION

Landform—The form, structure, and character of the surface of the land.

Landforms are usually the result of the interactions of various natural physical processes with the surface of the earth.

These processes include stream erosion, wind erosion, glacial action, earthquakes, volcanic action, the freeze-thaw cycle acting on surface materials, the leaching chemicals from rocks and soils, and the deposit of wind- or water-borne materials. These processes are usually (but not always) very, very slow.

Mankind also makes significant impacts on landforms through actions such as draining lakes and marsh areas, flooding lowland areas, massive grading operations, and diverting rivers. Man-made impacts on landform are usually very small in size, but very rapid when compared to the scale and pace of geologic change.

THE IMPORTANCE OF THE STUDY OF LANDFORMS TO DESIGNERS OF URBAN AREAS

Landforms are important to designers because they often place substantial limitations on the location, intensity, and character of urban development. For example, in some areas it is difficult or expensive to build because of steep slopes, extensive rock formations, or the presence of water; in other locations, it is dangerous to build because of natural hazards such as flooding, landslides, earthquake hazards or shoreline erosion.

On the other hand, landforms often identify opportunities because they may show locations that are most suitable for urban development, areas suitable for the exploitation of natural resources (through farming, mining, and forestry), or areas where the natural features are of such ecological importance or social value that they should be preserved.

HOW LANDFORMS AFFECT URBAN DEVELOPMENT

Mountains and steep hillsides—Roads and buildings are difficult and expensive to build in mountainous or steeply sloping hillside areas. Their construction is relatively expensive because of the cost of excavating the uphill section of a road right-of-way (ROW) or a level building site, and the cost of filling and compacting the downhill section. Aside from the economics of development, grading in hillside areas may have very serious adverse
environmental impacts: it can cause severe soil erosion and can disrupt much vegetation.

Rocky hillside areas may experience rockfalls, especially in the freeze-thaw cycle of winter-spring. Avalanches may occur in areas with heavy snowfalls. Some soils tend to lose their cohesion when they are saturated with water. If they are on a steep hillside, the force of gravity pulls them downhill which may result in a landslide.

Vee-shaped valleys—The bottoms of these valleys usually have rivers or streams which pose flooding problems, and the steep sides of the valleys may be expensive building sites. Flash flooding is often a serious threat in these valleys.

Flood plains—Many plains are subject to periodic flooding, especially those located where there is no place into which the flood waters can drain. These areas are often suitable for agriculture but may be hazardous for urban development.

Bare rock—These include areas where the depth to bedrock is slight. Installation of underground utilities is difficult and expensive. Grading for level building sites or parking lots is expensive. In some cases, it may be more economical to leave the landform alone and build structures above it.

Sand—Wind blows sand around. You may find that sand intrudes on urban development and may cover it as the years go by, or the sand around and under the development may be blown away.

Lakes—It is possible but often expensive to build urban development on barges or houseboats. Or, piles can be driven down to a firm bearing soil (or to the point of resistance) and used for foundations, but that’s expensive, too. Installing underground (or underwater) utility lines is also a severe problem. Of course, there are environmental costs to be considered; they are usually significantly adverse.

Marshes, bogs, and mud flats—These have problems that are similar to those present in lakes, although the water is thicker in them. Some of these areas can be drained and developed, or filled and developed. Note, however, that areas which have water on their surface (seasonally or more frequently) are classified as “wetlands,” and most of them are considered to be valuable ecological resources. Current legislation places severe restrictions on how they may be used or modified.

Shoreline areas—Shorelines adjacent to the Pacific Ocean are sometimes inundated by tsunamis (“tidal waves”). On the Atlantic and Gulf coasts, hurricanes occasionally do great damage to shoreline development.

Earthquake areas

- Sites which are crossed by a fault zone—Often, when an earthquake occurs, the land on one side of the fault moves, while the land on the other side of the fault does not. This plays havoc with any building foundations and underground utilities that straddle the fault line.

- Sites which are not directly on, but are in the vicinity of, a fault zone—These areas may experience severe shaking, which may cause substantial damage to aboveground structures in the area. Underground utilities may be compressed and then stretched by the shaking motion, which may cause severe damage or failure.

- Sites which undergo liquefaction—When some soils contain substantial water, they may undergo “liquefaction” when shaken by an earthquake, causing them to act like a liquid for a brief period of time. This can result in slides or slumps
of the soil, and destroy the foundations of any structures built on them.

THE INFLUENCE OF LANDFORMS ON THE LOCATION OF CITIES

The earliest cities appear to have been built in areas where it was easy to grow crops. This often meant that their locations were on or adjacent to the flood plains of rivers such as the Nile, Tigris, Euphrates, and Indus.

Many of the earliest North American cities were built in coastal areas where there were good harbors. The cities of Boston, New York, and Charleston are examples. Cities (such as Montreal and St. Louis) were also built in inland areas which were accessible by ships and barges using navigable rivers.

Later, as the interior of the country was being settled, canals were built to provide water-borne transportation. The alignment of these canals, of course, had to observe the local landforms. Most often they followed existing river beds and, when the river was no longer navigable, they had to avoid mountains and rock outcroppings. The growth of a number of cities in the United States was greatly accelerated by the construction of these canals.

The canal-building era in the United States was soon eclipsed by the railroad-building era, which started about 1830 and lasted into the 20th century. Rail lines strongly influenced urban growth in America: many cities that had good transportation (by water or rail) flourished; those without tended to stagnate or decline.

The location of rail lines, like the location of canals, has to observe the restrictions imposed by local landforms. Rail lines are generally built with a maximum grade of 1 percent, so they are most often found on level to gently sloping terrain, or following the alignment of river valleys which zigzag across the face of hillside areas, or cutting or tunneling through hills and mountains. Since rail-line locations are so strongly influenced by landforms, in many cases the locations of many cities were also influenced by landforms.

