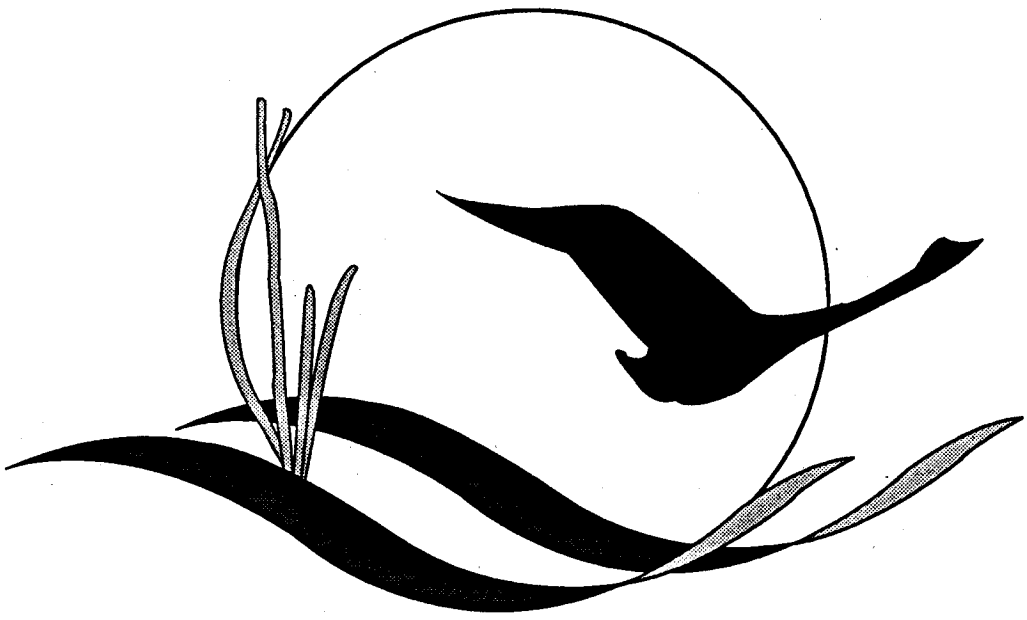
Cost of Providing Government Services to Alternative Residential Patterns



Chesapeake Bay Program

Cost of Providing Government Services to Alternative Residential Patterns

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Executive Summary

Study Context

The Subcommittee on Population Growth and Development (the Subcommittee) was established to assist in the implementation of one of the seven goals of the 1987 Chesapeake Bay Agreement which reads "Plan for and manage the adverse environmental effect of human population growth and land development in the Chesapeake Bay watershed."

An important precursor to the work of the Subcommittee was a panel established by the 1987 agreement, known as the year 2020 Panel. The Panel's report, *Population Growth and Development in the Chesapeake Bay Watershed to the Year 2020,* known as *The 2020 Report,* contained a number of significant findings, including:

- A total of 1,716,418 new housing units will be constructed between 1990 and 2020; within the Chesapeake Bay watershed; if current development trends continue, 80 percent of these units will be located on one-third of the land converted to residential use. The remaining 20 percent of the dwelling units, consisting of large lot residential development, will be built on two-thirds of the land converted to residential uses.

- "It is unlikely that the roads, sewers, and other public facilities needed to fully support growth could be built, if growth continues in present patterns and densities (p. 33)."

- "Sprawl is an ineffective use of the land, difficult to service with infrastructure and transportation, requiring extensive use of automobiles, and consuming large land areas (p. 36)."

The 2020 Report noted that "the low density residential alternative produces environmental effects and infrastructure demands that are more expensive to remedy than medium and high densities" (p. 38). All of the above and other findings contained in the report have led the Subcommittee to seek additional information regarding the environmental and economic costs of low density residential development, often referred to as "sprawl" development to provide vital information to those making land use decisions within the Chesapeake Bay watershed.

In this report, "sprawl" is defined as residential development at a density of less than 3 dwelling units per acre, which does not have a locational component. That is, sprawl can occur either as leapfrog development located outside of existing service areas or as a development located in or adjacent to existing service areas.

Objective

As a result of these concerns, the Subcommittee established a two step process to begin to analyze the environmental and economic impacts of residential development. Its objective is to determine if there are significantly different economic and environmental costs that can be attributed to different types, forms, and locations of residential development. While the Subcommittee's objectives are set within the overall environmental context of the Chesapeake Bay Agreement, its initial focus is to assess the economic impacts of different types of residential growth. In particular, the Subcommittee has decided to investigate how the capital cost per dwelling unit of providing services and infrastructure, specifically public services and infrastructure, varies according to type, form, and location of new residential development.

