Regional Sewer System Rate Structure Study

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December 7, 1992

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I. <u>Statement of Objectives</u>

1992 Minnesota Laws chapter 601, section 16 required the Metropolitan Council to contract with the Board of Regents of the University of Minnesota to "study the allocation of current costs [for waste water collection and treatment] among local government units in the metropolitan area in order to examine the social, economic and environmental effects resulting from (1) the allocation of current costs to communities within service areas for which the costs are attributable versus (2) the allocation of current costs to communities uniformly throughout the metropolitan area." The law further states that (3) "the study must specifically address the effects of alternative cost allocation methods on the council-defined fully developed area." In performing tasks (1) through (3), "[t]he study may consider various configurations of service areas, and must consider service areas reasonably consistent with the council's geographic policy areas." Finally, the law states: "The study may consider [(4)] effects arising from the location and placement of other infrastructure elements on the fully developed and developing areas." This report deals with tasks (1) through (3). A second contract will be written to deal with issues raised by (4), with the work to be performed early in 1993.

This study addresses the first two tasks by: (a) estimating the full operating and maintenance (O&M) and capital costs of the waste water collection and treatment system operated by the Metropolitan Waste Control Commission (MWCC) in 1991 (the most recent year for which full data are available); (b) allocating those costs to municipalities in the system by procedures based on their contributions to total flows of waste water within the total system and within treatment plant "sewer-sheds"; and (c) comparing these cost estimates to a system that assesses a uniform fee per gallon of flow to all municipalities. The use of plant sewer-sheds to determine the baseline configuration of service areas is driven by the fact that water treatment costs represent the bulk of costs in the system and vary significantly plant by plant. The link to Council-defined policy areas and task (3) is achieved by summarizing the cost estimates for municipalities in the developed, developing, and free-standing growth areas of the region.

The social, economic and environmental effects of the alternative fee structures are assessed by examining the likely outcomes in regional housing and labor markets of changing from the current uniform fee structure to one that is based on actual costs as estimated in this work. This discussion relies on two bodies of existing empirical literature and analysis of the development incentives embodied in the alternative fee structures. The relevant empirical literatures examine, first, the effects of inter-local development cost and tax differentials on settlement and employment patterns and, second, the effects of settlement patterns on the costs of providing local and regional public infrastructure. These issues cover the most important social and economic effects of the alternative fee structures.

The fee structure comparisons also speak to two central environmental questions. First, does the overall rate structure reflect the total costs of treating wastes, thereby sending accurate signals to consumers regarding the level of care they should exercise in there use of the collection and treatment services? Second, do inter-local fee differences reflect the fact that different sinks in the region have different capacities to absorb treated waste water? If waste has to be treated to a higher level for one sink than for another (or if plant sizes are limited by sink capacity), then efficiency requires that the resulting differences in treatment plant costs should be passed through to consumers to provide incentives reflecting the greater environmental costs associated with locating near the lower capacity sink.

The procedures and conclusions of the analysis are presented in seven sections. Section II provides an overview of the study. Sections III and IV review the relevant empirical work and discuss a set of methodological issues affecting the cost calculations and fee-structure comparisons. Sections V and VI report the separate findings for treatment plant and interceptor costs. Section VII combines the findings from the previous two sections and the final section discusses the implications of the findings.

II. Executive Summary

Objectives

This study examines the economic, social and environmental implications of the fee structure the Metropolitan Waste Control Commission (MWCC) currently uses to allocate the costs of its waste-water-collection and treatment services among municipalities and between present and future users. The analysis is limited to MWCC-owned assets -- nine waste treatment plants and the 600+ miles of interceptor sewers that convey flows from locally operated sewer systems to the plants. The study compares the current level and distribution of charges with the distribution of the costs that present and future users in the various municipalities impose on the system. The cost distribution provides a useful comparison point primarily because a fee structure properly designed to reflect full costs would lead, according to economic theory, to efficient utilization of the region's resources. The comparison also provides a useful starting point for evaluating the costs of alternative fee structures in which considerations of equity rather than efficiency play an important role.

Development Costs, Settlement Patterns, and Public Infrastructure Costs

User fees, like taxes, are part of the total costs of residing or doing business in a particular municipality. Differences among places in user fees, therefore, can affect regional development patterns. Development patterns, in turn, affect the cost of providing regional and local public services such as waste collection and treatment, transportation and education.

Published research on the effects of cost differentials on settlement patterns suggests that fee differences of the size of those in waste collection and treatment costs in the Twin Cities are likely to affect development patterns in modest, but significant, ways. For instance, a 50% fee differential between two communities could, in the long run, result in 4% to 7% fewer jobs and residents in the high-fee community than would have located there with equal fees. The over-all level of fees in the metropolitan area also affects the settlement pattern of the region as a whole. The lower is the average fee, the larger in area and less densely settled the region will be.

To the extent that the level and distribution of fees affect settlement patterns -- the density of development, in particular -- they, in turn, affect the current and future costs of providing services with characteristics like waste-water collection and treatment, electric power, or natural gas distribution. In general, the more dense is the settlement pattern, the lower are MWCC costs per household. Higher density eases the trade-off between the cost savings available from economies of scale in waste treatment (larger plants have lower unit costs) and the diseconomies of scale for the longer collection systems needed by larger plants. The more dense is the settlement pattern, the shorter and less costly is the interceptor system needed to serve a given plant size. Decreases in the distance that waste must be transported translate into significant savings in capital expenditures. The magnitude of these savings in initial construction costs can be as much as $1,500 per dwelling unit per mile of distance.

Methods

Substantial scale economies exist in constructing waste-water treatment plants and, to an even greater extent, sewers. These economies make it efficient when expanding capital plant to cover not just current capacity requirements but also anticipated requirements for a substantial period into the future. Costs must, therefore, be allocated not just among the communities that the MWCC presently serves but also between present and future users. This study finds fault both with the way in which the MWCC measures capital costs and in the way in which it allocates all costs both among communities and between present and future users.

Fee Structures. The MWCC charges a community a fee for its services that is proportional to the volume of wastes disposed by its residents and is independent of which treatment plant processes its wastes and how far the community is from that plant. A fee structure that results in efficiently utilizing the resources which provide waste-water collection and treatment would charge each consumer the marginal cost of serving that consumer, where "marginal cost" is the increment to total costs caused by adding that consumer to the system. In the case of sewage collection and treatment, marginal costs are difficult measure. In addition, if a system is designed to minimize total costs, the presence of scale economies implies that marginal-cost prices would not recover the full costs of providing the service. Average costs are much easier to measure, generate fees that fully recover costs, and, in most cases, are comparable to marginal costs. We therefore use average costs to measure the costs of serving consumers in different municipalities.

Measuring Capital Costs. Although the MWCC regards the respective lives of treatment plants and sewers as being 40 and 80 years, state law limits bond financing to a maximum of 20 years. The MWCC measures this year's "capital costs" as the sum of the interest due on outstanding bonds and the face value of bonds that mature this year. The costs of capital purchased with federal grants and of assets that are currently still in use but that were financed in the past are not passed through to consumers.

This practice has two undesirable outcomes. First, since consumers are not charged the full costs of MWCC services, they are not provided proper incentives to economize on their consumption of those services. An unrealized potential exists for cost-saving behavior by users of MWCC services. Second, a system that finances assets over a period of time that is shorter than their actual lifetimes and charges consumers only for currently incurred debt generates an essentially arbitrary set of income transfers over time. This year's charges for capital services cover appreciably more than the true costs of assets that are still being paid for. This year's users are, therefore, effectively subsidizing services that future users will receive after currently outstanding bonds are retired. At the same time, however, present users are effectively being subsidized by past users who financed currently used assets that are more than 20-years old. Only by accident would these two subsidies balance. This problem is particularly important for the interceptor system, where assets exhibit very long useful lives.

This study treats the annual capital cost of an asset as the outlay required during each year of its life -- to repeat, 40 and 80 years respectively for treatment plants and sewers -- to cover the initial cost of the plant when discounting takes place at an assumed real rate of interest of 4%. All costs are measured in 1991 dollars.

<u>Allocating Costs to Municipalities</u>. The principal objective of this study's cost calculations was to allocate system costs among the region's municipalities in the way that the costs of waste-water collection and

treatment differ among them and to contrast this allocation with that achieved by a flat fee per thousand gallons. This study divides costs into several categories. The costs incurred by current users are distinguished from the costs of holding capacity in reserve for future users. Costs in both categories are divided into solids-treatment, liquids-treatment, and interceptor costs. For current users, costs are further separated into capital and O&M (operating and maintenance) categories. Only capital costs are allocated to future users.

Our base calculations make the same assumption as is implicit in the MWCC's allocation of capital costs between present and future users: an asset deteriorates only with age; its depreciation is independent of the intensity with which it is used. Given this assumption, the annual cost of holding one "SAC unit" -- 100,000 gallons per year of an asset's capacity, the amount of sewage disposal services an average household uses -- for a future user is the same as the capital cost a current user imposes by using a SAC unit of the asset. This study's cost allocation scheme treats the cost of holding an asset in reserve for a user as the cost accumulated at interest of a SAC unit for each of the years since the asset was purchased. The connection fee we compute for a new user equals this cost summed over all assets held in reserve on the user's behalf.

We calculated costs for current and future users separately for each of the MWCC's nine treatment plants.[1] Liquid treatment costs and all O&M costs that could be traced to a specific plant are allocated directly to it. For

[1] The Anoka and Baywater plants are excluded from the analysis since they are scheduled to be closed in the near future. The municipalities currently served by these plants are included in the plant-sheds that will serve them after the close-downs.

the three plants that treat solid wastes, O&M costs are distributed between solid and liquid treatment in a 60/40 ratio.[2] Solids treatment costs at the Metro plant are then distributed across the seven plant-sheds that use this facility according to each plant-shed's share of total flow in the seven areas. O&M costs which could not be allocated to individual plants or interceptors are distributed system-wide based on each plant-shed's share of total system flow.

A municipality's interceptor capital cost for current users is a function of the cost of the interceptor segments used by the municipality, the miles of interceptor used, and the volume of the municipality's flow. Interceptor O&M costs are allocated on a system-wide basis to current users according to each municipality's share of the total gallon-miles used in the system.

Findings and Implications

Total Costs. This study's cost estimates reveal that the MWCC's charges to current and new users are less than the full costs of providing the region's waste-water collection and treatment services. Current user fees fall about 16 percent short of full costs.[3] Therefore, current users do not face adequate incentives to economize on their use of MWCC services. The

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[2] This ratio was suggested by MWCC staff. The findings are not very sensitive to reasonable changes in the ratio.

[3] Offsetting considerations require qualifying this estimate. First, data limits require us to assume that industrial-strength fees cover the full costs of serving industrial users. If they do not, the difference between current residential revenues and the full costs of treating residential wastes are less than we have estimated. Second, if, as seems reasonable, capital assets depreciate with use as well as time, then we have under-estimated current user costs; the difference between costs and current user fees would be greater than 16%.

resulting excess consumption increases the long run costs of providing services -- and of protecting the region's environment.

The study's connection-cost estimates also reveal that current MWCC revenues from service availability charges (SAC fees) are less than the full costs of holding capacity for new users. The average difference is about $270 per SAC unit -- the rough equivalent of the present value of the annual user cost subsidy. However, our connection cost calculations, particularly for interceptors, must be viewed with some caution. Problems with data reliability and the sensitivity of results to assumptions about asset lifetimes and ages make these estimates less reliable than those for current users.

Cost Variations across Plant-sheds. The cost of serving current users varies substantially among the nine plants. Costs vary from a low of about $112 per 100,000 gallons per year at the Metro plant to a high in excess of $250 at Hastings. Much of this variation relates directly to plant capacities; significant economies of scale exist in the current system. Unit costs decrease by more than ten percent with each doubling of plant capacity. The largest plant -- Metro with a daily capacity of 250 million gallons -- has unit costs that are less than 45 percent of those of the smallest plant -- Rosemount at 72,000 gallons per day.[4]

Interceptor costs for current users also vary significantly across the region. A few communities use no interceptors; Anoka, which uses about 38 miles of interceptors, incurs the highest cost -- $25 per 100,000 gallons. However, interceptor costs are a small fraction of plant costs. The system-

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[4] A qualification is in order here: when treatment plant assets are assumed to depreciate with use as well as age, Metro's cost advantage increases.

wide average cost of conveying 100,000 gallons through the interceptor system is less than 10% of the cost of treating that amount of waste. As a result, although the variations from place to place in interceptor costs are large proportionally and determined primarily by distance, they are not great enough to offset economies of scale in treatment. In none of the municipalities served by Metro -- Anoka included -- do interceptor costs raise total treatment plus interceptor costs to a level as high as treatment costs alone at Seneca, the second most efficient plant.

The total-cost variations among plant-sheds imply that Metro plant users currently pay roughly full costs for services while users in all of the other plant-sheds pay less than cost. In effect, all regional benefits from past federal aid is distributed only to users outside the Metro plant-shed. A uniform fee for current users designed to generates revenues equal to full costs would generate significant subsidies from Metro plant-shed users to all others. With a uniform fee that would recover full costs as this study measures them, the subsidy coming out of the Metro plant-shed is modest -- $10 per 100,000 gallons -- but translates into substantial transfers into some of the smaller plant-sheds. The subsidies per 100,000 gallons would range from $18 for Seneca to $136 in Hastings. The capital value of the Hastings subsidy is effectively a house-purchase subsidy of more than $3,600.

With subsidies of this magnitude, a uniform fee sends signals to consumers that could, in the long run, significantly increase the regional costs of treating waste and protecting the environment. A uniform fee provides no incentive for potential consumers to locate where they can be served at lower cost. With a 30% cost differential between the two lowest-cost plant-sheds and costs in some parts of the region that are 100%

greater than the average, the long-run cost implications of the settlement patterns that result from a uniform fee system are potentially significant.

Costs allocable to future users -- connection costs -- also vary greatly across plant-sheds from a low of $392 per SAC unit in the Empire plant-shed to a high of roughly $2,500 for Hastings. In general, connection costs are lower than average in the plant-sheds with the newest capital stocks -- Empire, Seneca, Blue Lake, and Rosemount -- roughly at the mean for Metro and Stillwater, and above average at the older, small plants -- Chaska, Cottage Grove and Hastings. Again, however, data problems and the sensitivity of calculations to changes in assumptions make these estimated differences less reliable than those for current user costs.

Cost Variations across Policy Areas. Most of the Developed Area is served by the most cost-effective plant in the system, Metro. As a result, a uniform fee generates subsidies from the Developed Area to the Developing and Free-standing Growth Areas.

While modest -- $13 per household per year -- the cost to the Developed Area of a uniform fee that would cover full system costs translates into a potentially significant total dollar flow out of the Developed Area -- more than $6 million per year. Minneapolis and St. Paul bear most of this cost -- more than $2.75 million a year in each city.[5]

On the receiving end, many municipalities in the rest of the region benefit significantly from these transfers. Twenty municipalities primarily in the southern and western parts of the region would receive subsidies with present values of between $1,000 and $3,700 per household under a uniform fee

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[5] These figures represent estimates of subsidy rates with a uniform fee covering full costs, not subsidies under the current fee structure.

that would cover full costs. In ten places, the dollar value of the subsidy exceeds $250,000 per year per municipality. Numbers of this magnitude are great enough to generate incentives with measurable effects on settlement patterns and local municipal budgets.

Finally, the direction of the subsidy pattern raises important equity questions for elected officials. In the context of the current system, a uniform fee transfers income from parts of the region with generally lower-than-average incomes and higher-than-average public-service needs to higher-income places better able to finance services.

Conclusion

We believe that the efficiency and equity costs of a uniform fee system for current consumers of MWCC services warrant transition to a system that more closely reflects total system costs and cost differentials around the region. The data are less clear regarding the effects of the current fee charged new users. The cost estimates do not suggest major inefficiencies or inequities in the current system and the findings are very sensitive to assumptions and data limitations.

Shifting to a differentiated fee system for current users would impose new administrative costs on the MWCC. These are unlikely to exceed the subsidies inherent in the current system, however. In addition, some of the added administrative costs would provide other benefits. Prominent among them is careful year-to-year monitoring of the value and depreciation of the very valuable pool of public assets that the Commission manages.

III. Literature Review

Two categories of research on location costs and decisions are relevant for this work. First, there is a large body of work examining the extent to which differences across communities in tax rates and other publicly generated costs (such as user fees) affect settlement patterns. Second, there is a small group of studies examining the public infrastructure costs associated with different development patterns. The central issue in much of this work is how costs vary with the density of development.

A. The effects of development cost differentials on location decisions

There is a large empirical literature that examines the effects of local fiscal policies on the location decisions of firms and households. Much of this work concentrates on taxation, especially local property tax differentials. However, the findings are relevant in evaluating the implications of infrastructure pricing as well. A dollar is a dollar and differentials in user fee rates across municipalities should affect location decisions in much the same way that tax differentials do. This is particularly true if, as is the case with the MWCC, fee differentials reflect differences in the costs of providing services rather than differences in the level or quality of service. Since the MWCC provides essentially the same service to all parts of its service area, fee differentials represent pure cost differences to individuals and businesses. These cost differences are not offset by differences in the benefits from the provided service.