With the development of automobiles and trucks in the 20th century, it became feasible to locate large cities in areas not served by rail lines or waterways. It should be noted, however, that most cities which have major commercial or industrial uses relying on the shipment of heavy or bulk cargo must have access to rail or water-borne carriers. Cities that do not require bulk cargo shipments can now rely on highway transportation. (An example of this is the "Silicon Valley" metropolitan area in California.) We observe that today's city location is far less restricted by landforms than it was 50 years ago. Nevertheless, we still select sites for city development where the landforms are friendly to urban development (such as on gently sloping plains that are not subject to flooding).

THE INFLUENCE OF LANDFORMS ON THE FORM OF CITIES

Many city planners acknowledge that the forms of most cities are strongly influenced by economic considerations. At the same time, they also acknowledge that economic considerations are often strongly influenced by the character of local landforms.

For example, activity centers in American cities are usually located in areas with good access; areas with good access are located where roads or rail lines can be built at a moderate cost. This rules out mountainous areas, lakes, and marshes for the location of high-intensity urban uses.

Gently sloping terrain, which is well drained and has easy-to-build-on soils, is usually the most suitable for agricultural uses. Economic forces, if left to work in an
unfettered manner in urban areas, tend to displace the very low-intensity uses (such as agriculture) with medium-intensity uses (such as subdivisions) which, in turn, may be outbid by high-intensity uses (such as business parks or shopping centers).

While it is true that (almost) any terrain can be made buildable for urban development, the economic cost of doing so in some areas may make it prohibitively expensive, to say nothing of the environmental costs. For example, mountains can be leveled (for a price), lakes and marshes can be filled (for a price), and sites can be constructed above rock formations (for a price). It seems that areas with difficult landforms are avoided for urban development largely because of economic considerations. As a result, when there are no regulations to the contrary, land uses which generate high economic returns tend to get first choice of location; low-intensity land uses, which generate a low economic return per unit of land area, get what's left over.

In North American cities, we can observe the interaction of economic forces with landforms. For example:

- Port development often takes place on level lands adjacent to navigable waterways.
- Central business districts are often found in areas that have good accessibility and fairly level building sites.
- Rail lines, freeways, and major streets are located where the terrain does not require excessive grades.
- Areas that are subject to occasional flooding are occupied by land uses which do not expose residents to danger and which, if inundated, do not incur an unreasonable economic cost. Land uses such as agriculture or parklands are sometimes found here.
- The slope of the terrain usually identifies which land uses are economically and environmentally suitable. Level terrain can accommodate many types of land uses; steeply sloping terrain is suitable for relatively few. The effect of the slope of terrain on land uses will be discussed at greater length in Chapter 3.

- The elevation above sea level of various sections of an urbanizing area may strongly influence the location and timing of land development because of constraints imposed by utility systems. Water supply, sewage disposal, and storm drainage systems rely primarily on "gravity flow" for their operation. If a city has built a water supply system that serves all land uses below the 1,000-foot elevation, those areas above 1,000 feet cannot be served without the construction of new pumping stations and storage facilities, which may require a considerable economic investment. If a city has a sewage treatment plant that receives an inflow of sewage at an elevation of 500 feet above sea level, those areas below that level cannot be served by gravity-flow sewers; this means that pumping stations and force mains would have to be built, perhaps at a considerable economic cost, if areas below the treatment plant are to be developed. This subject will be discussed in greater detail in Chapters 4 and 5.

The constraints of landform, combined with economic forces, have had a noticeable effect on the forms of North American cities. Cities that are located on gently sloping, well-drained plains can (and do) expand outwards from their centers, almost without limit; the result is what is sometimes known as "spread city." (The Los Angeles area is often pointed out as an example of this.) Cities that are built in valleys, and which are bounded on several sides by mountains or steep hillsides, usually
develop in a linear pattern along the valley floor and often extend for miles. Cities that contain pockets of difficult-to-develop landforms within their boundaries (such as lakes, bogs, steep hills, flood plains, and rock outcroppings) tend to develop urban patterns with holes in them, leaving vacant areas or areas of low-intensity land uses.

**DEFINITIONS OF SOME FREQUENTLY USED GEOLOGICAL TERMS**

*Alluvial fan*—A cone-shaped deposit of alluvium made by a stream where it runs out onto a level plain or meets a slower stream.

*Alluvium*—An unconsolidated terrestrial sediment composed of sorted or unsorted sand, gravel, and clay that had been deposited by water.

*Arroyo*—A steep-sided and flat-bottomed gully in an arid region that is occupied by a stream only intermittently, after rains.

*Bedrock*—The solid rock that underlies gravel, soil, or other superficial material.*

*Butte*—A conspicuous, isolated, flat-topped hill or small mountain, especially one with very steep or precipitous sides.*

*Canyon*—A steep-walled chasm, gorge, or ravine; a channel cut by running water in the surface of the earth, the sides of which are composed of cliffs, or series of cliffs, rising from its bed.**

*Cliff*—A high, steep face of rock; a precipice.*

*Delta*—An alluvial deposit, usually triangular, at the mouth of a river.**

*Diveide*—A ridge of high ground separating two drainage basins emptied by different streams.

*Drainage basin*—A region of land surrounded by divides and crossed by streams that eventually converge to one river or lake.

*Drumlin*—A low, smoothly rounded, elongated hill composed of glacial till.*

*Dune*—A mound, ridge, or hill of wind-blown sand.*

*Erosion*—A group of processes whereby earthy or rock material is loosened or dissolved and removed from any part of the earth's surface. It includes the processes of weathering, solution, corrosion, and transportation.**

*Esker*—A glacial deposit in the form of a continuous winding ridge, formed from deposits of a stream flowing beneath the ice of a stagnant or retreating glacier.