As a next step, the Subcommittee will be investigating the specific water-quality impacts of various forms and patterns of development. With detailed analysis of both the economic and ecologic issues in place, the Subcommittee will be able to fully inform the Chesapeake Bay Program, the policy-makers of the region, and the development community regarding these issues.

The Subcommittee retained CH2M HILL to perform a comprehensive review of the literature dealing with how the capital cost of providing services and infrastructure varies according to the characteristics of residential development. The consultant's charge is to present the findings from the literature and draw conclusions where appropriate. The information in the study will then be one of many sources to be used by the Subcommittee in fulfilling its responsibility to "Plan for and manage the adverse environmental effect of human population growth and land development in the Chesapeake Bay watershed."

This first study has the following specific objectives:

- Provide an in-depth review of the current cost of development literature and other studies that address the cost of providing public services and infrastructure to different residential developments

- Describe the methods, approaches, and assumptions of the studies, and describe the applicability of their conclusions to the Subcommittee's mission and to the Chesapeake Bay watershed

- Identify factors that affect the capital cost of providing services and infrastructure to residential development

- Present data and conclusions from relevant studies concerning variations in the capital cost per dwelling unit of providing services and infrastructure, specifically for providing public services

The objective of the second study will be to examine the relationship between different arms of development and their affects on surface and groundwater quality-. The study will attempt to concentrate on the effects of different residential patterns, and will explain the processes through which water quality is affected. Where they exist, recent and current watershed-wide studies in the Chesapeake Bay watershed will be examined. the results of the study will help local planning officials to better understand the water quality impacts of the different development terms they are faced with deciding upon at the local level.

Activities

CH2M Hill performed a comprehensive survey of the literature on cost of development studies (that is, those such as The *Costs of Sprawl* that had calculated variations in capita! and annual service costs for different types of dwelling units), and other related planning studies. According to the Subcommittee's wishes, this search was primarily focused on identifying studies whose results would be the most applicable to the Chesapeake Bay watershed. The review encompassed a broad range of studies that had been performed throughout the country. The consultant contacted planning agencies within the watershed to obtain relevant studies. A number of planning agencies and non-profit organizations (such as the American Planning Association, Lincoln Land Institute, universities, trade organizations, etc.) were also contacted. A list of the organizations and individuals contacted is presented on pages G1 through G-4 following Chapter 5.

Organization

The literature review appears in Appendices A and B. Appendix A contains the more relevant studies that provided information about the costs of serving different types of residential developments. Each review describes the methodology and results, and presents a summary of the applicability of the results. Appendix B contains reviews of less directly applicable but interesting studies.

The report begins with Chapter 1 which presents the context of this study within the context of the mission of the Subcommittee and the Chesapeake Bay Program. Chapter 2 presents a review of the general approaches used in cost of development studies, based primarily on the material in Appendix A. Chapter 2 also identifies three types of public services based on the service characteristics and identifies factors that effect the capital cost of the different types of services. Chapter 3 describes the relationship between the cost factors and the capital costs of different types of services. Summary tables presented in Chapter 3 are supported by more detailed tables contained in Appendix C. Chapter 4 presents information from the literature about the capital costs per dwelling unit for providing infrastructure to different types and forms of residential development. Chapter 5 presents conclusions.

General Approaches Used in Cost of Development Studies

Chapter 2 contains an analysis of the methods and assumptions used in the reports analyzed for this study.

Types of Developments Analyzed

Most cost of development studies, such as The *Costs of Sprawl* and a number of others identified in Frank's *The Costs of Alternative Development Patterns,* defined prototype communities to control as many variables as possible, and to focus on cost variations due to differences in density, lot size, type of dwelling unit, and proximity to service areas. These studies usually use different mixes and densities of dwellings units for different prototypes with the same total number of dwellings units and the same total area. The distribution of dwellings units and density is not uniform across the prototypes.

Cost Approaches

The two approaches used in estimating capital costs produced by new residential development are the per capita and the marginal cost approach. The marginal cost is defined as the true cost incurred by a local government in supplying service or infrastructure to a new increment of residential demand, such as a subdivision. Marginal cost is the preferred approach and is used in project-specific studies. The definition of prototypical communities, used in such studies as The *Costs of Sprawl, is* an attempt to estimate marginal capital costs.