The work in this area is logically divided into two categories: employment location decisions and household location decisions. The employment literature is relevant because the bulk of jobs in the region are subject to the fee structure examined in this work. Charges to communities are based on flows that include discharges from virtually all employment sectors in local economies. These fee differentials translate into differences across places in the cost of doing business, just as tax differentials do.

For many years, the conventional wisdom regarding the effects of tax differentials on job growth rates was that, although the possibility exists that tax differentials could have large effects on employment location, their effects are, in fact, small. For example, Due's 1961 review of the early work in this area[6] found that the impact of local tax differences on intra-metropolitan location decisions is likely to be very small. However, in the late 1970's and the 1980's, many studies concluded that inter-local tax differentials translate into very substantial differentials in job growth rates. Bartik's extensive 1991 review of this literature[7] finds that the long run elasticity of employment in a community with respect to that community's property tax is in a range centered on -1.9. This implies that an unmatched 10 percent (<u>not</u> percentage point) increase in the community's property tax rate would decrease the rate at which employers locate jobs in the community by 19 percent in the long run.[8] This cannot be regarded as a precise estimate because the literature yields a range of estimates. In addition, one would expect the elasticity to vary from place to place within a region depending on

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[6] Due, John, Studies of State-Local Tax Influences on Location of Industry, <u>National Tax Journal</u>, v. 14 (June), pp. 163-173.

[7] Bartik, Timothy, <u>Who Benefits from State and Local Economic Development Policies</u>, W. E. Upjohn Institute, chapter 2, 1991.

[8] This assumes that local services do not change in the community instituting the tax increase and that service levels and tax burdens in equivalent communities in the metropolitan area are also constant.

other attributes of places that may tie jobs to specific locations (such as proximity to regional or national transportation links). However, the general implication is clear -- cost differentials matter to businesses when they decide where to locate within a metropolitan area.

In general, sewer fees charged to municipalities by the MWCC are smaller in magnitude than property taxes. This means that a 1 percent change in fees represents a smaller cost change than a 1 percent change in property taxes. A 1 percent fee change should therefore translate into a proportionately smaller employment change. However, the differential between sewage fees and property taxes is not so large as to rule out significant effects. MWCC sewer fees are roughly $100 per household per year in the region while total property taxes in a typical inner ring suburb would normally be in a range from $1200 to $2600 per household per year.[9] If user fees affect costs in roughly the same way that taxes do, this implies an elasticity of employment relative to sewer fees between -.07 and -.15. This means, for instance, that if the user fee in a community rose by 20% relative to its neighbors then employment would be expected to decline by 1.4% to 3.0% in the long run -- magnitudes great enough to be of interest to many localities.

The empirical literature regarding the effects of tax or user fee differentials on household location is less helpful for this work. In contrast to the employment-location literature, there has been very little work done which directly estimates the effects of tax/user fee differentials within metropolitan areas on population growth at the local level. The

[9] For example, total 1990 city, county and school district property taxes in Brooklyn Center, Brooklyn Park, Burnsville, Richfield, St. Louis Park and Roseville were $1,865, $1,580, $2,177, $1,270, $2,072 and $2,608 per household, respectively.

principal reason for this is that tax changes (or differentials) are likely to translate into a more complicated combination of price (housing value) and quantity (population growth) changes in housing markets than in labor markets, where quantity or growth effects are the primary variable of interest. Much of the literature on household location concentrates on the extent to which tax differentials generate variations in housing prices rather than on how they affect population growth rates.

Theory and evidence both suggest that the capitalization of tax differentials into housing and land values is an important feature of local housing markets. When a buyer purchases a home, s/he also takes on the legal obligation to pay local taxes. If potential home buyers are aware of tax differentials -- and the evidence implies that they are in general -- then homes in high-tax jurisdictions will command a lower price, all else equal, than those in a similar low-tax jurisdiction. Some portion of the tax differential is capitalized into the value of the home.

The process occurs in two steps. First, an increase in a tax or user fee increases the total cost of living in a particular community (the purchase price of a house plus the associated taxes or fees). This results in a decrease in the demand for housing across the full spectrum of housing prices.[10] Second, the revised demand schedule interacts with the supply of housing in the community to yield a balance between supply and demand at new levels for price and quantity. The final effect of the tax/fee increase is

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[10] In the case of sewer charges, if households react to the higher fee by decreasing their consumption of the service, the shift in demand will be less than the associated fee change. However, in the short run, the majority of the fee increase is likely to translate into changes in the demand forthcoming at a particular price. See Weitz, Stevenson, "Who Pays Infrastructure Benefit Charges," in Nicholas, James C., The Changing Structure of Infrastructure Finance, Lincoln Institute of Land Policy, Cambridge, 1985.

thus a combination of lower prices for housing and fewer housing units in the community. The mix between the two effects depends on the sensitivity of supply and demand to price changes.

Because the ultimate mix of price and quantity effects depends on the nature of supply and demand, it is likely that the final outcomes of tax/fee changes will vary from place to place. For instance, in an exclusive, high amenity suburb where new construction is tightly regulated, one would expect a fee increase to translate into changes in housing costs for the most part, because the quantities demanded and supplied would both be relatively insensitive to price. On the other hand, in a more typical suburb which contains some undeveloped land and which competes for residents with many similar (and nearby) places, demand and supply are both likely to be very price-sensitive, meaning that fee changes are likely to translate primarily into quantity (location or density) changes. Finally, in a very diverse community (such as a central city), one would expect to see different types of outcomes in different housing sub-markets. For housing types that are unique to the central city -- such as high-end housing close to urban amenities or low-end housing which is largely absent from suburban areas -- price effects would dominate. For housing types that are not unique to the central city -- middle income housing for instance -- quantity effects would be more important.

As noted above, there is very little empirical work examining the sensitivity of housing demand at the local level to price (the primary determinant of the extent to which fee changes will translate into quantity effects). This is largely the result of methodological problems and a scarcity of the needed data. Metropolitan-level estimates imply a price elasticity of roughly -1.0.[11] However, one would expect municipality-level demand to be more sensitive to price than this because potential buyers have the opportunity to substitute locations in nearby municipalities for those in any single jurisdiction.[12] Intra-metropolitan location decisions involve substantially lower moving costs than inter-metropolitan choices.

As a general proposition, an area-wide increase in the price charged for a service such as waste-water collection and purification can be expected to increase the cost of housing in a metropolitan area. An increase in price, in turn, can be expected to reduce the quantity of housing services purchased by households at every income level. Therefore, since land use and the quantity of housing services consumed by a household are positively related, an increase in sewer charges can be expected to induce a long-run increase in residential densities.

This general conclusion doers not necessarily mean that sewer charges and population densities could never be negatively related. To see why, suppose that an unmatched 50% increase in sewer charges is imposed on a single small community in a large metropolitan area. The price of a house can be thought of as the difference between the present value of the future services it is expected to render less the present value of the out-of-pocket expenses--e.g., utility bills, real estate taxes, repair cost--incurred in producing these services. The immediate effect of an increase in

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[11] See, for instance, Witte, Ann Dryden, "An Examination of Various Elasticities for Residential Sites," Land Economics, November, 1977, 401-409 or Sirman, C. F. and Arnold L. Redman, "Capital-Land Substitution and the Price Elasticity of Demand for Urban Residential Land," Land Economics, May, 1979, 167-176.

[12] See Dowall, David E., "Methods for Assessing Land Price Effects of Local Public Policies and Actions," in Urban Land Markets: Price Indices, Supply Measures, and Public Policy Effects, J. Thomas Black and James E. Hoben, eds., Urban Land Institute, Washington D.C., 1980.

out-of-pocket expenses would be to reduce this difference. Thus, continuing to assume a 4% real rate of interest, the present value of $100 a year in sewer charges is $100/.04 = $2,500. A 50% increase in this fee would increase its value by $1,250. Since, by assumption, all other communities in the metropolitan area have not been affected by the sewer price change, the area-wide housing market will force the small community's home owners to bear this sewer cost increase in the form of a reduction in their property values. In the very short run, this windfall loss would be the only effect of the fee increase.

Over the longer run, however, a $1,250 fee increase would induce a $1,250 fall in the value of a house's worth of land. Such a price reduction would result in the substitution of land for capital in the production of housing services. A less dense community with lower total population would result. To get a rough idea of the magnitude involved, on average about 25% of the value of a house is accounted for by the land it uses -- $25,000 of land for a $100,000 house. $1,250 is 5% of $25,000. A 5% reduction in the price of land would result in about a 5% increase in the amount used per house and, hence, in about a 5% reduction in population density.

B. Development patterns and public infrastructure costs

This literature examines how various community characteristics, particularly density, affect the costs of providing public services. Of particular relevance for this report is the work that investigates how settlement patterns affect the cost of providing sewer services.

Frank [1989][13] reviews a set of studies that examine how the costs of development are affected by the density, size, and location of development. The reviewed pieces cover a span of twenty-five years. To facilitate comparisons Frank inflates all findings to 1987 dollars using the Engineering News Record Construction Cost Index.

Wheaton and Schusseil [1955].[14] This is an analysis of suburban Boston communities (Natick, Wayland, Newton). The costs of streets other than those for exclusive use of a development and the costs of drainage other than gutters were not included. They classified capital facilities as:

> 1. Primary: (today referred to as "frontage facilities") These serve new developments exclusively--sewer laterals, water distribution lines, streets, sidewalks, lighting, and storm sewers are examples.
>
> 2. Secondary direct: These serve other areas as well but not the community as a whole--e.g., elementary schools, trunk sewers, fire stations.
>
> 3. Secondary indirect: These serve the community as a whole--high schools, water reservoirs and treatment plants, sewage treatment plants.

Wheaton and Schusseil classified costs as:

1. Capital
2. O&M
3. Precipitated--costs over and above pre-development costs;
4. Full--precipitated costs plus the allocated cost of inherited facilities.

They combined facility and cost elements into a combined taxonomy:

1. Precipitated capital
   primary
   secondary direct
   secondary indirect
2. Full capital cost
3. Annualized full capital cost
4. Yearly O&M costs

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[13] Frank, James E., The Costs of Alternative Development Patterns: A Review of the Literature, Washington, DC: Urban Land Institute, 1989.

[14] Wheaton, William L. and Morton J. Schussheil, The Cost of Municipal Services in Residential Areas, Washington, DC: US Dept. of Commerce, 1955.

5. Total annual cost.

Findings: Full Capital costs ranged between $27,224-33,024 per new dwelling unit as "systematic effects of variations in":

Characteristics of population--students per dwelling and ratio of private to public schools municipal standards--20-25 v. 40-45 pupils per class (This plus students per household led to difference between $8,578/pupil in Newton and $16,905 in Wayland). 22-foot unpaved ($81 per house) v. 29-foot paved streets ($162 per house)

Lot size--septic tanks for 20,000 ft^2 lots cost $1,418 while largest sewer cost was $7,671. water system costs ranged between $2,471-$5,808

Precipitated direct capital costs ranged between $15,682-$23,798. (Precipitated cost reflects actual capital outlay; full capital cost includes allocation of costs of existing facilities.) Going from 30,000 ft^2 lots with 150 foot fronts to 10,000 ft^2 lots with 80 foot fronts in Natick reduced precipitated primary costs by $1,400. The total variation attributed exclusively to lot width was $1,400-$2,000 while differences in standards yielded variations of $1,500-$2,100. Precipitated secondary direct costs ranged between $543-$9,242.

Conclusion: For builders, costs do not vary much with location. Municipalities, though, should be sensitive to variations in indirect capital costs which can precipitate major cost differences.

Isard and Coughlin [1957].[15] The study estimated costs borne by a municipality exclusively for things on a development site except for sewage which was estimated as part of 16,000,000 gal/day treatment plant serving area with 200,000 people. Capital costs for roads, sanitary and storm sewers, and schools ranged between $17,467 and $24,041 for 16 and 4 dwelling units per acre respectively. Capital outlay for one dwelling unit per acre were $18,245

[15] Isard, Walter and Robert E. Coughlin, Municipal Costs and Revenues Resulting from Growth, Wellesley, MA: Chandler Davis, 1957

because a septic tank was assumed to be supplied by the household and storm drains were assumed not to be necessary.

Urban Land Institute [1958].[16] This work looked at the costs associated with a "full standard development" involving paved 27-ft-wide streets with curbs and four-ft sidewalks, fully piped storm sewers with manholes, catch basins, and culverts, water supply, and sanitary sewers. These costs were proportional to lot width: $6,000 (60-feet), $15,000 (150-feet), $24,000 (250 feet). But reduced standards in storm sewers and paving were regarded as sensible for large lots. Taking these reduced costs into account led to cost differences of only $13,250-$14,500 in the 80- 160-ft range.

Kain [1967].[17] This work divided service systems into:

inter-neighborhood or trunk--e.g., connector sewers
intra-neighborhood--e.g., sewage collection network
lot--e.g., house connections
structure--e.g., plumbing

Interneighborhood costs, Kain said, depend largely on shape and size of the region served rather than on density. "Noting that the length of trunk transmission lines behaves the same as the radius of a circle, he asserted that a 25 percent increase in the area of a circle translates into a 1.7 [sic] percent increase in its radius; hence, a ... 25 percent increase in average lot size results in a situation in which 'even if trunk line costs were completely invariant with capacity, trunk distribution costs would increase by less than 2 percent.'"

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[16] Effects of Large Lot Size on Residential Development, Technical Bulletin 32, Washington, DC: Urban Land Institute, 1958.

[17] Kain, John F., Urban Form and the Costs of Urban Services, Cambridge, MA: MIT-Harvard Joint Center for Urban Studies, 1967.

Stone [1973].[18] Findings: An increase from 9 to 29 dwelling units per acre resulted in an increase from $10,919 to $16,677 in building costs per capita and a decrease from $1,273 to $482 in development costs per capita or from about $4,417 per household to $1,648.

Real Estate Research Corporation [1974].[19] This study incorporated as costs: Schools, streets (arterial, collector, and minor), police, fire, sewers, storm drains, water supply, gas, electricity, telephone, other. Costs are cited for mixes of dwelling types and range between $20,000-$40,000 from least to most expensive mix. Costs were evaluated for 1,000 dwelling units of six densities:

> Single family conventional: 1,600-ft^2 houses on 14,000 ft^2 lots for a net density of 3 dwelling units/acre and neighborhood density of 2.5 dwelling units.
>
> Single-family clustered: 1,600-ft^2 on 8,700 ft^2 lots with curvilinear street pattern and much more public open space net density of 5 dwelling units/acre and neighborhood density of 2.5 dwelling units per acre.
>
> Townhouse clustered: 1,200-ft^2 attached in groups of 5 on curved streets with ample recreation space--15 dwelling units/acre and neighborhood density of 10/acre.
>
> Walk-up apartments: 1,000-ft^2 units at 15/building with curved streets and ample recreation space--15 dwelling units/acre and neighborhood density of 10/acre.
>
> High-rise apartments: 900 ft^2 units in 6-floor buildings for 30 dwelling units/acre and neighborhood density of 10 units/acre.

Windsor [1979].[20] This study recomputed costs from Stone [1973] to hold floor space and pupils per household fixed. These changes reduced cost

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[18] Stone, P. A., <u>The Structure, Size, and Costs of Urban Settlements</u>, Cambridge, UK: Cambridge University Press, 1973.

[19] Real Estate Research Corporation, <u>The Costs of Sprawl: Detailed Cost Analysis</u>, Washington, DC:US Government Printing Office, 1974.

[20] Duane Windsor, "A Critique of The Costs of Sprawl," <u>Journal of the American Planning Association</u>, 45(3) (1979), pp. 279-292.

variations substantially, but left the essential findings of Stone [1973] intact.

Daugherty et al. [1975].[21] This study analyzed the effects on costs of adding 20,000 people to Gilroy, CA's 13,000 population over a 20-year period by either compact (adjacent to current perimeter of growth), scatteration and leapfrog (2- and 5-miles away respectively). Site densities were assumed independent of type. But too many other things varied to take the resulting numbers very seriously.

Downing and Gustely [1977].[22] This study dealt only with water, drainage, and sewers costs. The annualized capital costs per 1,000 dwelling units per mile of distance between dwellings and treatment facilities were $48,510 for water, $13,921 for drainage, and $27,403 for sewers. The respective capital costs per dwelling unit were $518, $149, and $293 per mile.

Frank's summarization of the studies: Costs of streets, sewers, water, storm sewers for sprawl with 3 dwelling units/acre is $35,000 per unit plus about $15,000 if development is 10 miles from sewage treatment and water supply sources; $24,000 per unit for contiguous 12 dwelling units/acre; $18,000 per unit for a mix of housing types with single-family and town houses accounting for 30 percent and apartments 70 percent.

A final study, not included in Frank's review, that is relevant is

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[21] Daugherty, Laurence, Sandra Tapella, and Gerald Sumner, Municipal Service Pricing: Impact on Fiscal Position, Santa Monica, CA: RAND, 1975.

[22] Downing,Paul B., and Richard D. Gustely, "The Public Service Costs of Alternative Development Patterns: A Review of the Evidence: in Paul B. Downing, ed., Local Service Pricing Policies and Their Effect on Urban Spatial Structure, Vancouver: University of British Columbia Press, 1977.

Fagerlund [1979].[23] This work is especially pertinent to the analysis of interceptor costs. Fagerlund's objective was to build a model to aid in minimizing the costs of providing sewer service to an area and to determine the extent to which the marginal and average costs of providing service vary with settlement patterns and the temporal and spatial layouts of pipe systems. He determined the cost of an optimally staged pattern of government services but not the interaction between the location decisions of households and developers on the one hand and the investment plans of service providers on the other.