*Fault*—A fracture or fracture zone along which has been displacement of the sides relative to one another and parallel to the fracture.*

*Flood plain*—A level plain of stratified alluvium on either side of a stream, submerged during floods and built up by silt and sand carried out of the main channel.*

*Gully*—A small ravine; any erosion channel so deep that it cannot be crossed by a wheeled vehicle or eliminated by plowing.**

*Hill*—A prominence smaller than a mountain. In general, the term “hill” is properly restricted to more or less abrupt elevations of less than 300 meters; all altitudes exceeding this are considered mountains.**

*Hillock*—A small, low hill; a mound.**

*Karst*—A type of topography that is formed over limestone, dolomite, or gypsum by dissolving or solution, and is characterized by closed depressions or sinkholes, caves, and underground drainage.*

*Landslide*—The rapid downslope movement of soil and rock material, often lubricated by ground water; the tongue of stationary material deposited by such an event.

*Meander*—Broad semicircular curves in a stream that develop as the stream erodes the outer bank of a curve and deposits the sediment against the inner bank.
**Mesa**—A tableland; a flat-topped mountain or plateau bounded on at least one side by a steep cliff.*

**Moraine**—A glacial deposit of till left at the margin of an ice sheet.

**Mountain**—A tract of land considerably elevated above the adjacent country. Mountains are usually found connected in long chains or ranges; sometimes they are single, isolated eminences. Generally, a mountain is considered to project at least 300 meters above the surrounding land.**

**Plain**—A region of generally uniform slope, comparatively level, of considerable extent, and not broken by marked elevations and depressions; it may be an extensive valley floor or a plateau summit.**

**Plateau**—A relatively elevated area of comparatively flat land which is commonly limited on at least one side by an abrupt descent to lower land.*

**Ravine**—A depression worn out by running water; larger than a gully and smaller than a valley.**

**Sinkhole**—A small, steep depression caused in Karst topography by the dissolution and collapse of subterranean caverns in carbonate formations.

**Spurs**—The subordinate ridges which extend themselves from the crest of a mountain, like the ribs from a vertebral column.**

**Subsidence**—A sinking of a large part of the earth’s surface.**

**Terrace**—A relatively flat, horizontal, or generally inclined surface, sometimes long and narrow, which is bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side; also known as a bench.**

**Till**—A body of unconsolidated sediment that may contain a variety of fragment sizes (from clay to boulders) which has been deposited by glacial action.

**Tsunami**—A great sea wave produced by submarine earthquake or volcanic eruption; commonly misnamed “tidal wave.”*  

**Valley**—Any hollow or low-lying land bounded by high ground, usually traversed by a stream or river which receives the drainage from the surrounding heights.*

**Note**
Definitions marked with * are adapted from the American Geological Institute, Dictionary of Geological Terms. 3rd ed., 1984. Reprinted with permission.
Those marked with ** are adapted from the American Geological Institute, Dictionary of Geological Terms, 1976 ed. Reprinted with permission.

**Sources of Further Information**
When you have developed this information, take your engineer's scale and lay out a grid with cells that measure 660 feet on each side, at the scale of the map you are measuring. Or, if you choose to use dots to represent grid cells, space the dots 660 feet apart. You can choose to draw your grid showing the boundaries of all grid cells or prepare a grid in which each dot represents one grid cell. You will find that the dot representation makes life a lot easier when it comes to counting grid cells.

You can draft your grid pattern directly on drafting film; an easier way is to draft it on plain paper, and then use a photocopy machine to transfer your grid onto transparent film (often used for making overhead projection sheets).

To use your grid, place it on top of the map you wish to measure and tape it in place temporarily. (You must not move it around on top of the map once you have started counting grid cells.)

The next step is to count the number of grid cells that represent the land area you are measuring. This is no problem where each cell on your grid is fully filled by land area. On the edges of the area being measured, however, you are going to have to make judgment calls on whether a cell is more or less than half filled by the land area; if it is more than half filled, you count the cell; if it is less than half filled, you don't. (If you are using a grid made up of dots that represent cells, the number of these agonizing decisions is greatly reduced.)

To calculate the area of the land you have measured, simply multiply the number of cells you have identified as covering the land by the area that each cell represents.

Notes
1. Although you may think of the engineer's scale as a form of ruler, it is considered bad form to use it for drawing straight lines because your pen or pencil may damage the delicate edges of the scale.
2. (A) A minute of latitude is equal to 1 nautical mile, which is 6,076 feet in length. There are 60 minutes to a degree. (B) The length of a minute of longitude is equal to 1 minute of latitude multiplied by the cosine of its latitude. For example, at the equator, 1 minute of longitude has a length of 6,076 feet; at 45 degrees latitude, it has a length of 4,296 feet; at the North and South Poles, it has a length of 0 feet.

USGS Additional Information
The USGS's "Topographic Mapping" is a 20-page brochure describing the mapping process and topographic maps (free upon request).

Additionally, the USGS's "Topographic Map Symbols" is a folded brochure (sheet size 11 x 15 inches) that graphically shows the symbols used on USGS topographic maps (free upon request).

The USGS publications listed above, as well as maps and information on geology and hydrology, are available from any of the offices of the Earth Sciences Information Centers (ESICs), which are located in the following locations:

Reston-ESIC
507 National Center
Reston, VA 20192

Anchorage-ESIC
4230 University Dr., Room 101
Anchorage, AK 99508-4664

Denver-ESIC
P.O. Box 25286
Denver, CO 80225

Menlo Park-ESIC
345 Middlefield Rd.
Menlo Park, CA 94025-3591

Rolla-ESIC
1400 Independence Rd.
Rolla, MO 65401

Salt Lake-ESIC
222 W. 2300 South, 2nd Floor
Salt Lake City, UT 84119
The home page of the USGS on the internet is:
http://www.usgs.gov/

This address can lead to many sources of mapping and earth science information.