The per capita approach is more commonly found in county-wide fiscal impact models. This approach will be accurate where capacity utilization is high but not where it is in over-capacity, so that the average cost is close to the marginal cost. In situations where this is not true (that is, there are large amounts of current excess capacity), this approach will not be as accurate because the marginal costs of serving new development will be low.

Allocating Costs

One issue that confronts many studies is how to accurately allocate the true costs for new services and infrastructure to different types of land use, such as new residential development. This is relatively easy to do for infrastructure, such as water distribution pipes, sidewalks, streetlights, sewer collector pipes, and local streets, required within a new subdivision. Allocating costs is harder to do for other types of services and infrastructure, such as police, fire, recreation centers, libraries, and general government. Accurate allocation is particularly important for studies employing the per capita cost approach.

The most common approach is to allocate costs based on the residential proportion of the jurisdiction's total assessed valuation. This ratio is sometimes modified by also

considering the ratio of the number of residential taxable parcels to the total number of taxable parcels, and by considering the average size of residential parcels to the average size of all taxable parcels. Allocation of costs can be done at a department level by examining service and use statistics, such as the distribution of police and fire calls, and solid waste flow records.

Classification of Services

Chapter 2 presents a classification of services based on their characteristics, including capital intensity (ratio of annual capital cost to total annual costs - defined as annual capital plus annual operating and maintenance costs); form (linear vs point), spatial arrangement, and the size of the service area (within a subdivision or neighborhood vs county or region). Four classes of services were identified:

- **Onsite**. These are the capital facilities- on the lot that connect the dwelling unit to nearby, offsite public systems and right-of-ways

- **Intra-neighborhood.** These services are provided to individual dwelling units within distinct residential developments, such as subdivisions or neighborhoods

- **Interneighborhood.** These services are provided over a larger service territory that covers a subarea of an entire municipality that contains many separate neighborhoods or residential developments. The services are provided to a group of neighborhoods and consist of the capital facilities connecting them.

- **Regional**. These services are provided to an entire municipality or to a larger region consisting of a number of municipalities

This study addresses only three types of off-site services: Intraneighborhood, interneighborhood, and regional. This study does not address on site services because these are almost always incurred by the property owner.

Services were classified as follows:

Intraneighborhood

- Sewer collector lines
- Water distribution lines
- Stormwater collector lines
- Collector streets, including subcollectors, loops, and cur-de-sacs
- Streetlighting
- Stormwater and drainage improvements, excluding the collector lines

Interneighborhood

- Capital-intensive
  - Sanitary sewer trunk or collector lines, and interceptors
  - Stormwater trunk or collector lines
  - Water trunk or distribution lines, and supply mains Parks and recreation
  - Arterial streets

- Labor-intensive
  - Police
  - Fire
  - Solid waste collection
  - Emergency medical
  - Education, particularly elementary and possibly junior high/middle schools

Regional

- High schools
- Wastewater treatment plants
- Water treatment plants
- Water supply reservoirs
- Solid waste disposal facilities
- Highways
- General government administrative buildings

Chapter 2 describes the attributes of these services,, noting their level of capital intensity, size of the service area, ability to allocate costs to residential uses, form, and arrangement.

Factors That Influence the Cost of Providing Service

Chapter 2 also presents a list of factors that influence the costs of providing services to new residential development. The primary focus is on the capital cost. The effect of the following factors is described below:

Attributes of the Service

- Capital intensity
- Form
- Spatial arrangement

Development Density

- Gross density
- Net density

Characteristics of the Development

- Lot size and shape
- Type of dwelling unit

Population Characteristics.

- Total population served
- Population density
- Number of school-age children

Locational Attributes

- Proximity to existing service areas
- Proximity to employment
- Proximity to community facilities

Service Characteristics

- Capacity utilization
- Service and design standards
- Regulatory standards
- Shape of service area

Chapter 2 describes how these factors affect service costs, noting how variations in these factors affect the demand for and the cost of providing services.

Sensitivity of Capital Costs for Different Service Classes

Chapter 3 describes the sensitivity of capital costs for individual services within each of the three classes of off-site services (listed above) to the different factors. For example, for Intraneighborhood services, the sensitivity of the capital costs of sewer collector pipes to the various factors is described in qualitative terms; for interneighborhood services, the sensitivity of the capital costs of elementary and middle schools to the. same set of factors is presented.