Fagerlund described the technology of collection systems and optimal pipe design but did not deal with optimal two-dimensional layouts of pipes; he assumed, rather, that interceptors are designed only to connect exogenously specified nodes, one in each individual zone. Fagerlund took it as given that a cost-minimizing pipe system is one with sufficient capacity to serve the ultimate population of an area up to 50 years in the future and that treatment plants should be designed for anticipated demand 25 years in the future. The elasticity of the capital costs of a treatment plant with respect to its capacity is approximately 75%. He cited information that there are substantial scale economies in the provision of sewer services. There appears to be a general belief among engineers familiar with sewer construction that a doubling of a sewer's capacity requires only about a 10% increase in its costs. Fagerlund cited information suggesting that the capacity of a sewer line increases with the 0.375-power of its diameter. He assumed, however, that costs are proportional to the square root of capacity--the proportion

[23] Fagerlund, Edward Arthur, The Urban Settlement Pattern and the Cost of Providing Wastewater Disposal Service, University of Minnesota Doctoral Dissertation, 1979.

suggested by the fact that a doubling of the diameter of a pipe quadruples its surface area.

Fagerlund designed an integer programming model to deal with areas of between 5 and, perhaps, 1,000 square miles that are to be settled over a period of years in five-year increments. Optimally linking together zones of sizes that can be varied over the range 1-10 square miles is the problem. Since intra-zone layouts are taken to be given, this problem typically reduces to when to build each segment.

Using the model with appropriate data shows variations in costs with project type, time and distance of settlement, and zone size as well as on the relative costs of on-site and sewer-based systems. Total sewer capital costs (not just interceptor costs) per dwelling unit ranged between 1,436 late 1970s dollars for dwellings in high-rise apartments and $5,012 for scattered single-family dwellings. Replacing sprawled development by planned development reduced sewer and sewage treatment capital and operating costs by about 20%.

What does this literature review tell us? Differences in fees for publicly provided services, like differences in taxes, affect the locational decisions of business firms. To relate these effects to sewage collection and treatment, an unmatched 20% increase in the rates the MWCC charges a community would, on average in the long run, result in a 1.4-3.0% reduction in business employment in the community. Household locations are also affected by changes in fee structures. Although data limitations prohibit making precise quantitative statements about these effects, the sketchy evidence implies that demand for housing could change by magnitudes in a similar range, depending on the characteristics of the community.

These location effects may also translate into changes in the costs of providing public services because these costs are negatively related to the density of residential and business structures in a community. According to one study, in 1987 dollars, the costs of 27-foot wide streets, curbs, sidewalks, storm and sanitary sewers, catch basins and culverts, and water supplies, averaged about $100 per front foot for a dwelling.

The distance between a community and the facilities that provide it with fresh water and with waste-water collection and treatment have a substantial effect on the costs of delivering these services; one study estimated annual and capital costs of $90 and $1960 for water, drainage, and sewage per household per mile of separation in 1987 dollars.

IV. Discussion of Conceptual Issues and Methodologies

The primary goals of this study are to estimate the distribution across communities of the costs of waste water collection and treatment in the region and to investigate the implications of different fee structures given the underlying costs. These tasks raise a set of issues related to how to measure costs and how to structure fees. This section lays out some of these issues and describes how we have dealt with them.

A. Fee Structures and Scale Economies

The Commission designs capital improvements with capacities to serve expected system demands over a substantial future period. Its doing so reflects the existence of substantial scale economies in providing treatment facilities and, to an even greater extent, sewers. Fagerlund cites evidence suggesting that the capital cost of a treatment plant can be written in the approximate form

$$\text{Cost} = A \cdot (\text{Capacity})^{0.75}$$

where A is a parameter. An analysis discussed at greater length in Section V D indicates that operating costs for the MWCC's treatment plants adhere quite closely to

$$\text{Cost} = A \cdot (\text{Capacity})^{0.84}$$

The fact that our estimates of costs at two of the smaller plants are probably biased downward (see footnote 32) implies that the true cost function for the MWCC system corresponds to Fagerlund's estimate more closely than this. However, in either case, economies of scale are implied by the exponent that is less than one. As for sewers, statistical analysis of data on 156 interceptor segments for which we had complete information yielded[24]

$$\text{Cost} = A \cdot (\text{Length})^{0.78} \cdot (\text{Capacity})^{0.35}$$

In designing a cost-minimizing sewage collection and treatment system, a balance must be struck between scale economies in the provision of sewage treatment services and scale diseconomies in collecting the sewage to be treated. The larger is the treatment plant, the lower are its unit costs. At the same time, however, the larger is the plant, the greater is the average distance from which sewage must be brought if the plant's capacity is to be fully utilized. While scale economies in sewer provision limit the costs of greater distance, they do not eliminate them. This being the case, it is unwise to consider sewer and sewage treatment costs in isolation. A small treatment plant will almost inevitably have higher treatment costs than a large plant but also almost inevitably will have lower costs of transporting the sewage to be treated.

A fundamental proposition of economic theory is that setting price equal to marginal cost is a necessary condition for achieving an efficient allocation of an economy's resources. There are, however, two serious problems with marginal-cost pricing when increasing returns to scale are present. First, with scale economies, marginal cost prices will not, as a general proposition, generate revenues sufficient to cover the total costs of an optimal system. Second, marginal costs are difficult to define and calculate in complex systems. This is especially the case for the interceptor system.

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[24] Cost is in dollars per year, capacity is in million gallons per year, and length is in feet. The t-statistics on these parameter values is highly significant---11.06 for length and 14.40 for capacity. Despite its goodness-of-fit measure, however, the exponent on length should be viewed cautiously. We treated the capacity of a segment as the capacity of its largest component. The longer is a segment, the greater is the extent to which its components are telescoped.

Given these problems, we investigated the implications of using average cost pricing by developing a computer simulation of a hypothetical interceptor system. We computed marginal costs, scaled them up to cover system costs, and then compared the scaled-up values to average costs. We found that (1) average costs varied in the same direction as marginal costs (areas with high marginal costs had high average costs) and (2) the two costs were typically within 15% of each other. In a larger simulation, we expect that these differences would decrease, implying that a much easier to implement average cost fee system would have many of the desirable efficiency properties of marginal cost pricing. Our cost estimates therefore reflect average costs.

We also took distance into account in the interceptor cost calculations. The current method of charging for use of the metropolitan interceptor system is based on a charge to communities for the flow from each community. This method introduces an inefficiency into location decisions for residential and commercial development by disregarding the additional costs to the system when development occurs in areas distant from treatment facilities. In making development decisions, the benefits of locating farther from treatment facilities (such as lower land prices and traffic congestion) are taken into account, while the costs of providing interceptors to more distant locations do not influence development decisions.

Our work charges each community by the fraction of its use of the interceptors "downstream" from it. In this way communities located near treatment facilities, for which only short segments of the interceptor are needed, are charged only for the portion of the system that they use. Similarly, communities located near the periphery of the M.U.S.A. are charged for more miles of interceptor but only for a portion of each interceptor carrying their flows that reflects their share of capacity.

This distance-based fee structure is not without problems. The location of treatment plants is, to some degree, arbitrary. Locations are limited, of course, by the availability of sinks. But where on a particular river a plant is located is discretionary to some extent. Facility locations may also change after many consumers have already made location decisions. Alternative locations for an interceptor that leave total system costs unchanged can alter substantially the costs of serving individual communities. These issues deal essentially with the fairness of the system and are not appropriately in the domain of this study.

B. <u>Measuring Capital Costs</u>

In general, we have reservations about the way in which the capital costs of sewage transportation and treatment are accounted for in MWCC records and about how they are allocated to the Commission's present and future customers. Were our reservations to be taken into account in the Commission's pricing procedures, it is likely that it would charge more for its services generally, although not necessarily to all of the classes of its customers that can be usefully enumerated. The Commission's operations would be "profitable" thereby generating net revenues that could be used to offset the operating costs of the Metropolitan Council or, more broadly, Metropolitan Area governments. Higher prices would induce more careful use of wastewater collection and treatment services thereby reducing required capital spending in future years.

The primary reservation regarding current practices involves the way that capital costs are accounted for in the current fee structure. The current system effectively treats debt service costs as the only cost of capital in the system. This practice creates problems in three ways. First, it excludes the portion of capital costs financed with federal money. Second, it allocates the costs for individual projects inappropriately over the lifetime of the investment. And third, it makes it extremely difficult to allocate costs on a plant by plant basis.

During the first decade or so of the MWCC's existence, Federal Government grants covered a large share of the capital costs of the Commission's new treatment plants and the interceptor sewers that serve them. Whether because of a mandate of the US Congress or the Minnesota legislature or a Commission view that equity dictates not collecting twice to cover any given cost, these capital costs having been taken off the Commission's collective shoulders, were not passed on to its customers.

While grants may reduce the direct cost of capital plant to Twin Cities residents, basing infrastructure pricing or provision decisions on anything other than full costs creates undesirable outcomes in several ways. In determining user fees, omitting costs covered by grants would lead to fee structures that are dependent on the geographic distribution of grants -- a distribution that is essentially arbitrary given the changes in federal funding patterns and the timing of development in different parts of the region.[25] In addition, future federal support for construction of regional facilities in this policy area is very uncertain. The fact that federal grant programs have concentrated on financing construction (capital) costs means that decision-making regarding provision and/or construction based solely on

[25] Note that the current system does not make this mistake. The current procedure, in effect, distributes the financial benefits of federal grants uniformly across the region.

local debt service costs would lead to decisions regarding the mix of inputs (capital, labor ....) that are likely to be inefficient in the long run, both from a local and a national point of view. Using an under-estimate of capital costs would also distort the determination of access fees for new users.

The second problem with the current procedure is that it allocates the cost of assets incorrectly over time. To an economist, the value of an asset is equal to the value of the flow of services that it generates. A measure of the asset's cost should reflect the fact that an alternative use of the money could generate a stream of services of equal, or nearly equal, value. These foregone returns represent the full cost of the asset. As the Commission uses the term, however, annual "capital costs" are the annual outlays required to service its bonded debt--payments for interest and to retire maturing bonds. The bonds issued to finance the Commission's investments are set up to recover total costs in 20 or fewer years, periods that are substantially shorter than the expected service lives of most Commission investments (40 - 80 years). This means that a fee system based on debt service costs results in "early" users of a given asset subsidizing "later" users. Given the different timing of asset acquisition in the current system, it would be extremely difficult to evaluate whether the subsidies received by current users from past users outweigh their subsidies to future users. Basing fees on direct measures of total capital costs spread over the full life-time of assets avoids this problem.

The third problem is that, according to MWCC staff, tracing debt service costs to specific locations would be extremely difficult, if not impossible. Estimating capital costs directly from asset values allows us to trace costs directly to assets with known locations, enabling us to allocate costs among users on a plant by plant basis.

In summary, our estimates of capital costs are designed: (1) to reflect the full value of assets; (2) to properly match the costs of service flows to asset life-times; and (3) to distribute costs plant by plant. See section V.A for the full description of the procedure.

C. Allocating Operating and Maintenance Costs to Individual Plants

MWCC accounting procedures report roughly 60% of O&M expenditures on a plant by plant basis with the remainder reported under such general categories as quality control and research and development.[26] We assigned expenditures in the first category to the plant for which they are reported. We assume expenditures in the second category to have system-wide effects and therefore treat them as system costs to be shared by each municipality in proportion to it's contribution to system flows.

D. Allocating Costs Between Current and Future Users

Our study takes as its starting point the proposition that the fee charged an individual user should reflect the costs that user imposes on the system. The clearest example of the importance of accounting for the time profile of costs and benefits involves the practice of taking advantage of scale economies to reduce costs by building capacity in advance to accommodate future users. The clearest way to approach this issue is to analyze the cost of holding in reserve for a future household the 100,000 gallons per year of sewer and treatment plant capacity that an average household currently uses.

[26] Metropolitan Waste Control Commission 1993 Operating and Capital Budget, Metropolitan Waste Control Commission, 1992.

These costs depend on (1) how long the capacity is held idle; (2) the outlay required to produce this capacity; and (3) how the assets depreciate: through wear associated with use, through aging that is independent of use, or both.

The role of the first two considerations is straight forward. The longer an asset is held idle and the greater is its initial cost, the larger is the appropriate connection fee.

The third consideration -- the causes of depreciation -- is more complicated. The two extremes and an intermediate case illustrate the issue. At one extreme is an asset with a life that depends only on calendar time, not on how intensively it is used. Well-maintained sewers come close to this extreme. A stream of annual payments over the life of such an asset can be determined that had a present value when the asset was acquired equal to its cost of construction. Dividing the payment for a given year by the asset's capacity yields the appropriate annual charge for each unit of capacity. This charge is appropriate, it should be emphasized, for units that are held in reserve for future users as well as for those that are currently in use. Current users pay currently for the units they presently use; future users should pay the charges for idle capacity effectively incurred in their behalf plus accumulated interest at the time they tie into the system.

At the other extreme is an asset that depreciates only with use--an asset that would have an infinite life if held idle. Holding a unit of such an asset's capacity for a future user does not diminish the stream of services that the asset will ultimately deliver. Users should be entirely responsible for covering the costs of such an asset; *when* a user enters the system has no effect on the costs that user imposes--only use imposes costs.

The intermediate case is one for which an asset depreciates with both use and the passage of time. For such an asset, the appropriate connection fee applies to a fraction of the asset's costs equal to that proportion of its depreciation that is attributable exclusively to aging. The connection fee is otherwise comparable to that for an asset which depreciates only with time.

Determining the appropriate distribution of capital costs between current and future users is straight-forward for cases (probably rare) at the two extremes. For intermediate cases, finding the appropriate distribution requires information that is difficult to compile (e.g., the time profile of use) or unavailable (e.g., the relative importance of time and use in the depreciation of assets).

Current MWCC practice seems implicitly to assume depreciation to be exclusively a function of the passage of time; present users bear a fraction of debt service costs equal to the fraction of current capacity that they utilize. This implicit assumption seems more plausible for interceptors than for treatment plants. If maintained properly, they have very long lives regardless of the rate at which they are used. We have, therefore, followed the MWCC example in assuming interceptor depreciation to be solely a function of age. The case is less clear for treatment plants. We have, therefore, calculated an all-age baseline case for them and an alternate case that splits depreciation evenly between age and use. Since we have no information on the actual split, the alternative can be viewed as a sensitivity test that suggests the possible importance of research aimed at determining the relative roles of these two causes of depreciation.

All of this report's connection cost calculations are relevant to a second point of concern about access fees. Access charges should give builders incentives to time development efficiently. To the degree that depreciation of an asset depends on time rather than use, once the asset has been built, capacity that goes unutilized until several years after construction imposes the same costs on the system as immediately utilized capacity. Encouraging orderly growth reduces system average costs by reducing unutilized capacity. The pricing system arising out of our analysis provides an inducement to early development by imposing connection fees that increase with the time that has elapsed since construction of the assets being put into use.

V. Treatment Plant Cost Calculations

This section describes the cost calculations for treatment plants. Section A reports the data sources and basic procedures for the calculations. Sections B through D describe the calculations and findings under the assumption that all depreciation of assets is the result of aging and none is due to use. (See Section IV.D.) The last section presents the findings under the alternative assumption that aging and use contribute equally to depreciation.

A. Data Sources, Cost Classifications, and Indexing

The base year used for the analysis is 1991. This is the most recent year for which actual fiscal and flow data are available. 1991 was also the final year in the transition from service area pricing to uniform pricing. This means that the implications of uniform pricing must be simulated, rather than derived directly from actual data.

The primary data sources for the treatment plant analysis were the Metropolitan Waste Control Commission 1993 Operating and Capital Budget (MWCC-1), the Metropolitan Waste Control Fixed Asset Inventory: 9/1/92 (MWCC-2), the Metropolitan Waste Control Commission Final Cost Allocation for Budget Year 1991 (MWCC-3), and the Location and Cost Study and Current Value Apportionment of Interceptor and Treatment Works, Black and Veatch Consulting Engineers, 1971 (BV).

MWCC-1 was the primary source for O&M costs for plants and interceptors, and for system-wide administrative costs. MWCC-1 breaks out interceptor and plant-specific expenditures directly. System-wide administrative costs were calculated as the residual of total costs minus industrial strength charges, debt service, plant costs, and interceptor costs. Industrial strength charges were excluded because they are not included in the fees charged to municipalities.[27] Debt service was excluded because capital costs were calculated directly from MWCC-2 (see below).

MWCC-2 was the primary source for treatment plant capital costs. For assets acquired since 1970, the costs shown in this source were assumed to represent the full construction costs of the assets at the time they came into use. Current valuations were derived by inflating the data to 1991 dollars using the acquisition date and cost indexes for sewer and for fresh-water treatment plant construction derived from Construction Reports, series C-30, Bureau of the Census.[28]

Values for assets purchased from municipalities in 1970 were computed from BV. The Black and Veatch study estimated asset values by deducting grants and outstanding debt from construction costs, inflating the result to 1970 dollars, and then adding outstanding debt back in. This procedure does not provide an estimate of full costs. Values shown for these assets in MWCC-2 are therefore not consistent with those shown for later acquisitions. 1970 values for the purchased treatment plants were estimated by inflating the year-by-year investment data shown in Section II of BV to 1970 using the same

[27] Due to data limitations, we have no way to isolate the expenditures associated with treating industrial waste from those associated with residential and commercial users. All comparisons of actual fees with our cost estimates, therefore, assume that industrial strength fees cover the full costs of treating industrial waste. Discussions with MWCC staff suggest that this is an issue worthy of a study in itself.