Sources of Further Information


holding the two maps together in front of a well-lit window.

The "rationalized" map should then be colored, using a carefully selected range of colors. The lightest colors are generally used to indicate the flattest areas; the strongest colors are used to indicate the steepest areas. It is preferable to use colors in the same general color family (such as pinks-to-red, light-greens-to-dark-greens, and tans-to-browns) when illustrating features on a map that have some obvious relationship.

Figures 3.3, 3.4, and 3.5 give examples of the steps involved when preparing a slope map using the techniques outlined above, other than the map coloring.

**Note**

1. Some computer programs for Geographic Information Systems (GIS) can produce slope maps after appropriate data are keyed in.
DEFINITIONS

Acre-foot—Unit quantity of water; an amount which would cover 1 acre to a depth of 1 foot; consists of 326,000 gallons.

Aquifer—A subsurface zone that yields economically important amounts of water to wells. (The word “aquifer” is synonymous with the term “water-bearing formation.”) An aquifer may be porous rock, unconsolidated gravel, fractured rock, or cavernous limestone.

Domestic use—Water use in homes and on lawns, including use for washing, cooking, flushing toilets, laundry, washing cars, air coolers, and swimming pools.

Evaporation—The process by which water is changed from a liquid to a gas or vapor.

Flood—Any relatively high stream flow overtopping the natural or artificial banks in any reach of a stream.*

Flood plain—The lowland that borders a river, usually dry but subject to flooding when the stream overflows its banks.

Ground water—The water zone below the surface of the earth in which the rocks and soil are saturated, the top of which is the “water table.”

Hydrology—The science of the behavior of water in the atmosphere, on the surface of the earth, and underground.

Impermeable strata—A layer of soil or rock which is not permeable to the passage of water (e.g., clay).

Infiltration—The flow of a fluid into a substance through pores or small openings. The common use of the word is to denote the flow of water into soil material. (In sanitary engineering, the term refers to the flow of water from adjacent soils into a sewer line.)

Leaching—The removal into solution of soluble minerals from solids into percolating waters.

Percolation—The passage of water through the open pores of soils, or the fissures in rock.

Permeability—The property of soil or rock to pass water through it. This depends not only on the volume of the openings and pores, but also on how these openings are connected to one another.

Saturated zone—The zone of soil in which water occupies the pores between the solid soil particles.

Sediment—Fragmental mineral material transported or deposited by water or air.

Transpiration—The process by which water vapor escapes from the living plant and enters the atmosphere.*

Water table—The upper surface of the saturated zone.

Note

1. Dewberry and Davis.

Definitions marked with * are adapted from the American Geological Institute, Dictionary of Geological Terms, 1976 ed. Reprinted with permission.

Recommended Reading


Sources of Further Information


pressure system in which the wastewater would flow by gravity from multiple sources to a pump at a pump station; the pump would then push the wastewater into a force main, through which it would be transported to the treatment plant.

Both the vacuum and the pressure systems have advantages and disadvantages when compared with a gravity-flow system. Some advantages are that:

- The location of the sewer lines would not need to be constrained by the downhill flow concept; this means that large areas of land that are not now sewered could be opened up for urban development.

- Smaller pipes could be used which would often be less expensive to install.

The disadvantages of the vacuum and the pressure systems are that:

- They both use pumps (which cost money to install and maintain) and are subject to breakdowns.

- The vacuum system might be difficult to maintain because of infiltration problems (any cracks in the pipe joints would suck air or water into the system).

- The pressure system might suffer from exfiltration (loss of wastewater through faulty joints in the pipes). This is not desirable because of the noxious character of sewage. The pipes for carrying sewage under pressure would be similar to pipes used to distribute water under pressure, but would have to be better installed and maintained. It should be remembered that water mains typically lose 20 percent or more through unaccounted-for leaks.

### Alternative Methods of Sludge and Effluent Disposal

Sludge disposal is a very real problem for most cities because there is so much of it. Conventional methods of sludge disposal are:

- burying it in a sanitary landfill
- burning it
- dumping it at sea

The first two methods may have some adverse environmental impacts, depending upon the characteristics of the sludge and on the care with which the process is undertaken. The third method is always environmentally damaging and is now prohibited in most areas. A method of sludge disposal now used in some agricultural areas is the spreading of sludge over a field and disking it into the upper layer of soil; in this manner, it becomes an effective fertilizer. This method appears to be desirable, if the sludge does not contain undesirable elements (such as heavy metals or toxic chemicals) that would adversely affect the crops grown on the land or the ground water under the surface of the earth.

The use of effluent as irrigation water has been previously mentioned. Other alternative uses of effluent are in ponds for landscaping purposes and in small lakes for recreational uses. Another use of effluent is in “groundwater injection.” In this process, the treated effluent is pumped into a deep well so that it reenters the supply of ground water. This process appears to have a number of advantages, providing that the quality of the effluent is such that it will not degrade the quality of the ground water.

### Note

Recommended Reading

Tabors, Shapiro, and Rogers. Land Use and the Pipe. Lexington, MA: Lexington Books, 1976. This book is out of print, but it is excellent. It is recommended that you peruse it if you can find a copy in your local library.