A summary table for each class of service is presented in Chapter 3. It presents an ordinal ranking of capital cost sensitivity using the following scale:

- Highly Sensitive: a factor has a strong, direct effect on the capital cost of a service

- Sensitive: a factor has a direct, but not overly strong effect on the capital cost of a service

- Moderately Sensitive: a factor has a weak effect on the capital cost of service

- Minimally Sensitive: a factor has little or no affect on the capital cost of a service

Appendix C contains a set of tables that describes, in more detail, the capital sensitivity relationship between an individual service and each of the cost factors.

This scale expresses the sensitivity of the capital cost of a specific service to various factors. The determinations of capital cost sensitivity were made by CH2M HILL based on the literature reviewed for this study, on our experience in conducting planning studies, and on our engineering and design experience in preparing designs for different types of infrastructure.

The following trends can be observed in Tables 3-2, 3-4, and 3-6:

- The capital costs of intraneighborhood services are, for the most part, most sensitive to net density and lot size. These capital costs are also effected by service and design standards. Population and locational factors have moderate to minimal affects on the capital costs of intraneighborhood services.

- The capital costs of interneighborhood services tend to be, depending on their level of capital intensity, highly sensitive and sensitive to gross development density (for trunk lines and arterial streets), and highly sensitive to the population to be served (for labor intensive services). For the capital-intensive services, net density and lot size have less of an effect. Capital costs are also sensitive to service standards. Locational attributes have, with the exception of arterials,, a minimal effect on capital costs.

- The capital cost of regional services is most sensitive to the total population to be served, and is only slightly less sensitive to capacity utilization and to design and service standards. The type of dwelling unit affects the capital cost for some services, such as high schools, water supply and water treatment, and highways. The cost of regional services is not sensitive to development density or to lot size.

Relationship of Capital Cost to Annual Cost

While the focus of this report is on the capital costs per dwelling unit, the annual capital costs required to provide services and infrastructure to a new dwelling unit comprise a minority of the total annual costs (annual capital plus annual operating and maintenance costs) incurred by local governments. Three studies indicate that annual capital costs per dwelling unit are probably between 20 to 30 percent of total annual costs per dwelling unit. This assumes that public water and sewer are provided and that the bundles and levels of services provided are comparable to those supplied in most suburban counties located in metropolitan areas within the Chesapeake Bay watershed.

This proportion would be near or below the low end of this range when impact fees and proffer charges require property owners to pay the full marginal capital cost of providing services and infrastructure, particularly if some of the marginal capital costs of interneighborhood and regional services are incurred by property owners. The actual proportion could be higher where service levels are high or where high public capital costs are incurred in providing interneighborhood and regional services, such as water and-sewer trunk lines, new water and wastewater plant treatment capacity, and school expansions.

The Cost of Development

Chapter 4 presents data on the capital costs per dwelling unit for different types of density of housing. The two main sources were *The Costs of Alternative Development Patterns* and *The Costs of Sprawl.* This chapter provides readers with estimates of the capital cost per dwelling unit that are contained in the literature. The estimates are presented in Tables 4-1, 4-2, and 4-3. The information in these studies was modified to correspond to the classes of services identified in this study, although it was impossible for the information to correspond exactly.

Chapter 4 notes how difficult it is to develop capital cost estimates and to precisely measure the influence of different factors, such as density, lot size, location, service levels, etc. Chapter 4 presents a caveat concerning the complexity of the relationship between capital costs per dwelling unit and the factors identified in this study. This caveat is worth noting here:

> "Distinctions among alternative development factors form the experimental variables that are manipulated to observe the extent to which development costs change concurrently. The crucial terms are density and lot size or lot width, municipal improvement standards; characteristics of the occupants, contiguity of development, distance to central facilities, and size of the urban area. Each one, when allowed to vary, has a discernible effect on development costs, but when they are all allowed to vary at the same time, the independent effect of each is difficult to measure because of simultaneous effects" (Frank, p. 37).

Two important points are worth noting. First, there are factors that affect the capital costs per dwelling unit in addition to density and lot size; the list Frank identified corresponds to the list of factors identified in Chapter 2. Second, it is difficult to precisely isolate the effect of the different factors on the cost of providing public services to residential development.

Capital Costs of Intraneighborhood Services

Table 4-1 contains capital cost estimates for densities of 1 dwelling unit per acre or greater, and compares the cost of neighborhood services (updated to account for escalation) in *The Costs of Alternative Development Patterns* with intraneighborhood services as defined in this study. The figures in Table 4-1 show a decline in capital costs per dwelling unit as density increases. This should not be interpreted as density being the only factor causing such a decline in capital costs. Frank's caution presented above should be kept in mind. An examination of Table 3-2 indicates that factors other than density and lot size, such as service standards and the type of dwelling unit, affect intraneighborhood capital costs.