[28] Cost indices for the construction of sewers and of waste-water treatment plants were developed by the Environmental Protection Agency for the period prior to 1982. The EPA sewer index is reasonably consistent with that of Construction Reports. Similarly, the EPA index for waste-water-treatment plants is reasonably consistent with the Construction Reports' index of costs for facilities which treat fresh-water supplies. Given the similarity between the EPA and Construction Reports indices, we relied on the latter for the entire period under analysis.

inflators employed in BV. The revised estimates of 1970 values for these assets were then inflated again to 1991 dollars as described above.[29]

Capital assets were assigned to individual treatment plants by location codes in MWCC-2 and BV, inspection of asset descriptions in MWCC-2, and consultation with MWCC staff. MWCC-3 was the source for actual 1991 gross charges to jurisdictions and actual 1991 jurisdiction-level flow rates. Several municipalities are served by two plants. In all cases, a high percentage of the municipality's flow went to one of the two. These places (and their flows) were counted in the plant-shed that represented the majority of their flow.

B. <u>Procedures Used to Compute Current User Costs</u>

Operation and maintenance costs were allocated to municipalities in four steps. (1) 1991 expenditure data, broken out by plant in MWCC-1, were divided into two categories - liquid and solid treatment costs. O&M costs at the three plants that treat solids (Metro, Seneca and Empire) were allocated to liquid and solid treatment by the 40/60 ratio recommended by MWCC staff. For other plants 100% of expenditures were allocated to liquid costs.[30] (2) Liquid treatment costs (by plant) were allocated to individual municipalities

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[29] The calculation for the Metro plant excluded all investments that occurred prior to 1952. This represents the cut-off point for the expected lifetime of treatment plant assets, as defined by the MWCC. This procedure almost certainly excludes some assets that are still in use. However, it is also very likely that some assets built after 1952 are included that should not be. It is assumed that these factors balance out -- an assumption that is supported by recent estimates of the replacement cost of the Metro plant that are within 5% of the estimates used for this work. See footnote 28.

[30] The sensitivity of the findings to the 40/60 assumption was tested. In general, the findings are not very sensitive to changes in the assumption -- using a 50/50 split, for instance. In general, lowering the solids share marginally increases costs at the Metro (by less than 1%) and decreases costs by a slightly larger proportion at plants that send solid wastes to Metro for treatment.

according to each jurisdiction's share of total flows into the relevant plant. (3) Solid waste treatment costs were allocated to municipalities by the same procedure for municipalities in the Seneca and Empire watersheds.[31] Solid treatment costs at the Metro plant were allocated to all other municipalities according to their shares of the total flow from all of those municipalities combined. (4) System-wide administrative costs were allocated to municipalities according to their shares of total flows in the system.

Capital costs were allocated to municipalities in four steps. (1) Assets were divided into solid and liquid treatment categories. This was done through the asset descriptions from MWCC-2 and consultation with MWCC staff. Assets that could not be attributed unambiguously to one category or the other were distributed using the 40/60 rule applied to O&M costs. (2) Annual capital cost was computed for each asset. Annual cost was defined as the annual expenditure stream needed to finance the 1991 dollar value of the asset over its lifetime at a 4% real interest rate.[32] (3) Annual capital costs were summed within the treatment plants and the future user portion of costs was subtracted. This portion was assumed to be the percentage of plant capacity that was idle during 1991. (4) Annual capital costs for solid and liquid treatment were allocated to municipalities by a procedure identical to that used for O&M costs.[33]

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[31] The limited number of assets at the Blue Lake plant that are designated for treatment of solids were allocated to municipalities in the plant-shed in the same manner and added to the costs associated with shipping solids to the Metro Plant.

[32] The discount rate for this calculation should correspond to the long-run real interest rate (nominal interest rate minus the inflation rate). 4% is a typical level for this indicator during the last 30 years.

[33] Independent estimates of the replacement cost of the nine plants that became available while this work was in progress provide a rough check on the outcomes of these estimating procedures. The Metro plant estimate for this work is within 5% of the independent cost estimate ($641 million from this

C. <u>Procedures Used to Compute Future User Costs</u>

Estimates of the appropriate connection fee to be charged to new users for the plant portion of capital costs were calculated at the plant level. In principle, the estimates represent the cost per 100,000 gallons per year for treatment capacity that has been held in reserve through the end of 1992 over the actual lifetimes of the relevant assets. 100,000 gallons was selected to represent the approximate use per housing unit per year. The derived connection fee thus represents the holding costs associated with the addition of a net new user to the system.

For this work, connection costs were estimated controlling for cost and age on an asset by asset basis and controlling for capacity utilization at the plant level. Separate estimates were made for liquid and solid treatment assets in order to allow for the costs of holding solid treatment capacity at the Metro plant for consumers in the plant-sheds that send solid waste to Metro. The calculations were made in four steps. (1) The annual cost of each plant asset in MWCC-2 was computed in 1991 dollars -- C_{ij} = annual cost of

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work versus $608.5 million for the independent estimate of replacement cost). There were wider differences for the other plants -- $109.8M versus $73.1M for Seneca, $95.8M versus $57.8M for Blue Lake, $39.1M versus $29.4M for Empire, $4.5M versus $6.9M for Stillwater, $16.7M versus $10.5M for Hastings, $4.7M versus $3.8M for Cottage Grove, $7.8M versus $5.1M for Chaska, and $4.4M versus $5.1M for Rosemount. The difference for Stillwater is largely explained by the increase in capacity that occurred there after 1991. For Rosemount, the difference is due to the exclusion of the asset value of the old plant that was replaced in 1990, because no estimate of the proportion of the plant that is still in use was available. The differences for the other plants are potentially significant in some cases. However, the independent replacement cost estimates for Seneca, Blue Lake and Empire can be argued to be demonstrably low. The estimates for Seneca and Blue Lake are less than the total costs associated with the expansions of these plants in 1991. It would be reasonable to assume that the current replacement cost for the entire plants should exceed these expansion costs from such a recent time. Similarly, the Empire estimate exceeds the 1991 expansion costs by less than 40%. It is likely that the difficulty in determining exactly which assets are still fully in use from MWCC data means that our estimates include some costs that should be excluded. However, it seems clear that the recent replacement cost estimates omit significant costs as well.

asset i at plant j. (2) The future user portion of the cost for each asset was computed as the product of the proportion of plant capacity that was idle in 1991 ($XCAP_j$) and C_{ij}. (3) The total discounted value of the annual cost from step (2) over the actual age of the asset (y_{ij} = 1992 minus the construction date) was computed by $[(XCAP_j*C_{ij})/r] * (e^{ry_{ij}}-1)$, where r = .04 (the estimate of the long-run real rate of interest). These values were then summed across all assets in the relevant plant. And (4) this sum was translated into cost per 100,000 gallons per year by dividing by 1991 excess capacity (measured in units of 100,000 gallons) at the relevant plant -- $(XCAP_j*CAP_j)$.

D. Findings: Plant Costs Assuming That Time Alone Contributes to Depreciation

Tables 1 and 2 show the results of the cost calculations under the baseline assumption that all depreciation is attributable to aging (and none to use). Table 1 contains estimates of cost per 100,000 gallons broken out by plant for liquid and solid treatment, O&M and capital costs, and system costs.[34] Also shown are total costs as a percentage of the system-wide average and total 1991 flows through the plants.

The treatment cost estimates reveal several points of interest. First, the current charge structure does not recover the full costs of the system when the more complete definition of capital costs used in this work is substituted for debt service expenses. Actual charges to municipalities in 1991 averaged $106 per 100,000 gallons. This was less than our estimate of the average cost for plant services alone ($113.50). This "deficit" will, of

[34] Actual charges varied plant by plant in 1991 with some minor variations within plant-sheds. These variations are not large enough to warrant showing a municipality by municipality breakdown.

Table 1

1991 Treatment Costs per 100Kgal/year and Annual Flows by Treatment Plants

	Liquid		Solid					Total
	O&M	Capital	O&M	Capital	System	Total	% of Average	Flow Mgal/yr
Total	$24.33	$22.80	$28.30	$15.16	$22.89	$113.50	100.0%	103,252
Metro	20.23	18.18	26.62	15.43	22.89	103.35	90.9	81,406
Seneca	26.32	36.24	39.48	8.36	22.89	133.28	117.2	8,311
Blue Lake	40.97	38.34	26.62	18.53	22.89	147.35	129.6	8,217
Empire	38.35	49.99	57.52	17.85	22.89	186.59	164.1	2,158
Stillwater	57.51	13.94	26.62	15.43	22.89	136.38	119.2	1,172
Hastings	95.24	98.70	26.62	15.43	22.89	258.88	227.7	583
Cottage Grove	83.09	36.53	26.62	15.43	22.89	184.55	162.3	580
Chaska	64.55	64.77	26.62	15.43	22.89	194.25	170.8	596
Rosemount	79.16	84.00	26.62	15.43	22.89	228.10	201.0	229

course, increase when interceptor costs are included in the analysis and discussion of this issue is left for sections VII and VII.

Second, the Metro plant is easily the most efficient plant in the system. It's costs are nearly 10% lower than the system wide average and roughly 25% lower than the second most efficient plant. This means that with a uniform fee system covering the full costs for treatment plant services, users in the metro plant-shed would be subsidizing other users in the system by about $10 per 100,000 gallons per year (the difference between Metro costs and the system-wide average). However, because Metro serves such a large proportion of the system's total flow, these relatively small subsidies would translate into substantial subsidies for users in the rest of the system, especially those in the smallest plant-sheds. The subsidies range from $20 per 100,000 per year to Seneca plant users to $207 per 100,000 gallons for Rosemount users.[35] (It is important to note that these estimates represent the subsidies that would exist with a uniform fee covering full costs, not the subsidies generated by the current fee system. Under the current system, Metro users essentially pay full costs while the benefits of past federal aid are distributed to all other users in amounts reflecting cost differences and usage.)

Third, the data show clear economies of scale in treatment facilities. The cost and subsidy measures vary closely with plant capacities and actual plant flows. A very simple estimate of the relationship implies that if plant

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[35] The unit cost estimates for the Stillwater and Rosemount plants should be regarded as lower bounds. Expanded capacity was available at Stillwater in 1991, but the capital costs associated with the expansion were not yet included in MWCC-2 because the expansion was not completed at that time. For Rosemount, the problem is caused by the fact that a good estimate of the current value of the assets from the original plant that are still in use was not available. The full value of the original plant is excluded from the capital cost estimates for Rosemount.

capacity or flow is doubled, cost per 100,000 gallons per year declines by about 12%. This implies a unit cost ratio between the largest plant in the system (Metro at about 91,000 million gallons per year) and the smallest (Rosemount at roughly 250 million gallons per year) of about .3 -- a ratio very close to what the actual cost data show.[36]

Table 2 shows the connection cost estimates for treatment plant capital. The estimates vary with both asset ages and plant efficiencies. Regarding asset ages, recall that the older an asset, the longer charges for its unused capacity have accumulated. Also recall that asset costs have been adjusted to 1991 dollars. Unit costs of excess capacity and the average age of assets are, therefore, also shown in Table 2. The calculation breaks costs down into liquid and solid treatment capacity to allow for the assessment of Metro plant solid treatment costs to Blue Lake and the five smallest plants which export their solids to Metro for processing.

The connection cost estimates are high relative to the currently charged SAC fee ($700). The implication, again, is that basing fee structures on debt service costs understates the true cost of the system -- in this case, the cost of holding treatment capacity for new users. The average connection cost from the full cost estimates for plants alone comes to $674.[37]

The connection costs estimates fall into three groups -- the four largest plants and the four next largest plants, and Rosemount. Among the

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[36] These estimates were derived from a simple regression of ln(cost/100Kgal/yr) on ln(capacity/100Kgal/yr). The resulting equation was: ln(cost) = 6.55 - .16*ln(capacity). The t statistic on the capacity coefficient was 4.4 (significant at the 99% confidence level). A similar regression of costs on flows yields nearly identical results. Given that costs at two of the smaller plants -- Stillwater and Rosemount -- are likely to be underestimated, the coefficient on capacity may be biased downward, resulting in an under-estimate of economies of scale.

[37] This is a weighted average with flows used for weights.

Table 2

1991 Connection Costs by Treatment Plant

Plant	Capacity Mgal /Day	Prop. Excess Capacity	Avg. Age of Assets		Capital Cost/100Kgal/yr			Discounted Cost/100Kgal of holding capacity thru 12/91		
			Liquid	Solid	Liquid	Solid	Total	Liquid	Solid	Total
Metro	250	0.12	12.6	9.4	18	15	34	344	341	685
Seneca	34	0.33	3.1	11.7	36	8	44	155	188	343
Blue Lake	32	0.30	4.8	5.2	38	19	57	265	360*	625
Empire	9	0.34	2.9	6.8	50	18	68	138	191	329
Stillwater	4.50	0.29	26.8	9.4	14	15	29	734	341	1,075
Hastings	2.34	0.32	10.4	9.4	99	15	114	2,137	341	2,478
Cott. Grove	1.80	0.12	20.6	9.4	37	15	53	1,321	341	1,662
Chaska	1.66	0.02	10.8	9.4	65	15	81	1,182	341	1,523
Rosemount	0.72	0.13	1.9	9.4	84	15	113	172	341	513

Ages were computed as the weighted (by value) average of the ages of assets listed under the plant. Ages of assets acquired in 1970 were estimated in similar fashion from the stream of investments reported Location and Cost Study and Current Value Apportionment of Interceptors and Treatment Works: Metropolitan Sewer Service Region, Black & Veatch, 1971. Discounted costs per 100 Kgal for acquired assets were also computed using the stream of investments in the plants reported by Black & Veatch. For all other assets, ages and costs are from MWCC Fixed Asset Inventory: 9-1-92.

Discounted value = $\sum_i \{[(XCAP_j*C_{ij})/r] * (e^{ry_{ij}}-1)\} / (XCAP_j*CAP_j)$.

$XCAP_j$=excess capacity proportion at plant j; C_{ij}=cost/yr of asset i at plant j (1991$), r=.04, yij=age of asset i at plant j, and CAP_j=capacity per year in 100Kgal of plant j.

*: Solid treatment capacity is currrently being developed at Blue Lake. Cost estimates include costs of assets at both Blue Lake and Metro (where Blue Lake solids are currently shipped).

four large plants, Metro's overall lower unit costs are overwhelmed in the calculation by the relatively old age of its capital plant. It shows the highest connection cost among the four (at $685), followed by Blue Lake ($625), Seneca ($343), and Empire ($329). These comparisons show how important investment decisions about where and when to build capacity are in determining the incentives that the resulting fee structure generates. The Seneca, Empire, and, to a lesser extent, Blue Lake connection costs imply incentives for new housing units to be built in those plant-sheds, rather than in the Metro plant-shed (or the other districts). This reflects the relative newness of these plants and the logical time structure for connection fees -- lower fees early in the lifetime of the capital plant and higher fees later in order to encourage efficient timing of development.

The relatively high unit costs and aging capital stocks of the middle group of plants result in relatively high connection costs. This is especially true for the highest-unit-cost plant -- Hastings. Stillwater's relatively low unit costs put it at the low end of this group, but the relatively old age of its capital plant sets it apart from the four largest plants in the connection cost calculation.

The newness of the Rosemount plant overwhelms its high unit costs in the calculation, giving it a relatively low connection cost. However, because of the 100 percent exclusion of the value of the original plant, the data almost certainly understate the age and unit costs of the capital plant at Rosemount. This implies that the connection cost estimate should be regarded as a lower bound.

E. <u>Findings: Plant Costs Assuming that Time and Use Contribute to Depreciation</u>

As noted in Section IV.D, current MWCC pricing practices (as well as the calculations in the previous three sections) assume that only aging is responsible for the depreciation of plant infrastructure. Use is assumed to have no effect on the expected lifetime of assets. This section repeats the basic cost calculations shown in Tables 1 and 2 under the alternative assumption that time and use contribute equally to depreciation of treatment plant assets and that use of the asset increases linearly over time from zero utilization when it is new to 100% utilization at the end of its lifetime.

The derivation of these alternative cost estimates is considerably more complicated than for those reported in the previous three sections and may still contain conceptual flaws that overstate the extent to which costs currently treated as part of SAC fees should be shifted to current users. A full description of the methods is therefore not covered in this section. Appendix A reports the mathematics underlying the calculations.

Table 3 reports the alternative estimates of costs attributable to current and future users and the size of the change from the findings reported in previous sections. The results reinforce several conclusions from the baseline calculations. First is the conclusion that the current user-fee structure understates the costs that users impose on the system. Allowing use as well as time to contribute to depreciation shifts a significant portion of the capital costs previously assigned to future users onto current users. The implied user fee increase is 32% for the system as a whole and the appropriate connection fees are cut roughly in half.