Sources of Further Information

Crites and Tchobanoglous. Small and Decentralized Wastewater Management Systems. New York: McGraw-Hill, 1998. Cited by Kahn, Allen, and Jones as “The bible of small scale wastewater engineering. This is a 1,000 page textbook for both students and engineers, and contains up-to-date information on decentralized wastewater treatment systems.”
SOURCES OF HYDROLOGIC INFORMATION

Hydrologists get data on rates and amounts of precipitation, and on stream flows, from local records whenever it is available (which occurs all too rarely). A number of state agencies keep good hydrologic data, especially those agencies concerned with water resources and flood control. At the national level, the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the National Weather Service are notable sources of hydrologic data.

Notes

1. Thanks are given to Laurence C. Gerckens; he prepared the first version of this chapter.
2. Adapted from the *Highway Design Manual*.
3. Since 1 acre inch per hour is equal to 1.008 cubic feet per second, the rational equation is commonly assumed to give peak flow in cubic feet per second.

Recommended Reading


Sources of Further Information


2. How should the utility lines be located in relation to each other?

3. Should utility lines be located in the public street ROW, or in easements across private properties?

4. The underground installation of telephone and electric power lines is usually done for aesthetic reasons. Installation of these utility lines aboveground is usually far cheaper than for lines underground. How much added cost are we willing to pay for an improved aesthetic environment? Who should pay these costs?

5. Currently, a number of cellular radiotelephone ("cell phone") systems are being installed. Where is the most effective but least objectionable location for the many transmitter-receiver stations that are required for these systems?

Another factor to be considered concerning underground utility lines is the threat of the backhoe. All too often, backhoe operators snag or puncture underground lines, causing service disruption and the need for expensive emergency repairs.

Concerning the installation of utility lines in relation to each other, practices seem to be changing. Some writers on the subject say that any utility line may be in the same trench with any other line. Past practice, however, has been to keep some lines separated from each other, especially water from sewer, and electricity from gas and telephone. When a number of utility lines are in the same trench, most or all lines are uncovered and disturbed when a worker wants to get at one line to repair or splice into it; this sometimes causes problems for the other lines.

Another problem of putting all utility lines in one trench is coordinating the initial installation. It is rare when all the utility companies involved can get their scheduling worked out and agree to install their facilities in a specific sequence, in an open trench, in a short period of time. Although it costs more for each utility company to dig a separate trench, it does make the installation of utilities less complicated for each of them. In high-density urban areas (such as central business districts) where there are many utility lines, it is desirable to build underground galleries where the lines can be placed on racks, rather than burying each line in the soil. This makes maintenance and modification work far easier. Here again, problems arise concerning coordination and agreement regarding who is going to pay how much for what. Unfortunately, a lack of coordination has resulted in adherence to the old pattern in most cities, wherein each utility company digs its own trenches and buries only its own lines, even in the very busiest of urban streets.

As of 2000, there is considerable uncertainty about the future of communication lines. It is not now known what physical characteristics these lines will have: Will they use traditional copper wires, fiber optics, ground-based radio relay stations (as now used by cell phones), satellite-based relay stations, or will they take some other form? Will there be a need for only one connection to each house or place of business, or will we continue to have multiple lines (such as a line for voice telephone, a line for cable TV, and a line to connect with internet computer services)? As of this writing, it appears probable that there will be substantial changes in the means of communication that will be available to us in the near future, but it is not yet clear just what form those changes will take.

Sources of Further Information


intended to provide access to numerous small traffic generators such as roadside strip commercial uses or single-family homes.

Curbside parking and loading is often restricted or banned on major arterials; it is sometimes permitted on minor arterials, even though it slows the flow of through traffic.

Major arterials commonly have two or three lanes in each direction; minor arterials are more likely to have one or two.

Note that major traffic-carrying streets (such as arterials, expressways, and freeways) should be designed to go around residential communities, not through them. They should also avoid dividing commercial areas and industrial districts; traffic arteries should serve these areas, not destroy them.

Collector Streets

Collector streets are the principal arteries within residential or commercial areas. Their primary function is to provide a convenient link between major arterial streets, subcollector streets, and local access streets. They typically have one or two lanes of traffic in each direction. Parking may or may not be permitted on them. Access to many adjacent nonresidential properties is usually permitted. Since collector streets carry substantial through traffic, low-density residential uses such as single-family homes should not have direct access to collector streets. Typical traffic volume on collector streets is from 1,000 to 10,000 vehicles per day, at speeds ranging from 25 to 35 mph [40 to 55 km/h]. It is desirable to keep this figure to less than 3,000 vehicles per day in residential areas.

Subcollector Streets

Subcollector streets provide a linkage between collector streets and local access streets. They also may provide access to adjacent properties. Subcollector streets usually provide space for one lane of traffic in each direction, and may also provide space for on-street parking. These streets typically carry from 250 to 1,000 vehicles per day. Vehicular speeds on these streets should be kept at less than 25 mph [40 km/h].

Local Access Streets

The primary and perhaps sole function of a local access street is to provide access to adjacent residential properties; it is not intended to carry any through traffic. These streets take the form of cul-de-sacs and loop streets. (For an illustration of these types of streets, refer to Figures 8.2 and 8.3.) They may have two narrow lanes, or one wide lane, for two-way traffic, depending on anticipated traffic flow. The amount of on-street parking that should be provided depends upon the density of the adjacent residential development. In very low-density rural areas, it may be feasible and desirable to provide no on-street parking. In low-density residential areas, perhaps parking on one side of the street would be sufficient. In medium- and high-density residential areas, it is usually appropriate to provide parking on both sides of the street.

The typical traffic volume of a local access street is approximately 0 to 200 vehicles per day. Vehicular speed on these streets should never exceed 25 mph [40 km/h]; 15 to 20 mph [25 to 32 km/h] is more reasonable and prevalent.