The capital cost per dwelling unit of intraneighborhood services for residential development at a density of 1 dwelling unit per acre or greater declines on a per dwelling unit basis as density increases. While such a decline may be due primarily to development density and lot size, other factors also have an effect.

Capital Cost of Interneighborhood and Regional Services

Attempts at estimating the capital costs for interneighborhood services have been made in several studies while few attempts have been made at estimating the capital costs of regional services, with the exception of high schools. *The Costs of Sprawl* paid only limited attention to the capital costs for other interneighborhood services that are external to a residential development. As Frank has noted, even where interneighborhood capital costs, such as water and sewer trunk lines connecting treatment plants to leapfrog residential development, have been estimated, the estimate has been flawed.

Tabie 4-2 presents a partial estimate of the capital cost for providing both interneighborhood services and some regional services. This table includes the costs for sewer, water, and storm sewer trunk lines; all schools; solid waste collection and disposal; police, fire, parks and recreation; general government; and arterial streets. The table excludes the cost of constructing new wastewater and water treatment plants, and a new water supply facility. Capital costs are presented for 5-mile and 10-mile distances between the residential development and employment centers, water and wastewater treatment plants, and a receiving body of water.

The data for interneighborhood and regional services show that the capital costs per dwelling unit of inter-regional and some regional costs decline relatively little as density increases. Other factors, such as proximity to the service area (for sewer and water

trunk lines), population (for labor intensive interneighborhood services, water and sewer treatment plants), and locational attributes (for arterial streets and highways) have more of an effect on capital costs than does lot size or density.

Table 4-3 combines the figures from Tables 4-1 and 4-2 and presents the capital costs per dwelling unit for Intraneighborhood, interneighborhood, and some regional services. The total capital cost per dwelling unit of facilities needed to service new residential development declines as development density increases. Such a decline is due to many factors other than density and lot size, particularly for interneighborhood and regional services. The decline in capital costs per dwelling unit occurs primarily for Intraneighborhood services, assuming these are publicly funded-not incurred by property owners through impact fees and proffer charges.

The caveats contained in the literature, and the complexity of the relationship that determines the capital cost of providing services and infrastructure to residential development, make it virtually impossible to precisely specify the effect contributed by any one factor. For example, it would be inaccurate to interpret that these tables show that density is the most important factor. Density is clearly not the only factor in reducing capital costs per dwelling unit in providing public services and infrastructure. When looking individually at the three classes of service and assuming that the capital costs of the full bundle of services is incurred by local jurisdictions, some conclusions can be drawn about 15 dwelling units per acre, according to the literature.

The capital cost per dwelling unit of providing Intraneighborhood services declines as density increases, primarily because of the spatial effects noted in this study that increase the length of collector and distribution pipe, and local streets per parcel. High density, compact residential developments are cheaper to service, on a dwelling unit basis, up to about 15 dwelling units per acre, according to the literature. Above a certain point, for example for high rise apartments, the capital costs per dwelling unit begin to increase over the costs for attached housing, such as townhouses. The decrease in Intraneighborhood capital costs per dwelling unit observed as density increases is due to density and lot size, and other factors, such as the service standard.

Conclusions

Presented below are the conclusions that can be made from the literature reviewed for this study:

Conclusion 1: The capital cost per dwelling unit of Intraneighborhood services declines as density increases and lot size diminishes; although the decline is due primarily to development density and lot size, other factors also have an effect.

Conclusion 2: An increasing proportion of the marginal capital costs per dwelling unit, particularly for capital-intensive Intraneighborhood services, are being incurred by the homeowners through the imposition of impact fees and proffer charges.

Conclusion 3: Density and lot size are not the only factors that determine the capital cost of providing intraneighborhood services. Service and design standards also affect capital costs.

Conclusion 4: The precise contribution of cost factors in determining the total capital cost per dwelling unit remains unclear, particularly for interneighborhood and regional services, but some idea of relative effects can be ascertained.

Conclusion 5: The greatest reduction in total capital costs per dwelling unit through the use of higher density residential development is achieved in intraneighborhood services. The reduction in capital cost per dwelling unit from more efficient development forms is greater at the subdivision or neighborhood level and is smaller at the municipal, county, or regional level.

Conclusion 6: The use of compact, higher density residential development forms produces a small percentage savings in capital cost at the regional or statewide levels.