The finding that Metro users are subsidizing users in other plant-sheds is also reinforced. The change in assumptions has different effects on the

Table 3

Treatment Costs per 100Kgal/year and Plant Connection Fees
Assigning 50% of Capital Cost to the Passage of Time and 50% to Usage

Plant	Current User Costs: O&M and System Costs	Capital Costs: Liquid	Capital Costs: Solid	Total	Change	Future User Costs: Liquid	Solid	Total	Change
Total	$76	$42	$32	$150	32%	-	-	-	-
Metro	70	32	31	133	28	179	177	356	-48%
Seneca	89	65	15	169	27	78	94	172	-50
Blue Lake	91	69	37	197	33	129	191	321	-49
Empire	119	76	47	242	30	63	88	151	-54
Stillwater	107	25	31	163	20	382	177	559	-48
Hastings	145	177	31	353	36	1,086	177	1,264	-49
C. Grove	133	62	31	226	22	620	177	798	-52
Chaska	114	116	31	261	34	600	177	777	-49
Rosemount	129	152	31	312	36	86	177	263	-51

O&M and system costs are from Table 1. Capital costs and connection fees were computed with the assumption of a 50/50 split of capital costs to usage and aging.

current user cost estimates for different plants -- the proportional increases in estimated costs range from 20% to 36%. The increase for the Metro plant is 28% which is less than the average for the whole system. The implied net subsidy from Metro users to the rest of the system increases by 70%, from $10 per 100,000 gallons to $17 per 100,000 gallons. The changes in the net subsidies into the other plant-sheds vary from a decrease in the Stillwater plant-shed (from $23 per 100,000 gallons to $13 per 100,000 gallons) to significant increases for Hastings and Rosemount (from $143 per 100,000 gallons to $198 per 100,000 gallons and from $114 to $172, respectively).

The proportional change in the connection fee estimates is much more uniform than for user costs. There is a spread of just six percentage points, from 48% to 54%. Since we have no strong evidence supporting a particular allocation of depreciation costs to time and use, we cannot say that these cost measures are unambiguously more accurate than the prior estimates. However, it seems reasonable to suppose that use rates do play some part in the depreciation rates of treatment plant assets. These alternative estimates clearly reinforce the findings from the previous calculations that (1) user fees are currently too low and (2) a uniform fee structure for plant services generates subsidies from Metro plant users to users in the other plant-sheds.

VI. Interceptor Cost Calculations

This section describes the cost calculations for interceptors. Section A reports the data sources. Sections B and C describe the calculations and findings.

A. Data Sources

Interceptor cost and location data came from several sources. Metropolitan Waste Control Commission 1993 Operating and Capital Budget (MWCC-1) breaks out O&M expenditures for interceptors. MWCC in-house compilations of data (MWCC-3) from the Metropolitan Waste Control Fixed Asset Inventory: 9/1/92 (MWCC-2) and the Location and Cost Study and Current Value Apportionment of Interceptor and Treatment Works, Black and Veatch Consulting Engineers, 1971 (BV) provided construction cost, date of completion, and inflation indexes for interceptor capital costs. These compilations also provided the identifying codes needed to match the cost data with location and pipe characteristic data contained in computer files from the MWCC Geographic Information System software (GIS-1).

B. Procedures Used to Compute Current and Future User Costs

All cost estimates for the interceptor system assume that aging is the sole determinant of depreciation. (See section IV.D for a discussion of this issue.) Following MWCC practice, interceptor lifetimes were assumed to be 80 years. Interceptor capital costs were allocated to municipalities in six steps.

(1) MWCC-3 provides information on the capital costs of interceptors, with the system broken down into roughly 230 segments. The construction cost

data for each segment were inflated to 1991 dollars by the same procedure used for plant assets (described in section V.B).[38]

(2) The 1991 dollar cost estimates were then matched with pipe characteristic data from GIS-1. The GIS-1 data break the pipe system into roughly 3380 segments. Location codes from the two files were used to match the many short segments in GIS-1 to the corresponding 230 longer segments in MWCC-3. A single MWCC-3 segment might contain several GIS-1 segments, each with different characteristics such as capacity, length or building material. For our purposes, the important variables were length and capacity. Lengths for the 230 MWCC-3 segments were computed by summing the lengths of the relevant shorter segments from GIS-1. Capacities (measured in millions of gallons per day) for the 230 MWCC-3 segments were estimated by using the maximum capacity from the relevant shorter segments. Since flow from more than one municipality may feed into one of the longer segments, capacity at the downstream end of the segment is the best summary indicator of its overall capacity. We, therefore, assumed, in effect, the highest-capacity segment of the interceptor to be at its downstream end.

(3) Annual capital cost estimates were computed for each of the 230 MWCC-3 segments with procedures described in V.B.[39] The cost estimates were in units of dollars per year per 100,000 gallons of total capacity. The cost

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[38] For a limited number of interceptors that were acquired in 1970, BV calculations of construction costs and dates were replaced with estimates that controlled for the time profile of investments in the interceptors. BV used a simple averaging procedure that provided distorted estimates for some of the older and larger interceptors in the system. The revised estimates used weighted (by value) averages.

[39] An estimated annual cost per 100,000 gallons was used for several segments for which pipe characteristic data were available but construction costs were not. The results from a regression of the log of annual cost on the logs of length and capacity for the 155 segments with full data were used to fill in the missing values.

estimate shown for a segment is the annual cost of transporting the flow from an average housing unit (or SAC unit) through the segment. Given the nature of this cost estimate, it was not necessary to explicitly estimate capacity utilization of the segments in order to distribute costs between current and future users. Given the assumption of no use-related depreciation of sewers, the cost estimate is both the annual cost of transporting 100,000 gallons through the segment and the annual cost of holding one SAC unit of capacity for a future user.

(4) The total connection cost associated with each of the MWCC-3 segments was computed from the estimate of the annual cost per SAC unit, the date of construction and a long run rate of return of 4% as described in section V.C.

(5) The cost per 100,000 gallons per year for an individual municipality was computed by summing the cost estimates from (3) for the pipe segments used by the municipality. GIS software (MAPINFO) using location data provided by MWCC on the interceptor system was used for this step. There are multiple possible routes through the interceptor system to the relevant treatment plant for many municipalities in the system. For those places, the cost for each route was computed and the mean was used as the estimate for the municipality. Since an average user in a given municipality would use only one-half of the length of an interceptor passing through the municipality, only one-half of mileage within a municipality was included in its cost estimate. Exceptions to this assumption were made for municipalities at the end of an interceptor. In those places 100 percent of within-border length was assigned to the municipality itself. This ensured that costs for all interceptor segments within a plant-shed were assigned to at least one municipality. The effects

of this assumption are most notable in the Empire and Seneca plant-sheds. The relatively small scope of these plant-sheds means that the majority of the municipalities both contain (or border on the place that contains) the treatment plant and represent endpoints for interceptor segments. Nearly all of the municipalities in these plant-sheds were, therefore, assigned the costs of the total interceptor mileage within their borders.

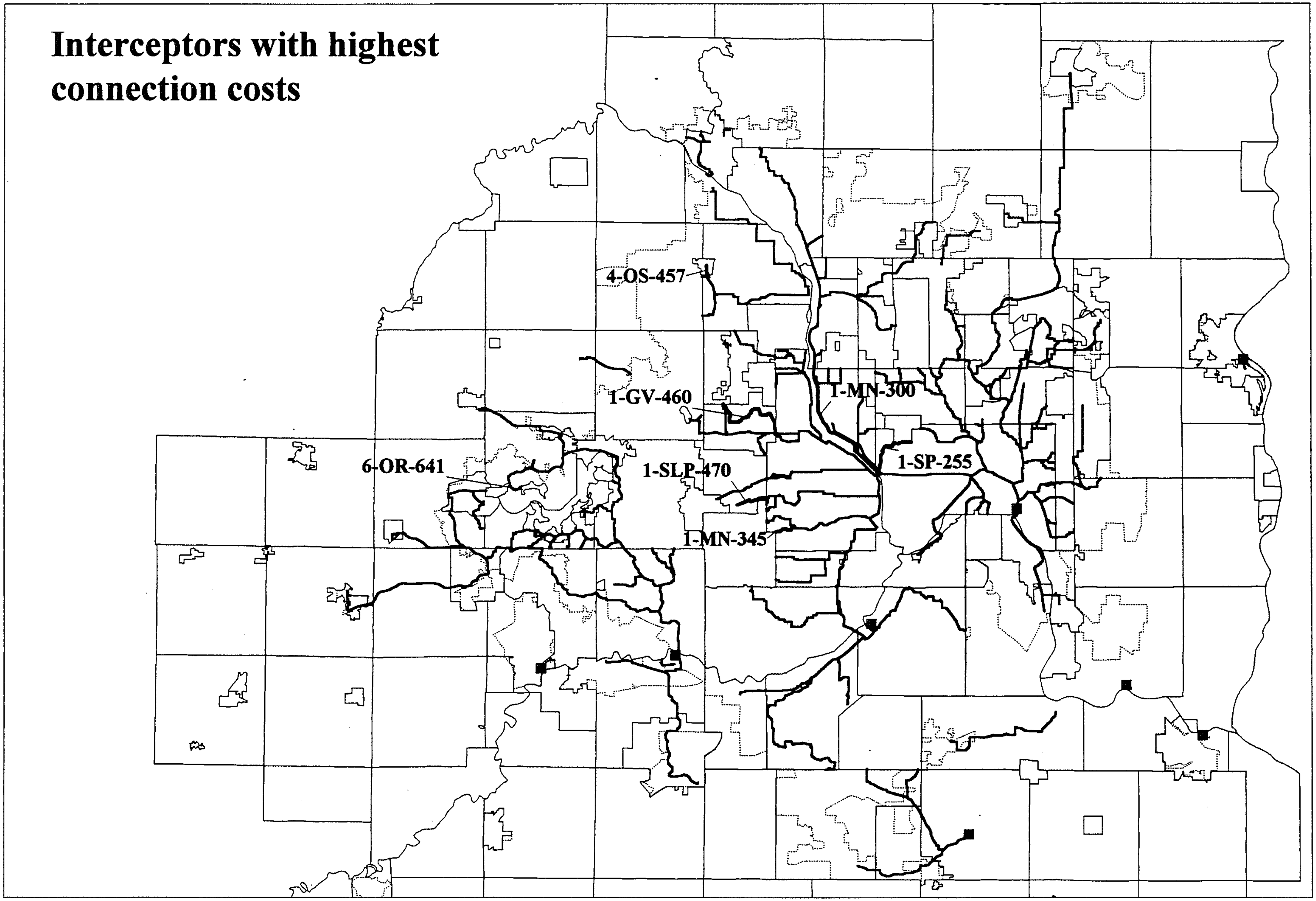
(6) The interceptor connection fee for an individual municipality was computed in identical fashion by summing the appropriate estimates from (4).

This procedure generated a small group of segments with very high relative connection cost estimates. A group of seven segments showed costs in excess of $450, with a maximum of $1,250. Excluding the outliers, the mean connection cost estimate for the 230 segments was $57. The problem segments are highlighted in Figure 1. Four of the seven are very old interceptors in the inner part of the system which serve a large number of northern and western suburbs. The extreme age of these segments were responsible for the high costs. In these cases, the fact that the segments have exceeded (or nearly exceeded) the estimated lifetime of interceptors (80 years) clearly justifies treating the connection cost estimate with caution. An alternative estimate that deleted the costs for the outlier segments was computed for the affected municipalities.

The other three extreme values were for interceptors serving (1) Orono and Minnetonka Beach (at $1,250, the highest estimate), (2) Golden Valley, New Hope and Crystal, and (3) Osseo. These outliers appear to be the result of very high construction costs.[40] In two of the cases, the presence of a lift

[40] It is important to note that in none of the seven cases were the extreme connection cost estimates due solely to length.

Interceptors with highest connection costs



station may be affecting the data in unusual ways. It is more difficult to justify "correcting" the cost estimates for the affected communities in these cases. If the construction cost estimates for these segments are indeed accurate and due to factors such as terrain or soil conditions, then the fundamental logic of our cost estimates would warrant counting the full costs. However, the values are extreme enough to provoke doubt about the accuracy of the data. The affected municipalities are treated in the same way as those affected by the very old segments.[41]

There was a second group of seven interceptors which generated connection costs between $250 and $450. They are highlighted in Figure 2. All of these are old segments in the inner part of the system. With one exception, they do not affect a large number of municipalities. In addition, they affect municipalities where the averaging procedure used to account for multiple possible paths through the system dampens their effects on the cost estimates. These segments were therefore treated in the usual fashion and are not noted in the tables.

The exception in the second cluster of segments is the main interceptor that runs from the Mississippi River through central St. Paul to the Metro plant (interceptor 1-MS-100). It affects the connection cost estimate for all

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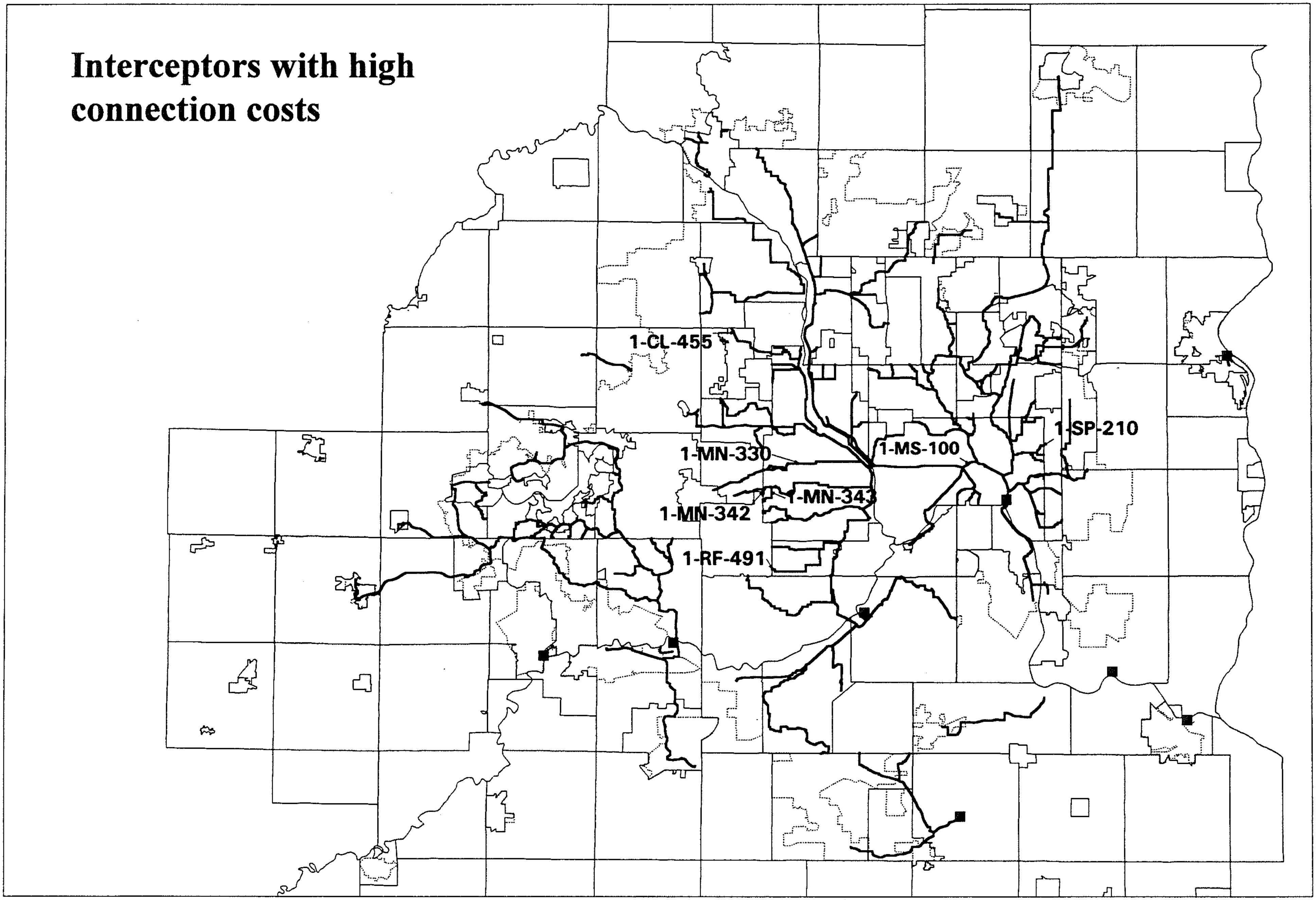
[41] This modified estimate, of course, over-corrects for the problem. The alternative cost estimates should, therefore, be viewed as a lower bound. Given the extreme levels of the connection cost estimates for the problem segments, we assume that an alternative procedure that controlled for the age and data problems more rigorously would generate municipality-level cost estimates closer to this lower bound than to the estimates that include the original, inflated, estimates for the problem segments. In general, we have less confidence in the reliability of the data underlying the interceptor cost calculations than for the plant data. It was not possible to completely verify the cost data from MWCC-3 with cross-checks to MWCC-2 or BV because the data were not reported in the same way across the three sources. These problems are concentrated in the data for the older assets in the system. They are, therefore, more of a problem for the connection cost calculations (which are affected most by the older segments) than for the current user cost calculations.

Interceptors with high connection costs



of the Metro plant-shed west of the Mississippi. However, it is the lowest cost interceptor in the group, at roughly $270, and is, therefore, not given special treatment. If its relatively old age is of concern, then the affected estimates could reasonably be adjusted by the estimated cost of $270.