Notes

1. This definition is adapted from the Institute of Transportation Engineers. 1995 Membership Directory. Washington, DC.
2. Ibid.
3. There are many possible categories of trip purposes, such as trips related to work, home, shopping, school, recreation, social meetings, dining, medical/dental, and religious services. However, when coding
data for use in a computer model to predict future travel flows, the categories are very often condensed into these three: home-based work trips; home-based nonwork trips; and nonhome-based trips.

4. For a brief description of various traffic-counting techniques in current use, see Homburger et al., pp. 5-2, 5-3.

5. There are a number of other functions that the rights-of-way of streets provide but which are not usually considered to be of primary importance. These are (A) space for parked vehicles, (B) walkways for pedestrians, (C) an attractive, landscaped setting for adjacent properties, and (D) a location for aboveground and underground utilities.

6. In highway design, the term “grade” refers to the elevation of the surface of the roadway. “At-grade” means that the roadway runs along the surface of the earth. “Grade-separated” means that the elevations of intersecting roadways are separated by space, as you can observe in cloverleaf interchange structures on some freeways. This separation of the roadways permits traffic on one roadway to flow freely, without interference from traffic on the other roadway.

7. Average daily traffic on a freeway ranges from 20,000 to more than 200,000 vehicles per day.

8. Average daily traffic on an expressway is often from 20,000 to 50,000 vehicles per day.

9. ASCE-NAHB-ULI, p. 28.

10. Ibid.

Recommended Reading


Sources of Further Information


Some suggested sources of current information on computer programs for use in transportation planning and engineering are:

- **PC-TRANS**: A quarterly magazine/catalog of program applications relating to highway engineering and transportation using personal computers; has an extensive list of transportation software that it offers for sale. It is published by: Kansas University Transportation Center 2011 Learned Hall Lawrence, KS 66045

- **McTRANS**: Similar in function to the PC-TRANS. It is published by: Center for Microcomputers in Transportation Transportation Research Center P.O. Box 116585 Gainesville, FL 32611-6585
Figure 9.2. Conceptual Relationship of Level of Service to Some Measures of Quality of Flow Under Ideal, Uninterrupted Flow Conditions


in Figure 9.2. For freeways and multilane highways, the relationship varies with the design speed of the roadway and with the number of lanes. For two-lane highways, the relationship varies with the design speed, the type of terrain and, more significantly, the percent of no-passing zones of the roadway. For more information, consult the "Highway Capacity Manual."

Notes
2. Ibid., p. 1-3.
3. Homburger et al., p. 8-1.
4. AASHTO, p. 53.
6. Ibid.
7. Freeways, under some conditions, may carry higher traffic volumes. The 1997 update of the "Highway Capacity Manual" will include consideration of capacities of 2,250 passenger cars per hour per lane (pcphl) for a 55 mph free-flow speed, and 2,400 pcphpl for a 70 mph free-flow speed.
10. A layperson might calculate the capacity of a two-lane street by multiplying the number of lanes (2) by 2,000 vehicles/hour/lane, resulting in 4,000 vehicles/hour.
11. For further discussion of this topic, see the Transportation Planning Handbook, pp. 418-420.
12. HCM-1985, p. 7-7. See also AASHTO, p. 477.
13. AASHTO, p. 497.
15. Ibid., p. 7-9.
17. Ibid., p. 6-15.
18. The effects of stop signs on traffic flows are reviewed in detail in the “Highway Capacity Manual.”
20. The preceding LOS descriptions were adapted from HCM-1985, pp. 1-4, 1-5.
21. An uninterrupted flow is one that is not interrupted by stop signs, traffic signals, traffic from cross streets, or flows of merging or departing traffic.
22. The relationships between the V/C and LOS given in this discussion are only approximations.

Sources of Further Information


tion of this line and BC marks the "point of tangency" (PT) of the horizontal curve.

![Diagram](image)

**STEP 3**
- With a compass set to draw a curve with a radius of R, draw in the curve from the PC to the PT, using the center point of the horizontal curve. The centerline of the road has now been constructed. It runs along a line defined by the following points: A, PC, PT, and C.

![Diagram](image)

**Part 2: Drawing the Edges of the Roadway**

*Given:* The centerline of the horizontal curve of a road

*Required:* The edges of a roadway which has a width of W, and which follows the horizontal curve

*Discussion:* You know that if the roadway has a width of W, 1/2 the width W will lie on either side of the centerline of the road. If the radius of the centerline of the road is R, then the radius of the inside edge of the roadway will be R-W/2, and the radius of the outside edge of the roadway will be R+W/2.

**STEP 1**
- Using a compass, draw the two curves shown in the diagram below. Each curve starts at the line that connects PC and the center, and ends at the line that connects PT and the center.

![Diagram](image)

**Notes**
2. The abbreviation "SI" stands for "Système International," the French name for the expanded and modified version of the metric system, which is widely used throughout the world (except in the U.S.).
3. Homburger et al., p. iv.
5. The form of this curve is known to mathematicians and engineers as a "Euler spiral."
8. For more information on spiral curves, see AASHTO-1994, pp. 174-175, or ITE-1982, p. 595.


Definitions marked with * are adapted from the Institute of Transportation Engineers, 1982. Used with permission.

Those marked with ** are adapted from *A Policy on Geometric Design of Highways and Streets*, Copyright 1994, by the American Association of State Highway and Transportation Officials, Washington, DC. Used by permission.

**Sources of Further Information**


nience of their customers. Whether or not this practice will continue is a matter of conjecture because of the apparent slowing of new construction of retail outlets in downtown areas and the rise of suburban shopping centers.

**Shopping Center Parking**

Modern shopping centers rely almost entirely on private automobiles to bring their customers and employees; public transit provides a very low percentage of transportation used by those people. Naturally, the cars of the employees and customers must be parked somewhere. Calculating how much parking to provide, and determining where to locate it in relation to the activities of the shopping center, takes skill and judgment. Proprietors of shopping centers want to be sure that they have enough parking for their busiest days but don't have an excess amount that is expensive to build and maintain, and that, on slow days, may give the observers the impression that the shopping center is not well patronized.