Conclusion 7: Infill development or contiguous development will minimize marginal capital costs for interneighborhood services and, to a lesser extent, for regional services.

Conclusion 8: Increases in the population growth rate and population density produce increases in local per capita annual operating and maintenance expenditures and, to a lesser extent, in annual per capita capital spending.

Conclusion 9: The capital cost per dwelling unit of providing services is only a minor proportion of the total annual costs per dwelling unit (annual operating and maintenance cost plus annualized capital cost).

Conclusion 10: Not all local jurisdictions provide comparable bundles of services, either in terms of the types provided or service levels. This complicates comparing the cost of providing services to dwellings units located in rural areas to that of suburban areas.

Conclusion 11: Demographic characteristics of the occupants of dwellings units to be served are a major factor in determining the demand for and resulting cost of providing labor-intensive services to new residential development.

Conclusion 12: The cost of providing education services, both capital and operating, is the largest cost per dwelling unit expense in most local budgets. Education costs are only minimally sensitive to development density and lot size, and, to a lesser extent, to the location of new development.

Presented below are conclusions about capital cost for each of the three types of services considered by this study.

Intraneighborhood Services

Because of their linear, capital-intensive nature, the capital costs of intraneighborhood services are the most sensitive to the form and development density of residential development. These services have the greatest potential for shifting capital costs from local governments to property owners through the use of impact fees.

- The capital cost of all intraneighborhood services, except stormwater structures, is highly sensitive to lot size and net development density Both factors interact to determine the spacing between dwelling units; frontage length of pipe, streets, street lighting, and sidewalks required per residential lot; and, ultimately, capital cost.

- Intraneighborhood capital costs are sensitive to gross density. Where gross and net densities are nearly equal (as in standard subdivisions where there is no clustering), capital costs are highly sensitive to gross density.

- Intraneighborhood services can be provided most efficiently (cost per dwelling unit) for high-density, compact, residential developments, although density and lot size are not the only important factors. As shown in Table 3-2,-intraneighborhood capital costs vary in sensitivity to service and design standards.

- The marginal capital cost of providing intraneighborhood facilities to new residential development is much lower when density is increased or infill development occurs than it is when the new development is built in unserved areas in a leapfrog or scattered form. Changes in density and flow coming from within a given residential area produce relatively small changes in the capital cost of intraneighborhood and interneighborhood facilities, particularly water and sewer pipes.

Interneighborhood Services

The capital cost of interneighborhood services are, in general, less sensitive to lot size and net density, and are more sensitive to gross density and to the size of the population to be served. Major conclusions about interneighborhood services are presented below:

- The capital cost of interneighborhood services is less sensitive than that of intraneighborhood services to the development density and lot size of the residential areas being served, and is more sensitive to population density within the service area and to locational factors

- The cost of linear, interneighborhood services, such as water, sewer, and stormwater trunk lines, and roads, are highly sensitive to the gross development density of the service area. This determines the total length of the network that connects demand centers, such as neighborhood and subdivisions, with interceptors or central treatment facilities.

- The most expensive residential land use pattern in capital costs per dwelling unit consists of scattered, noncontiguous neighborhoods and subdivisions, which results in low service area gross density

- The capital cost of interneighborhood services, with the exception of education, is a much smaller proportion of total capital costs per dwelling unit than that of intraneighborhood services

- Locating new residential development at the edge of existing service areas decreases the capital and annual costs of providing interneighborhood services. The capital cost of providing the linear capital facilities that connect a new development to the existing infrastructure systems is minimized. A contiguous location also allows for more cost-effective capital facilities that support such labor-intensive interneighborhood services as solid waste, police, fire, and emergency medical.

Regional Services

In general, the capital costs for providing regional services are most sensitive to the population factors and service standards, and are less sensitive to the development density, type, and location of the new residential development. Regional services, with the exception of general government, generally are provided in large increments of capacity, have long service lives, and often enable economies of scale in unit capital and operating and maintenance costs to be obtained.

- The capital costs of water and wastewater treatment, water supply facilities, and solid waste disposal facilities are highly sensitive to the number of persons to be served, which includes the current and projected populations. Often, these facilities must be designed with substantial initial excess capacity to accommodate future development.

- The capital cost of most regional services are sensitive to service characteristics, specifically service standards and capacity utilization. Design standards determine the capital cost of regional facilities through engineering standards and regulations that may specify treatment methods. Underutilized regional facilities, particularly water and wastewater treatment plants, highways, and water supply facilities, can impose high initial marginal costs on existing residents.