Interceptor O&M costs (from MWCC-1) were allocated to municipalities according to the gallon/miles of the interceptor system used by each community. Gallon miles were computed by summing the lengths of the appropriate segments and multiplying by the municipality's total flow.

C. Findings: Interceptor Costs

Table 4 shows the results of the interceptor cost calculations for current and future users. Since the length of interceptor used by a community was such an important factor in the calculations, these estimates are also shown. In all cases, costs are measured per 100,000 gallons per year.

The average total current user cost estimates imply that interceptorcosts are less than 10 percent of total treatment costs -- $9.33 per 100,000 gallons per year compared to $114.[42] However, the cost estimates show a wide degree of variation, creating the potential for significant subsidies in a uniform fee structure. The plant-shed averages vary from $0.00 for the plant-sheds with no interceptors to $13.54 for Blue Lake. The Metro plant-shed shows average costs surprisingly close to the over-all average -- $9.44 versus $9.33. Given that it is the plant-shed at the extreme end of the plant-size versus interceptor-length trade-off, it might be expected to show higher relative interceptor costs. However, a very high proportion of the

[42] This compares with 1991 actual charges of roughly $7.50 per 100,000 gallons of use -- the $4.99 shown in Table 4 under O&M plus roughly $2.50 per 100,000 gallons attributed to interceptor costs in MWCC-2.

Table 4

Interceptor Costs: Current User and Connection Costs
Per 100Kgal per year

	Interceptor Miles used	Current User Costs O&M	Current User Costs Capital	Current User Costs Total	Connection Cost* 1	Connection Cost* 2
Total	17.5	$4.99	$4.18	$9.17	$494	$279
Metro	19.6	5.12	4.32	9.44	637	353
Andover	31.1	10.09	7.22	17.31	1,142	291
Anoka	37.7	12.23	13.05	25.28	1,298	447
Arden Hills	13.7	4.46	3.46	7.92	286	
Birchwood Village	14.0	4.55	2.55	7.10	118	
Blaine	26.6	8.63	8.06	16.69	1,244	393
Brooklyn Center	23.3	7.58	6.69	14.27	659	
Brooklyn Park	36.7	11.91	8.17	20.08	1,152	301
Centerville	26.3	8.55	12.24	20.79	380	
Champlin	32.1	10.43	6.84	17.27	1,055	204
Circle Pines	31.0	10.06	5.63	15.69	1,088	237
Columbia Heights	20.7	6.71	5.68	12.39	1,507	657
Coon Rapids	32.4	10.51	7.32	17.83	1,153	303
Crystal	23.1	7.51	8.27	15.78	975	515
Edina	17.3	5.61	3.97	9.58	578	496
Falcon Heights	10.5	3.39	2.37	5.76	594	297
Forest Lake C	32.1	10.43	13.84	24.27	445	
Forest Lake T	31.8	10.32	13.36	23.68	430	
Fridley	25.9	8.42	5.11	13.53	1,095	244
Gem Lake	11.9	3.88	2.36	6.24	81	
Golden Valley	18.9	6.12	5.36	11.48	658	543
Hilltop	17.8	5.77	5.27	11.04	1,395	545
Hopkins	19.2	6.22	2.05	8.27	552	
Hugo	24.6	7.98	11.44	19.42	369	
Inver Grove Hgts	6.7	2.18	2.62	4.80	79	
Lake Elmo	6.2	0.00	0.98	0.98	63	
Landfall	5.3	1.71	1.01	2.72	65	
Lauderdale	12.9	4.18	1.99	6.17	565	
Lexington	29.1	9.45	4.73	14.18	1,075	224
Lilydale	9.7	3.14	5.15	8.29	457	
Lino Lakes	24.4	7.92	9.95	17.87	700	343
Little Canada	14.7	4.76	6.27	11.03	173	
Mahtomedi	16.6	5.40	2.74	8.14	111	
Maple Grove	30.1	9.76	6.25	16.01	1,109	259
Maplewood	10.2	3.31	4.95	8.26	336	
Medicine Lake	22.0	7.15	10.87	18.02	774	
Medina	25.3	8.23	14.04	22.27	799	
Mendota	10.3	3.34	7.64	10.98	476	
Mendota Heights	10.2	3.33	3.14	6.47	489	
Minneapolis	14.9	4.83	2.59	7.42	587	475
Mounds View	27.5	8.92	5.88	14.80	1,126	275
New Brighton	28.4	9.21	8.06	17.27	1,195	345
New Hope	28.1	9.12	13.08	22.20	1,158	698
Newport	6.6	2.14	3.25	5.39	96	
North Oaks	15.7	5.10	6.59	11.69	205	
North St. Paul	7.8	2.52	2.60	5.12	269	
Oakdale	9.8	3.18	3.95	7.13	188	
Osseo	28.4	9.21	7.80	17.01	1,270	73
Plymouth	24.4	7.90	13.09	20.99	792	
Ramsey	36.6	11.89	12.23	24.12	1,271	421
Richfield	26.8	8.69	10.87	19.56	1,181	484
Robbinsdale	21.2	6.89	2.24	9.13	241	

Table 4 (cont.)

	Interceptor Miles used	Current User Costs O&M	Capital	Total	Connection Cost 1	2
Roseville	18.5	6.00	5.60	11.60	422	
Shoreview	22.7	7.36	6.80	14.16	800	374
South St. Paul	5.1	1.67	2.19	3.86	66	
Spring Lake Park	23.6	7.67	7.95	15.62	1,239	388
St. Anthony	13.6	4.43	1.96	6.39	269	
St. Louis Park	21.1	6.84	4.55	11.39	802	247
St. Paul	3.3	1.07	1.55	2.62	225	175
St. Paul Park	7.2	2.33	3.85	6.18	113	
Vadnais Heights	18.9	6.12	11.26	17.38	397	
West St. Paul	9.1	2.95	1.36	4.31	202	
White Bear Lake	22.2	7.22	6.08	13.30	307	
White Bear T	20.6	6.67	10.38	17.05	335	
Willernie	15.2	4.92	3.43	8.35	150	
Woodbury	7.2	2.35	2.37	4.72	118	
Seneca	13.4	4.60	3.22	7.82	91	
Bloomington	12.8	4.15	3.98	8.13	164	
Burnsville	22.0	7.16	3.48	10.64	112	
Eagan	10.1	3.29	1.85	5.14	67	
Savage	8.8	2.87	1.48	4.35	20	
Blue Lake	20.4	6.26	7.39	13.65	323	219
Chanhassen	14.8	4.80	4.17	8.97	59	
Deephaven	13.2	4.29	5.62	9.91	199	
Eden Prairie	13.3	1.09	1.14	2.23	16	
Excelsior	14.3	4.65	6.61	11.26	236	
Greenfield	24.3	7.90	13.03	20.93	319	
Greenwood	12.4	4.02	5.49	9.51	197	
Independence	24.3	7.90	13.03	20.93	319	
Laketown T	24.7	8.02	7.88	15.90	150	
Long Lake	20.6	6.67	10.95	17.62	303	
Maple Plain	24.3	7.90	13.03	20.93	319	
Minnetonka Beach	24.7	8.03	10.07	18.10	1,508	263
Minnetonka	16.9	5.64	6.83	12.47	234	
Minnetrista	25.2	8.18	9.42	17.60	201	
Mound	27.0	8.75	7.77	16.52	218	
Orono	25.5	8.26	12.81	21.07	1,557	311
Prior Lake	11.0	3.55	0.35	3.90	10	
Shakopee	9.1	2.94	3.02	5.96	101	
Shorewood	15.9	5.31	11.76	17.07	127	
Spring Park	23.6	7.67	5.40	13.07	99	
St. Bonifacius	22.8	7.42	5.08	12.50	81	
Tonka Bay	15.8	5.13	5.64	10.77	217	
Victoria	21.2	6.88	6.83	13.71	131	
Waconia	28.2	9.15	8.70	17.85	167	
Wayzata	17.0	5.51	7.12	12.63	246	
Empire	9.5	3.91	3.81	7.72	78	
Apple Valley	10.6	3.43	3.87	7.30	114	
Empire T	5.1	1.67	1.81	3.48	36	
Farmington	6.2	2.01	1.07	3.08	25	
Lakeville	16.3	5.28	4.84	10.12	137	

Table 4 (cont.)

	Interceptor Miles used	Current User Costs O&M	Capital	Total	Connection Cost 1	2
Stillwater	.1	0.07	0.11	0.18	1	
Bayport	0	0.00	0.00	0.00	0	
Oak Park Heights	0	0.00	0.00	0.00	0	
Stillwater C	.3	0.10	0.16	0.26	5	
Stillwater T	0	0.00	0.00	0.00	0	
Rosemount	7.8	2.54	1.25	3.79	54	
Chaska	0	0.00	0.00	0.00	0	
Cottage Grove	0	0.00	0.00	0.00	0	
Hastings	0	0.00	0.00	0.00	0	

* The two connection cost estimates represent an unadjusted estimate (1) and an estimate which deletes the effects of seven interceptor segments with extraordinarily large connection costs (2) for the relevant municipalities. See section VI.B.

users of the Metro plant are clustered relatively close to the plant and the weighted average for the plant-shed (with flows determining the weights) reflects this. The age of the capital plant does not have a great deal of influence on the inter-plant-shed comparisons. Metro's relatively older interceptor system does not generate annual user costs significantly higher than the newer systems in the Seneca, Blue Lake and Empire plant-sheds.

There is also a great deal of variation within plant-sheds. For the most part, the variations reflect differences in the distances from municipalities to the relevant plants, rather than differences in capital costs per mile. For instance, Anoka shows both the most miles of interceptor usage (37.7 miles) in the entire system and the highest current user cost ($25.28 per 100,000 gallons per year). In some cases, however, variations in capital cost per mile are an important factor. This is especially true in the Blue Lake plant-shed. For instance, Waconia and Mound show the greatest usage in miles of interceptor in the plant-shed (28.2 and 27.0 miles respectively) but their total costs per 100,000 gallons per year are only slightly above the average for the plant-shed.

As described in VI.B, two interceptor connection cost estimates were computed. Both are shown in Table 4. The first column of estimates shows the degree of distortion caused by the seven outlier segments. The range of connection costs within the Metro and Blue Lake plant-sheds (the two affected areas) exceed $1,400. The second column of estimates shows that much of this variation disappears when the seven outliers are excluded from the analysis. The ranges of values in the two plant-sheds decline to roughly $700 (Metro) and $500 (Blue Lake).[43]

The general pattern of the connection cost estimates reflect both the age and mileage of interceptors used. The relatively older and longer system in the Metro watershed shows higher than average costs, even with the revised measure. On the other hand, the relatively short and new systems in the Seneca and Empire plant-sheds show relatively low connection costs. The Blue Lake plant-shed contains roughly the same mileage per municipality as the Metro system, but it is significantly newer. As a result, it shows costs between the Metro estimate and those for the two, more compact, plant-sheds.

As with the plant connection cost estimates, the interceptor estimates show how important the time profile of investments in the recent past are in determining the incentives embedded in a cost-based fee structure. Being newer, the interceptor system in the Blue Lake, Seneca and Empire plant-sheds would generate incentives (in the form of lower connection fees) in such a system for locating in those areas rather than in the Metro plant-shed.

In general, the interceptor connection cost estimates should be treated with some caution. They exhibited more sensitivity to assumptions and presented more data problems than the calculations for the other cost categories. Our confidence in the interceptor connection cost estimates are, therefore, lower than for plant costs (current and future user costs) or for

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[43] Some anomalies remain with the alternative estimate. For instance, Brooklyn Center, which does not use any of the outlier segments, shows a connection cost of $659 while its neighbor, Brooklyn Park (which does use one of the outlier segments), shows a revised estimate of just $301. Since the waste water from the two municipalities follow different routes to get to the Metro plant, the difference may be justifiable from the data. However, over a large part of their routes to the plant (the part running through north Minneapolis), the two places use parallel pipes. A more sophisticated approach to routing questions, especially for routes through Minneapolis where many parallel lines exist, might control for this kind of problem by grouping parallel interceptor segments in the cost calculations.

current user costs in the interceptor system.

VII. Combined Treatment and Interceptor Costs

This section combines the findings from sections V and VI and reports the findings for both plant-sheds and Metropolitan Council policy areas.

A. Treatment and Interceptor User Costs

Table 5 reports the combined user cost estimates for treatment plants and interceptors along with the subsidies that would be generated by a uniform fee structure that covered total costs. The data are organized by plant-sheds. The first four columns repeat data from earlier tables and the last two columns show the combined treatment and interceptor costs and subsidies.

At the plant level, the findings parallel the treatment cost findings reported in section V. This is not surprising, given that treatment costs exceed interceptor costs by more than an order of magnitude. Across the system as a whole, unit costs exceed the current fee by about 16 percent ($123 per 100,000 gallons per year in costs versus $106 in fees).

Under a uniform fee schedule, Metro plant users would subsidize users of the rest of the system by about $10 per 100,000 gallons per year. However, including interceptor costs means that the subsidies vary within the plant-shed. Positive subsidies for interceptors actually outweigh the negative plant-cost subsidy in some parts of the Metro plant-shed. (Recall that a negative subsidy implies that users in the municipality are paying more in fees than their use imposes in costs and are therefore subsidizing other users.) However, in the larger municipalities in the plant-shed, such as Minneapolis, St. Paul and most of the inner ring suburbs, the net dollar flow out of the municipality increases when interceptor costs are added to the calculation. Net subsidies increase in some places by up to 70% (in St.

Table 5

User Costs and Subsidies per 100Kgal by Municipality
Under a Uniform Fee Structure Covering Full System Costs

	Treatment Plants		Interceptors		Total	
	Cost	Subsidy	Cost	Subsidy	Cost	Subsidy
Total	114		9		123	
Metro	103	-10	9	0	112	-10
Andover	103	-10	17	8	121	-2
Anoka	103	-10	25	16	129	6
Arden Hills	103	-10	8	-1	111	-12
Birchwood Village	103	-10	7	-2	110	-13
Blaine	103	-10	17	7	120	-3
Brooklyn Center	103	-10	14	5	118	-5
Brooklyn Park	103	-10	20	11	123	0
Centerville	103	-10	21	11	124	1
Champlin	103	-10	17	8	121	-2
Circle Pines	103	-10	16	6	119	-4
Columbia Heights	103	-10	12	3	116	-7
Coon Rapids	103	-10	18	8	121	-2
Crystal	103	-10	16	6	119	-4
Edina	103	-10	10	0	113	-10
Falcon Heights	103	-10	6	-4	109	-14
Forest Lake C	103	-10	24	15	128	5
Forest Lake T	103	-10	24	14	127	4
Fridley	103	-10	14	4	117	-6
Gem Lake	103	-10	6	-3	110	-13
Golden Valley	103	-10	11	2	115	-8
Hilltop	103	-10	11	2	114	-9
Hopkins	103	-10	8	-1	112	-11
Hugo	103	-10	19	10	123	-0
Inver Grove Hgts	103	-10	5	-5	108	-15
Lake Elmo	103	-10	1	-8	104	-19
Landfall	103	-10	3	-7	106	-17
Lauderdale	103	-10	6	-3	110	-14
Lexington	103	-10	14	5	118	-6
Lilydale	103	-10	8	-1	112	-11
Lino Lakes	103	-10	18	9	121	-2
Little Canada	103	-10	11	2	114	-9
Mahtomedi	103	-10	8	-1	111	-12
Maple Grove	103	-10	16	7	119	-4
Maplewood	103	-10	8	-1	112	-11
Medicine Lake	103	-10	18	9	121	-2
Medina	103	-10	22	13	126	3
Mendota	103	-10	11	2	114	-9
Mendota Heights	103	-10	6	-3	110	-13
Minneapolis	103	-10	7	-2	111	-12
Mounds View	103	-10	15	5	118	-5
New Brighton	103	-10	17	8	121	-2
New Hope	103	-10	22	13	126	3
Newport	103	-10	5	-4	109	-14
North Oaks	103	-10	12	2	115	-8
North St. Paul	103	-10	5	-4	108	-15
Oakdale	103	-10	7	-2	110	-13
Osseo	103	-10	17	8	120	-3
Plymouth	103	-10	21	12	124	1
Ramsey	103	-10	24	15	127	4
Richfield	103	-10	20	10	123	-0

Table 5 (cont.)