**Park-and-Ride in Connection With Transit**

There has been a trend for transit operators to provide parking lots or garages for their transit patrons. These are usually adjacent to transit stations, or are sometimes adjacent to freeway interchanges which have convenient access for busses running along the freeways. These park-and-ride lots appear to be well utilized; they seem to provide a means of getting people to leave their cars in suburbia instead of congesting the regional road system.

**Satellite Parking With Shuttle Bus Service**

At least two types of land use have established parking lots (usually in areas of low land value) some distance away from their major operations, and provided shuttle bus service between the remote parking area and their centers of activity; these include airports and universities.

The systems appear to be well patronized by people who require long-term parking but are not privileged to have parking permits for close-in parking. At universities, this usually includes staff and faculty, and students who will be on campus at least half a day. At airports, it includes employees who work all day (or night) and travelers who will be away for a day or more.

**Zoning Regulations**

Most cities and counties in the United States have zoning regulations that limit how private properties may be used. A section usually found in these regulations deals with the requirement for off-street parking. Most jurisdictions are interested in enacting fair and reasonable parking requirements; while they want to make sure that present and foreseeable future parking needs will be met, they do not wish to require private builders to invest in parking facilities that will not be needed. Determining how much off-street parking is reasonable to require for each type of land use takes good judgment, and should be based on careful studies of current local needs and trends in automobile ownership and usage.

**Notes**

1. Calculated from data provided by the U.S. Bureau of Transportation Statistics.
6. Ibid., p. 40, quoting the works of Levinson and Whilock.
8. Ibid.

Recommended Reading


Suggested Sources of Further Information


trips that will be made on each link of the transit network.

The foregoing is a simplified description of the process. More detailed descriptions can be found in many of the books on transit planning. A good description can be found in Levinson’s chapter in the ITE book, *Transportation Planning Handbook*, pp. 160-166. Levinson clearly considers transit planning as an integral part of the general transportation planning process. He includes a flow chart of the transit planning section in which a modal split is made early in the transportation planning process, and a separation at that time of those travelers who have a choice of transportation mode from those who do not (i.e., the captive transit riders). His diagram, which is reproduced as Figure 12.2, is well worth close examination.

**Notes**

2. It is true that some designers, such as Peter Calthorpe, have proposed that residential centers be built in such a pattern, but few of them exist today. See Calthorpe’s book, *The Next American Metropolis*.
4. *Ibid.*, Table 2.49.
6. For further information, see the chapter by Herbert S. Levinson in ITE’s *Transportation Planning Handbook*, pp. 284-290.
7. Many of the largest buses are articulated; that is, they consist of two-passenger compartments which are joined by a swivel that allows the bus to bend in the middle as it goes over a hump or around a corner.
8. Levinson, p. 140.
11. Ibid.
13. For a more detailed discussion of the population sizes and densities that make transit services feasible, see pp. 160-161 in the Levinson reference.


Sources of Further Information


Other References Cited in the Text
Table 13.2. Preferences for Dwelling Types By People in Various Stages of the Family Life Cycle

<table>
<thead>
<tr>
<th>Stage</th>
<th>Need</th>
<th>Possible Housing Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young single person</td>
<td>Bachelor housing, at a modest cost, close to adult activity centers</td>
<td>High-rise or midrise apartment building, or an apartment in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a converted house, perhaps shared with other young singles</td>
</tr>
<tr>
<td>Young married couple</td>
<td>A small dwelling, at a modest cost</td>
<td>Apartment or townhouse</td>
</tr>
<tr>
<td>Young couple with young</td>
<td>A ground-oriented building, close to children's facilities; probably at a</td>
<td>Garden apartment, townhouse, or single-family dwelling</td>
</tr>
<tr>
<td>children</td>
<td>modest cost</td>
<td></td>
</tr>
<tr>
<td>Middle-aged couple with</td>
<td>A large dwelling, with good access to transit services and to facilities used by teenagers</td>
<td>Single-family dwelling or townhouse</td>
</tr>
<tr>
<td>teen-aged children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle-aged couple with</td>
<td>A smaller dwelling with good transportation facilities, close to</td>
<td>Apartment, townhouse, or single-family dwelling</td>
</tr>
<tr>
<td>grown children</td>
<td>adult facilities</td>
<td></td>
</tr>
<tr>
<td>Elderly couple</td>
<td>A small dwelling unit designed for senior citizens that is close to health care and community facilities</td>
<td>Apartment, townhouse, or special housing for seniors</td>
</tr>
<tr>
<td>Elderly single person</td>
<td>A small dwelling unit; characteristics depend on the health and mobility of the person, and on care available from nearby friends and relatives</td>
<td>Apartment or special housing for seniors</td>
</tr>
</tbody>
</table>

Source: Adapted from Residential Site Development Advisory Document, Canada Mortgage and Housing Corporation, Ottawa, Canada, circa 1980.

Sources of Further Information on Housing In General


So, Frank S., and Judith Getzels, editors. The Practice of Local Government Planning, 2nd ed. Washington, DC: International City Management Association, 1988. See Chapter 12, “Planning for Housing” by Constance Lieder. The first half of this chapter, which deals with federal housing programs of the 1980s, is now out of date. The second half, which deals with housing programs in general, is still relevant.

Sources of Additional Information on Forms of Housing


Note

1. A review of Table 11.1 on page 125 will indicate how significant the growth of two- and three-car households has been between the years 1969 and 1995.