	Treatment Plants		Interceptors		Total	
	Cost	Subsidy	Cost	Subsidy	Cost	Subsidy
Robbinsdale	103	-10	9	-0	112	-11
Roseville	103	-10	12	2	115	-8
Shoreview	103	-10	14	5	118	-6
South St. Paul	103	-10	4	-5	107	-16
Spring Lake Park	103	-10	16	6	119	-4
St. Anthony	103	-10	6	-3	110	-13
St. Louis Park	103	-10	11	2	115	-8
St. Paul	103	-10	3	-7	106	-17
St. Paul Park	103	-10	6	-3	110	-14
Vadnais Heights	103	-10	17	8	121	-2
West St. Paul	103	-10	4	-5	108	-15
White Bear Lake	103	-10	13	4	117	-6
White Bear T	103	-10	17	8	120	-3
Willernie	103	-10	8	-1	112	-11
Woodbury	103	-10	5	-5	108	-15
Seneca	133	20	8	-1	141	18
Bloomington	133	20	8	-1	141	18
Burnsville	133	20	11	1	144	21
Eagan	133	20	5	-4	138	15
Savage	133	20	4	-5	138	15
Blue Lake	147	34	14	5	161	39
Chanhassen	147	34	9	-0	156	33
Deephaven	147	34	10	1	157	34
Eden Prairie	147	34	2	-7	150	27
Excelsior	147	34	11	2	159	36
Greenfield	147	34	21	12	168	45
Greenwood	147	34	10	0	157	34
Independence	147	34	21	12	168	45
Laketown T	147	34	16	7	163	40
Long Lake	147	34	18	8	165	42
Maple Plain	147	34	21	12	168	45
Minnetonka Beach	147	34	18	9	165	42
Minnetonka	147	34	12	3	160	37
Minnetrista	147	34	18	8	165	42
Mound	147	34	17	7	164	41
Orono	147	34	21	12	168	45
Prior Lake	147	34	4	-5	151	28
Shakopee	147	34	6	-3	153	30
Shorewood	147	34	17	8	165	42
Spring Park	147	34	13	4	160	37
St. Bonifacius	147	34	12	3	160	37
Tonka Bay	147	34	11	1	158	35
Victoria	147	34	14	4	161	38
Waconia	147	34	18	9	165	42
Wayzata	147	34	13	3	160	37
Empire	187	73	8	-1	195	72
Apple Valley	187	73	7	-2	194	71
Empire T	187	73	3	-6	190	67
Farmington	187	73	3	-6	190	67
Lakeville	187	73	10	1	197	74

Table 5 (cont.)

	Treatment Plants		Interceptors		Total	
	Cost	Subsidy	Cost	Subsidy	Cost	Subsidy
Stillwater	136	23	0	-9	136	13
Bayport	136	23	0	-9	136	13
Oak Park Heights	136	23	0	-9	136	13
Stillwater C	136	23	0	-9	137	14
Stillwater T	136	23	0	-9	136	13
Hastings	259	145	0	-9	259	136
Cottage Grove	185	71	0	-9	185	62
Chaska	194	81	0	-9	194	71
Rosemount	228	114	4	-6	232	109

Paul, for instance).

In the other plant-sheds, the effects of adding interceptors are relatively small. The net subsidy increases in Blue Lake by $5 per 100,000 gallons per year (or by about 15%), decreases by $1 in Seneca and Empire, and decreases by more in the smaller plant-sheds that either use little or no interceptor services.

B. <u>Plant and Interceptor Connection Costs</u>

Table 6 shows the municipality-by-municipality breakdown of plant and interceptor connection costs. The estimates of interceptor costs that excludes the effects of the seven outlier segments are used in the table. The system-wide average estimate is $977, which is roughly 40% greater than the current SAC ($700). As noted in section VI, the interceptor estimates are relatively volatile and municipality-by-municipality variations should, therefore, be viewed with some caution.

At the plant-shed level, the Metro district shows above-average connection costs, reflecting the relatively old age of its capital stock. However, the Metro figure is only about 6% higher than the system-wide average. The most significant departures from the norm are in the Seneca, Empire and Rosemount plant-sheds, on the low end, and in four of the smallest plant-sheds, on the high end. The relatively high plant connection cost estimates in these smaller plants overwhelm the very low interceptor connection costs associated with those plants.

In general, the overall pattern of the combined connection cost estimates is much like that for the plant costs. The newer systems generate the lowest connection costs, Metro is near the average, and the smaller plant-

Table 6

Plant and Interceptor Connection Costs by Municipality

	Plant Cost	Interceptor Cost	Total Cost	Subsidy*
System Average	708	269	977	---
Metro Average	685	353	1,038	61
Andover	685	291	976	-1
Anoka	685	447	1,132	155
Arden Hills	685	286	971	-6
Birchwood Village	685	118	803	-174
Blaine	685	393	1,078	101
Brooklyn Center	685	659	1,344	367
Brooklyn Park	685	301	986	9
Centerville	685	380	1,065	87
Champlin	685	204	889	-88
Circle Pines	685	237	922	-55
Columbia Heights	685	657	1,342	364
Coon Rapids	685	303	988	10
Crystal	685	515	1,200	222
Edina	685	496	1,181	203
Falcon Heights	685	297	982	5
Forest Lake C	685	445	1,130	153
Forest Lake T	685	430	1,115	138
Fridley	685	244	929	-48
Gem Lake	685	81	766	-212
Golden Valley	685	543	1,228	250
Hilltop	685	545	1,230	252
Hopkins	685	552	1,237	260
Hugo	685	369	1,054	77
Inver Grove Hgts	685	79	764	-213
Lake Elmo	685	63	748	-229
Landfall	685	65	750	-228
Lauderdale	685	565	1,250	272
Lexington	685	224	909	-69
Lilydale	685	457	1,142	164
Lino Lakes	685	343	1,028	50
Little Canada	685	173	858	-119
Mahtomedi	685	111	796	-182
Maple Grove	685	259	944	-34
Maplewood	685	336	1,021	43
Medicine Lake	685	774	1,459	482
Medina	685	799	1,484	507
Mendota	685	476	1,161	184
Mendota Heights	685	489	1,174	196
Minneapolis	685	475	1,160	182
Mounds View	685	275	960	-18
New Brighton	685	345	1,030	52
New Hope	685	698	1,383	405
Newport	685	96	781	-196
North Oaks	685	205	890	-87
North St. Paul	685	269	954	-24
Oakdale	685	188	873	-105
Osseo	685	73	758	-219
Plymouth	685	792	1,477	499
Ramsey	685	421	1,106	128
Richfield	685	484	1,169	191
Robbinsdale	685	241	926	-51
Roseville	685	422	1,107	130
Shoreview	685	374	1,059	82

Table 6 (cont.)

	Plant Cost	Interceptor Cost	Total Cost	Subsidy*
South St. Paul	685	66	751	-226
Spring Lake Park	685	388	1,073	96
St. Anthony	685	269	954	-23
St. Louis Park	685	247	932	-45
St. Paul	685	175	860	-117
St. Paul Park	685	113	798	-180
Vadnais Heights	685	397	1,082	105
West St. Paul	685	202	887	-90
White Bear Lake	685	307	992	15
White Bear T	685	335	1,020	42
Willernie	685	150	835	-143
Woodbury	685	118	803	-174
Seneca Average	343	91	434	-543
Bloomington	343	164	507	-471
Burnsville	343	112	455	-522
Eagan	343	67	410	-567
Savage	343	20	363	-614
Blue Lake Average	625	219	844	-133
Chanhassen	625	59	684	-293
Deephaven	625	199	824	-154
Eden Prairie	625	37	662	-315
Excelsior	625	236	861	-117
Greenfield	625	319	944	-34
Greenwood	625	197	822	-155
Independence	625	319	944	-33
Laketown T	625	150	775	-203
Long Lake	625	303	928	-50
Maple Plain	625	319	944	-34
Minnetonka Beach	625	263	888	-90
Minnetonka	625	234	859	-118
Minnetrista	625	201	826	-152
Mound	625	218	843	-135
Orono	625	311	936	-42
Prior Lake	625	10	635	-342
Shakopee	625	101	726	-251
Shorewood	625	127	752	-225
Spring Park	625	99	724	-253
St. Bonifacius	625	81	706	-272
Tonka Bay	625	217	842	-136
Victoria	625	131	756	-222
Waconia	625	167	792	-186
Wayzata	625	246	871	-107
Empire Average	329	63	392	-585
Apple Valley	329	78	407	-571
Empire T	329	114	443	-535
Farmington	329	36	365	-613
Lakeville	329	25	354	-623

Table 6 (cont.)

	Plant Cost	Interceptor Cost	Total Cost	Subsidy*
Stillwater Average	1,075	1	1,076	99
Bayport	1,075	0	1,075	98
Oak Park Heights	1,075	0	1,075	98
Stillwater C	1,075	5	1,080	103
Stillwater T	1,075	0	1,075	98
Hastings	2,478	0	2,478	1,501
Cottage Grove	1,662	0	1,662	685
Chaska	1,523	0	1,523	546
Rosemount	513	54	567	-410

* Subsidy assumes a system-wide uniform SAC equal to the system average SAC cost.

sheds with aging capital generate relatively high costs.

C. User and Connection Costs by Policy Areas

Table 7 tabulates the user and connection cost data by Metropolitan Council Policy Areas. The top panel shows the user cost summary. The treatment cost estimates again dominate the picture and the total subsidy figures show a relatively small subsidy from users in the Developed Area ($10 per 100,000 gallons per year) to other users. This translates into a $13 per 100,000 gallons per year subsidy, on average, in the Developing Area and into a $47 subsidy in the Free-standing Growth Areas.

Subsidies of the magnitudes found for the Developed and Developing Areas are comparatively small relative to the value of a typical house in the metropolitan area -- the present values of these subsidies are -$250 and +$350, respectively. It is, therefore, unlikely, that a uniform fee system (or the switch to a cost-based system) would imply major effects on settlement patterns at this very general level of aggregation. The average subsidy for users in the Free-standing Growth Areas is potentially more important. There, the $46 per year subsidy translates into a present value of $1,150 -- a level approaching a significant percentage of the value of a home.[44]

The bottom panel of Table 7 shows the tabulations for connection costs.

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[44] Transforming the per household data into present values gives a better feel for the likelihood that differences of this magnitude (or their removal) could translate into significant location incentives. The calculation shows the value now of a future stream of payments equal to the subsidy, assuming a long run real rate of return of 4%. A logical comparison point for this value is the purchase price of a home, which represents the present value of a future stream of housing services to the purchaser. Similarly, the estimated subsidy can be viewed as the potential change in a house's value that could result if sewage charges were adjusted to eliminate the subsidy (plus or minus) in each service area. (A positive present value would imply a potential decline in housing value of equal magnitude.)

Table 7

User Costs, Connection Costs and Subsidies per 100Kgal per year by Policy Areas Under a Uniform Fee Structure Covering Full System Costs

User Costs

	Treatment Plants		Interceptors		Total	
	Cost	Subsidy	Cost	Subsidy	Cost	Subsidy
Total	114		9		123	
Developed	105	-9	8	-1	113	-10
Developing	124	10	12	3	136	13
Free-standing	165	52	4	-5	169	47

Connection Costs

	Treatment Plants	Interceptors	Total	Subsidy
Total	708	269	977	0
Developed	670	439	1,109	132
Developing	644	246	889	-88
Free-standing	1,144	99	1,243	266

Reported data were rounded after totals and subsidies were computed. Columns or rows may not sum to totals.

Again, the subsidies implied by a uniform connection fee set at the region-wide average ($977) are relatively small. In this case, the estimates are directly comparable to housing values, since they represent a one-time windfall. The magnitudes of the connection cost subsidies are actually lower than those for user costs.

However, aggregating the estimates to such a high level masks a great deal of variation at the municipality level. In addition, it is at the local level that the potential impacts on municipal budgets are relevant. Table 8 shows various alternative measures of the user cost subsidies at the municipality-level. It translates the unit cost data into per-household values, present values of the per-household subsidies, and total dollar values to provide a measure of the potential impact on municipal budgets.[45] (Recall that the estimates measure the subsidies generated by a uniform fee covering full costs -- not the subsidies embodied in the current uniform fee which is set at a level lower than full costs in each of the plant-sheds.)

The developed area, which is served largely by the relatively low-cost Metro plant shows the lowest unit costs and, as noted above, these municipalities, as a group, subsidize the other two policy areas. Within the

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[45] Computing meaningful variations on the connection cost subsidies (beyond the absolute differences reported in Table 6) is more difficult. One might compute the net subsidy to a new household in a municipality by adding the present value of the user cost subsidy to the connection subsidy. For instance, in Minneapolis this would be -$454+$182, or in St. Paul it would be -$632-$117. However, the net effect in total dollars at the municipality level would depend on the number of new hook-ups in a given year. Also, the total dollar amount of net subsidies generated by a uniform connection fee would almost certainly be much smaller than for user fees, since the former applies only to new users and the latter applies to all users. For example, for the connection subsidy for new users in Minneapolis ($182 per hook-up) to offset the subsidy provided by current users per year ($2.9 million in 1991) would require roughly 15,000 new hook-ups per year. Given these factors and the sensitivity of the municipality-level connection cost estimates to changing assumptions and the inconsistencies in portions of the data, this exercise was not performed.

Developing Area, the largest subsidies, as measured by the present value of the subsidy per household, tend to be coming from the two central cities and the inner-most suburbs. Falcon Heights and South St. Paul pay subsidies to the rest of the system with present values of about $800, for instance. In the Developing and Free-standing Growth Areas, the largest subsidies tend to be going to municipalities in the south-central and western parts of the region, as well as to the municipalities served by the four smallest plants. Places receiving subsidies with present values in excess of $1,500 include Apple Valley, Farmington, Lakeville, Long Lake, Maple Plain, Rosemount, Shakopee, Shorewood, Spring Lake, and Wayzata. Several other municipalities near Lake Minnetonka also show subsidies approaching this level.

The total dollar value of the subsidy coming out of the Developed Area amounts to roughly $6.32 million per year, with Minneapolis and St. Paul each absorbing about 40% of the cost -- $2.87 million and $2.77 million per year respectively. These amounts do not, of course, represent a very large percentage of their respective budgets. However, at the margin, such totals could represent significant opportunity costs to the region's two central cities. For instance, recently reported estimates place the extra costs associated with fully funding Head Start in Minneapolis at about $4.0 million per year. Another way to assess the magnitude of the numbers is to calculate the 20 year bond issue that the annual streams of money could support. In both cases, it is roughly $35 million at an interest rate of 6%.

Table 8

Alternative Measures of Subsidies for Municipalities and Policy Areas

	Total Subsidy /100Kgal	Total Subsidy /H'hold	Present Value of /H'hold Subsidy	Total Subsidy
Developed	-$9.81	-$13.19	-$330	-$6,315,701
Bloomington	18.53	20.92	523	721,978
Brooklyn Center	-5.26	-5.54	-139	-62,208
Columbia Heights	-7.14	-5.37	-134	-41,255
Crystal	-3.75	-3.97	-99	-36,897
Edina	-9.95	-12.34	-308	-244,076
Falcon Heights	-13.77	-32.99	-825	-66,211
Fridley	-6.00	-9.24	-231	-100,770
Golden Valley	-8.05	-12.71	-318	-105,170
Hilltop	-8.49	-6.63	-166	-2,632
Hopkins	-11.26	-9.88	-247	-79,609
Lauderdale	-13.35	-7.23	-181	-8,413
Minneapolis	-12.11	-17.90	-448	-2,873,942
New Brighton	-2.26	-2.39	-60	-20,366
New Hope	2.67	3.18	80	26,918
Richfield	0.03	0.02	0	275
Robbinsdale	-10.40	-8.92	-223	-53,745
Roseville	-7.93	-10.56	-264	-143,522
South St. Paul	-15.67	-31.92	-798	-250,912
Spring Lake Park	-3.91	-4.01	-100	-9,421
St. Anthony	-13.14	-15.16	-379	-51,113
St. Louis Park	-8.14	-9.58	-239	-191,761
St. Paul	-16.91	-25.05	-626	-2,770,491
West St. Paul	-15.22	-19.04	-476	-162,429
Developing	13.43	14.50	363	4,772,066
Andover	-2.22	-1.01	-25	-4,476
Anoka	5.75	5.98	149	38,181
Apple Valley	71.02	64.46	1,612	719,404
Arden Hills	-11.61	-18.14	-454	-53,744
Birchwood Village	-12.43	-12.61	-315	-4,351
Blaine	-2.84	-2.54	-64	-32,614
Brooklyn Park	0.55	0.54	13	10,974
Burnsville	21.04	22.00	550	420,401
Centerville	1.26	1.63	41	843
Champlin	-2.26	-1.95	-49	-10,599
Chanhassen	33.45	51.30	1,282	208,377
Circle Pines	-3.84	-3.69	-92	-5,648
Coon Rapids	-1.70	-1.77	-44	-30,929
Cottage Grove	61.67	52.60	1,315	357,702
Deephaven	34.39	46.02	1,151	60,523
Eagan	15.55	17.68	442	307,712
Eden Prairie	26.70	29.00	725	421,913
Empire T	67.19	31.03	776	13,438
Excelsior	35.73	35.55	889	42,165
Farmington	66.79	100.56	2,514	209,065
Gem Lake	-13.29	-8.74	-219	-1,329
Greenfield	45.40	5.99	150	2,724
Greenwood	33.98	27.74	693	6,796
Hugo	-0.11	-0.04	-1	-55
Independence	45.40	3.44	86	3,178
Inver Grove Hgts	-14.73	-11.37	-284	-89,267
Lake Elmo	-18.55	0.00	0	0
Laketown T	40.38	17.03	426	9,691

Table 8 (cont.)