Recommended Reading


Sources of Further Information

American Public Health Association, Committee on the Hygiene of Housing. Planning the Neighborhood. Chicago: Public Administration Service, 1948. This early work really defined the concept of neighborhood, as used in urban planning, for many years. The statistics used in the book are now very out of date, but the basic ideas in the text are worth reviewing.


Downs, Anthony. Neighborhoods and Urban Development. Washington, DC: The Brookings Institution, 1981. This excellent book focuses on established urban neighborhoods. It discusses the causes of neighborhood decline, as well as factors that add to their stability and their revitalization.


spaces can be inexpensively paved. These spaces may be public (provided totally within the public ROW) or private (provided on the abutting private property). Unfortunately, parking bays of this type are very difficult to sweep or to remove snow from.

Parking areas should not be located within "clear sight triangles" at intersections, or on the inside curb line of street curves which have a centerline radius of less than 150 feet [45 meters]. Parking of all types should have finished slopes of less than 5 percent grade. They should also have finished grades of at least 1 percent slope, in order to provide adequate drainage.

Guidelines for the design of off- and on-street parking areas are provided in Chapter 11.

Notes

1. Laurence C. Gerckens was the original author of this chapter, but I have modified it substantially. Mr. Gerckens should not be held responsible for errors or omissions.

2. Blocks in the conventional grid pattern of streets are often 400 to 600 feet in length; occasionally, they are 1,000 feet long.

3. An extreme example of a gridiron street converted to a chicane can be found on Lombard Street in San Francisco, where the paved street twists its way downhill. Unfortunately for the local residents, the street is so intriguing to tourists that it has stimulated traffic flow rather than discourage it.

4. Woonerfs are streets that are for the primary use of pedestrians and bicyclists, although slow-speed vehicular traffic is allowed to weave its way through them. They were originated by the Dutch; they are described further in Lynch and Hack (pp. 199, 203, 204), and by Hoyle (p. 14).

5. In some circumstances a street can be blocked by flooding, snow, a fallen tree, or even a fire. This is often considered to be an acceptable risk if only a few residences are located on a long, dead-end street, but it becomes unacceptable when many homes are located there.

6. ASCE-NAHB-ULI, pp. 54, 55.

7. An exception to this rule is found when a block includes buried "flag lots." These are described in Chapter 18.

8. Their name comes from the French, and means "bottom of the sack."

9. For further information on the design of cul-de-sac turnarounds, see ASCE-NAHB-ULI (pp. 49-51) and AASHTO (pp. 443-335).

10. See also Table 10.8.

11. See Table 16.1.

12. AASHTO, p. 474.

13. ASCE-NAHB-ULI, p. 73.

Recommended Reading


Sources of Further Information


engineer, and perhaps engineers from local utility companies.

It is up to the land developer to consider when and how to discuss the plan with special interest groups and the general public.

UNDERTAKING PHASES II AND III

Phase II: Preparation of a "Tentative Subdivision Map"

The job of preparing a tentative map consists of refining the general design of the subdivision, and doing the necessary engineering analysis and design. This is the stage of the subdivision process that really benefits from the application of basic design skills and imagination.

Phase III: Preparation of a "Final Subdivision Map"

The preparation of a final subdivision map is primarily a job for experienced civil engineers and land surveyors.

Recommended Reading


Sources of Further Information


another? If so, does it produce a product that is substantially more valuable in the marketplace?)

PROVIDING COMMUNITY FACILITIES IN SUBDIVISIONS

Community facilities are those areas and facilities in a subdivision that are available for use by the residents of the subdivision but are not on the private building lots. These may be structures privately built on private land (and privately maintained), or privately built structures which are turned over to a public jurisdiction for ownership and maintenance.

Chapter 20 discusses planning for community facilities in greater depth.

Typical community facilities that are sometimes found in large subdivisions and in planned-unit developments are:

- tennis courts
- swimming pools
- paths
- golf courses (for very large subdivisions)
- children’s play areas
- clubhouses
- exercise rooms
- saunas
- undeveloped open space
- open space used as a storm water retention basin
- lakes, ponds, and waterfronts

Whoever owns the land and structures of a community facility must pay for its maintenance but can control who uses it. If the facility is publicly owned, almost any member of the general public must be allowed to use it.

Questions to be considered by the land developer concerning community facilities should include:

- What type of facility is appropriate?
- How large should it be?
- Who is to own and control its use?
- If it is to privately owned, what provisions will be made to assure its maintenance? (Usually a legal corporation, such as a homeowners’ association, must be formed. This association must have legal powers to collect fees for the maintenance and operation of the facilities.)

Notes

1. See Lynch and Hack (pp. 199, 203, 204) for a further description of woonerfs.
2. Bookout discusses zero-lot-line houses at greater length; see pp. 157-158 in his text.

Recommended Reading


Sources of Further Information


should also be considered when designing multifamily housing:

- **The location and design of parking areas for use by building residents.** Are they safe and secure? Are they conveniently located? Is access to them by way of routes which are well lit and safe?
- **The location of visitor parking areas.** Are they conveniently located? Are they of adequate size? Is access to them convenient and safe?
- **Pedestrian circulation patterns.** Are they convenient, attractive, and safe?
- **Safety issues.** Will there be assurance of personal safety in corridors, elevators, parking lots, recreation areas, and other public areas? ²

**Notes**

1. A useful reference for those who design large projects which will generate considerable traffic is *Transportation and Land Development* by Stover and Koepke.
2. See *Defensible Space* by Oscar Newman.

**Sources of Further Information**


Marcus, Clare Cooper, and Wendy Sarkissian. *Housing as if People Mattered.* Berkeley, CA: University of California Press, 1986. A constructive and detailed guide for designing large-scale, medium-density family housing. While the book is strongly oriented towards making public housing more livable, it contains many valuable guidelines for private housing as well.


Sources of Further Information