	Total Subsidy /100Kgal	Total Subsidy /H'hold	Present Value of /H'hold Subsidy	Total Subsidy
Developing Area (cont.)				
Lakeville	73.83	75.99	1,900	599,536
Landfall	-16.81	-13.47	-337	-3,866
Lexington	-5.34	-4.08	-102	-3,421
Lilydale	-11.24	-9.48	-237	-3,147
Lino Lakes	-1.66	-0.57	-14	-1,495
Little Canada	-8.50	-8.27	-207	-32,207
Long Lake	42.10	68.08	1,702	50,516
Mahtomedi	-11.38	-9.48	-237	-17,191
Maple Grove	-3.51	-3.58	-90	-44,840
Maple Plain	45.40	82.61	2,065	56,755
Maplewood	-11.27	-16.64	-416	-192,091
Medicine Lake	-1.51	-1.74	-44	-301
Medina	2.74	2.32	58	2,383
Mendota	-8.55	-27.35	-684	-684
Mendota Heights	-13.06	-19.75	-494	-65,440
Minnetonka	36.94	42.44	1,061	792,435
Minnetonka Beach	42.58	58.15	1,454	11,922
Minnetrista	42.07	28.16	704	35,338
Mound	40.99	46.54	1,164	172,577
Mounds View	-4.73	-4.85	-121	-22,749
Newport	-14.14	-11.42	-286	-15,273
North Oaks	-7.84	-1.25	-31	-1,332
North St. Paul	-14.41	-15.65	-391	-68,428
Oakdale	-12.40	-14.47	-362	-96,825
Orono	45.55	41.75	1,044	109,766
Osseo	-2.52	-2.32	-58	-2,292
Plymouth	1.47	2.18	54	39,651
Ramsey	4.59	0.38	9	1,378
Rosemount	108.92	90.14	2,254	249,421
Savage	14.75	19.71	493	64,614
Shakopee	30.43	64.06	1,602	267,207
Shoreview	-5.37	-5.55	-139	-50,205
Shorewood	41.74	83.49	2,087	167,808
Spring Park	37.54	62.65	1,566	46,548
St. Bonifacius	36.97	36.60	915	14,418
St. Paul Park	-13.35	-11.55	-289	-20,030
Tonka Bay	35.24	46.63	1,166	27,138
Vadnais Heights	-2.15	-2.36	-59	-9,142
Victoria	38.19	37.93	948	28,640
Waconia	42.33	39.79	995	55,871
Wayzata	37.10	66.21	1,655	113,157
White Bear Lake	-6.23	-6.43	-161	-58,403
White Bear T	-2.48	-2.69	-67	-8,764
Willernie	-11.18	-18.07	-452	-1,788
Woodbury	-14.81	-18.52	-463	-129,320
Free-standing	46.65	60.30	1507	1,543,635
Bayport	13.50	38.79	970	28,896
Chaska	71.38	101.96	2,549	425,397
Forest Lake C	4.74	6.59	165	14,540
Forest Lake T	4.15	3.58	89	7,629
Hastings	136.00	146.75	3,669	792,903
Oak Park Heights	13.50	14.98	375	19,984
Prior Lake	28.38	33.84	846	132,527
Stillwater C	13.77	22.05	551	111,361
Stillwater T	13.50	0.21	5	135

VIII. Implications of the Findings

A. Plant and Interceptor User Fees

The findings regarding plant and interceptor user costs have more significant implications, in general, than the cost findings for new users. The four central findings regarding current user costs are: (1) the current fee per 100,000 gallons of usage is lower than the average total cost of transporting and processing that amount of sewage; (2) costs vary significantly across the region; (3) in the current cost environment, the subsidies that would be generated by a uniform fee structure that would cover full costs involve transfers from users in the Developed Area (particularly from users relatively close to the Metro plant) to users in the Developing and Free-standing Growth Areas; and (4) there are signficant economies of scale in treatment plants which, with the current capital plant, out-weigh the diseconomies associated with the longer interceptor systems required to serve larger plants.

(1) Current fees are lower than actual costs. The central implication of this finding is that the current fee provides too little incentive to consumers to economize on their consumption of MWCC services.[46] Thus, from the viewpoint of overall regional (and national) efficiency, the service is over-consumed. This has implications in three dimensions. First, the quality of the region's waterways are lower than they would be if user fees reflected full costs. There is unrealized potential for consumers to economize on MWCC services. For instance, lower than optimal fees do not adequately encourage

[46] However, it is worth noting again that some, or possibly even all, of the shortfall is attributable to industrial users.

developers and homeowners to use water-saving plumbing fixtures.

Second, higher consumption levels imply greater future capital investment for transporting and treating waste. Higher fees (and lower consumption) would effectively increase the capacity of the existing infrastructure (measured in numbers of users served) and lessen the need for new investment.

Finally, subsidizing consumption in this dimension effectively subsidizes the consumption of housing services in general. As a result, in the long run, the region as a whole will be less densely settled than it would be if fees corresponded to total costs. Lower density settlement patterns increase the cost of providing a whole range of public services, including (but not limited to) waste water collection and treatment, transportation, and education.

(2) User costs vary significantly across the region. A uniform fee structure sends inaccurate signals to consumers regarding the costs of development in different parts of the region. The cost variations our work discovered are great enough to affect settlement patterns in the region -- effects that would generate greater than optimal long run service and environmental costs. The overall magnitude of these effects is uncertain, given the relatively small share of sewer costs in total housing costs. However, the subsidies implicit in a uniform fee schedule are substantial in some parts of the region.

(3) A uniform fee designed to cover full costs would generate subsidies flowing from the inner part of the region to outer portions. (Similarly, the current fee distributes the savings from past federal aid only to users outside the Metro plant-shed.) This finding has both efficiency and equity

implications. To the extent that the subsidies are great enough to affect settlement patterns, they enhance current trends toward increasing decentralization of economic activity in the region. In effect, the subsidies favor the fastest growing parts of the region over areas that are currently growing more slowly or, in some cases, actually declining.

The subsidies also enhance locations in plant-sheds that discharge into the Minnesota and Vermillion Rivers. Given that the carrying capacities of these rivers are lower than the Mississippi's, this implies that the uniform fee encourages settlement patterns with higher-than-necessary long-run costs for treatment and environmental protection. Plant-size limits are lower on these rivers, implying fewer gains from potential economies of scale. In the long run, required treatment levels are also higher for low capacity sinks.

The equity implications of the subsidy pattern are clear. The subsidies generated by a uniform fee that would cover full costs, in general, flow out of parts of the region with lower than average household incomes, greater than average public service needs, and lower than average capacities to finance those services. On the other side, the subsidies flow into parts of the region which generally show higher than average incomes, lower public service needs, and greater fiscal resources. This regressive pattern in the subsidies is most evident in the data for the two central cities. Minneapolis and St. Paul would generate roughly 80 percent (or about $5.7 million per year) of the total subsidy flowing out of the Developed Area to other parts of the region.

(4) Economies of scale in waste treatment. The findings imply that larger plants involve significantly lower unit costs for treatment. At the extreme, unit costs at the Metro plant are roughly 45 percent of those for the smallest plant in the system (Rosemount) and 40 percent of those for the most

costly plant (Hastings). The data also suggest that these economies in treatment are only partially offset by diseconomies in transporting waste. Unit costs for the Metro interceptor system are not substantially greater than those for the system's middle-sized plants. As a result, the total Metro system shows lower total unit costs than the other plant-sheds in the system.

B. Plant and Interceptor Connection Fees

The implications of our estimates of the costs of serving new users are less substantial than those for current-user costs. The general findings are that (1) the current Service Availability Charge or SAC is probably too low; and (2) the costs that the SAC offsets vary across the region.

(1) The implications of a lower than optimal connection fee are not overwhelming unless the costs of serving new users greatly exceed actual SAC fees. This does not appear to be the case at present. The average connection cost exceeds the actual fee by roughly $270. Given that the connection fee is a one-time cost, this difference is unlikely to have significant implications for the overall density of development in the region.

(2) The implications of connection cost variations are also unlikely to be substantial. The subsidies generated by a uniform fee are not likely to have large effects on settlement patterns for the same reason that a lower than optimal overall average will not. The differences are probably too small to translate into significant housing cost differentials.

Connection costs are lower, in general, at the newer plants which primarily serve outer portions of the region. Given that most new hook-ups are occurring in the outer parts of the region, the pattern of SAC subsidies offsets, to some extent, the pattern found in the user fee data. However, since user fees apply to all users over a long period of time while connection fees apply only to new users as a one-time expense, the offset is probably minimal.

The connection cost variations also highlight how important the time profile of investment decisions is in determining the present and future incentives embedded in a cost-based fee structure. When the MWCC builds capacity in growing parts of the region, it is implicitly doing more than simply reacting to recent growth. It is also generating a cost structure for the near future which, if reflected in user and connection fees, encourages further growth. In effect, MWCC decisions which appear purely reactive in nature may also have proactive impacts that amplify current growth patterns. The line between reactive policies and proactive policies is very fine in this dimension.[47]

C. Equity Implications of Changing to a Cost-based Fee Structure

Whenever major change is proposed in an existing public system, issues of equity inevitably arise. Some who would be made worse off by a change can reasonably claim that they had made major commitments on the assumption that the existing system would remain in effect and that the system should, therefore, not be changed or, if it is, that they should be compensated for the damage the new system will bring them. If compensation were to be required for all who are harmed by changes in public policy, changes would be very difficult to implement. The normal public view is that compensation

[47] This is true, of course, even if fees do not reflect costs. By building excess capacity into new parts of the system (rational behavior in the context of increasing returns to scale and extended construction times), the MWCC is lowering total development costs in those areas, regardless of whether future SAC fees reflect cost variations. Septic systems are more expensive, in general, than the services provided by the MWCC.

should be offered only for significant losses. Those who suffer a minor loss are forced to content themselves with the fact that their small losses from one policy change will, over the long run, be compensated for by gains -- small and large -- from other policy changes.

We believe that few if any individuals or business firms would be significantly disadvantaged by adopting the policy changes we have proposed. Neither present nor our proposed price policies for waste-water treatment would bulk large in the decisions of households and most business firms.[48] When the MWCC switched in 1987 from a system in which fees differed among plant sheds to a uniform pricing system which disadvantaged the metropolitan area's developed area, it felt the change to be sufficiently consequential that it should be phased in over a five-year period rather than instituted in a single step. Changing to a system that would reverse this disadvantage to the developed area could be effected by a similar gradual procedure.

Where along an appropriate sink to locate a waste-water treatment plant is, to a degree, an arbitrary decision. This decision affects the distances between individual communities and the treatment plants which serve them and, hence, what they would pay under a distance-based pricing system for sewer collection. Similarly, changing where a new interceptor will be located in a way that would leave total system costs unchanged could have significant effects on the costs of collecting sewage from individual communities. If we understand correctly, such considerations played a significant role in the 1987 decision to shift to uniform pricing. It is not our prerogative to decide whether the equity issues underlying this decision were correctly decided.[49]

We would, however, be derelict if we did not emphasize that decisions in which equity considerations dominate can have appreciable efficiency costs. The present locations of treatment plants and interceptors determine the costs of providing sewage transportation and treatment services. The prices of these services are not great enough to make them major elements in locational decisions. These prices can, however, have significant marginal effects on location. The costs of the resulting inefficiency should not be lightly set aside.

Viewed narrowly, returning to a former regime in which Lake Minnetonka served as a sink for the sewage of the communities that surround it would reduce the costs of transporting and treating their sewage. Similarly, using Lake Harriet as a sink for a new treatment plant that would serve South Minneapolis, Bloomington, Richfield, and Edina might lower the direct costs of disposing of these communities' sewage. The metropolitan area has decided that avoiding the resulting degradation in the quality of the lakes' waters justifies incurring greater transportation costs for these areas' sewage and reduced water quality in the Mississippi and Minnesota Rivers.

Who should pay these costs is an arguable issue. Should these communities pay the transportation costs that would be relevant if Lakes Harriet and Minnetonka were used as sinks? Efficiency considerations say,

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[49] It is worth noting, however, that these types of locational benefits are not limited to the inner parts of the region. For instance, Minneapolis and St. Paul do not benefit more than all other places from the use of MWCC interceptors as replacements for locally financed trunk sewers. A sample of 18 communities from the Seneca, Empire and Blue Lake plant-sheds yields 16 places with more interceptor footage per household than Minneapolis and St. Paul.

"No." So, too, would the view that Lakes Harriet and Minnetonka are the property not of the surrounding communities but, rather, of the entire metropolitan area.

D. Legal and Management Issues

A switch to a cost-based fee structure raises several legal and management issues. The primary legal consideration arises from the fact that full-cost pricing would generate a surplus for the MWCC. It is our understanding that the current limit for MWCC surpluses is 7 percent of its total annual budget. Full-cost pricing would exceed this limit in most years. The primary objective of cost-based pricing is to generate accurate incentives regarding the use of the services involved. This principle would not be seriously compromised if part of any surplus were "returned" to consumers in the form of general tax relief. However, a "refund" policy that was based on flow and costs within the system would compromise the principle. Therefore, if a return mechanism is necessary, it is important that funds be redistributed to municipalities in ways other than subsidizing sewer services -- tax base per capita is one possibility; lump-sum refunds to individual consumers is another.[50]

[50] Concerns have also been raised regarding whether it is allowable under federal regulations for the MWCC to include the cost of assets purchased with federal funds in its fee determination. This seems unlikely since some federal grant programs that helped finance construction of treatment plants in the 1960s and 1970s actually required that local authorities build reserve funds for future construction by including grant-financed costs in fees. The MWCC was required to get a waiver in order to exclude these costs. If later grant programs prohibit including federal costs in fees, this clearly poses problems for the type of fee system implied by our work. The most logical solution would be to follow current MWCC practice and distribute any implied fee reduction uniformly through the system, i.e. independently of cost structures. This would compromise the goal of sending accurate signals with the overall level of fees, but would maintain a pattern of relative fees that reflects costs.

The generation of a surplus would have one important advantage in the context of a cost-based fee structure. A cost-based structure like the one described in this work would estimate annual capital costs according to the actual expected lifetimes of assets. However, state law currently prohibits these assets from being financed with bonds exceeding twenty year terms. This means that, in some years, fees may not cover full debt service costs. The surplus implied by the cost-based system would enable the MWCC to build a reserve to cover costs in those years.

Finally, a differentiated fee system is more difficult to administer than a uniform fee. We cannot say with certainty that the efficiency gains associated with a switch to a differentiated system would exceed the administrative costs involved. However, given the magnitude of the implicit subsidies uncovered by our work, it seems unlikely that the adminstrative costs would exceed the efficiency gains. In addition, the relatively new geographic information system (GIS) technology that the MWCC is currently installing is a potentially powerful management tool that would ease the costs associated with administering a new fee system. Nor do the extra costs associated with determining fees and more carefully monitoring the value and depreciation of nearly $2 billion worth of public assets seem excessive for an organization with an annual budget approaching $150 million.

E. <u>Conclusions</u>

In sum, it is our belief that the efficiency and equity costs associated with the current MWCC uniform fee system warrant transition to a system more closely reflecting total system costs and cost differentials around the region. This is particularly true for the user fee system. The data and findings regarding connection costs are not as compelling. Any changes in that dimension should be preceded by more careful analysis of the value and expected lifetimes of MWCC assets and more comprehensive and up-dated linkage of asset value information with the location and pipe characteristics data in the GIS system.

Appendix A: Calendar Time Versus Use Time in Distributing Capital Costs Between Current and Future Users

Our base-line analyses of appropriate sewer-access charges were based on the implicit assumption that the passage of time was the only determinant of how fast a unit of equipment wears out. This note considers a machine in which both use and the passage of time determines length of life. Suppose that, when the machine is operating, out-of-pocket costs per unit of output are independent of either machine age or utilization rate. Suppose also that one year of use at α% of capacity or use at full capacity for α% of a year each would reduce the machine's remaining life by as much as would passage of one year of calendar time. The machine has a life of n year equivalents. That is, if it is never used, it will last n years. If it is used one year at α% of capacity and is idle for the remainder of its life, that life will be n - 1 years. If it is used at α% of capacity for its entire life, that life will be n/2 years--n/2 years associated with the passage of calendar time and another n/2 years for use time. A value of α greater than one implies a machine for which more than one year of use is required to match the depreciation that one year of life produces. Having an infinite α value is equivalent to having depreciation determined only by the passage of time.

Suppose that the machine's utilization rate increases linearly from zero to 100% and reaches 100% at the exact end of its life. A year of 100% use has the same effect on machine life as does $1/\alpha$ years of calendar time; the machine's average use will be 50%--a use equal, on average, to passage of $1/2\alpha$ years of calendar time per year of use. The actual life of the machine, then, will be x years where x satisfies:

$$x + x/2\alpha = (2\alpha + 1)x/2\alpha = n \text{ which implies } x = 2\alpha n/(2\alpha + 1).$$

A fraction, $1/(1 + 1/2\alpha) = 2\alpha/(1 + 2\alpha)$, of the capital investment in the machine is used up by the passage of calendar time; the remaining $(1/2\alpha)/(1 + 1/2\alpha) = 1/(1 + 2\alpha)$ wears out with use.

A plausible allocation of the machine's costs between user and access fees would be to have:

(a) each user year and the ultimate user of each unused but available user-year of capacity pay equally for depreciation that is related to the passage of time; and

(b) each user pay an annual fee for depreciation that depends on system use that is independent of either the current date or the user's date of entry into the system.[51]

For a machine the use of which increases linearly from 0 to 100% on the date at which it has completely depreciated, alternative values of α imply the following fractions of total capital costs belonging to category (a)--equal charges for a user year and to an ultimate user for an unused but available year of capacity:

α	Fraction of Capital Cost Allocated to Calendar Time
0%[52]	0%
25%	33.3%
50%	50%
75%	60%
100%	66.7%

[51] A machine for which depreciation is caused entirely by use would provide a number of user years that is independent of the pattern of use. The longer is the period of use, however, the greater is the fee per user year that would be required to cover the machine's capital costs. This pricing system does not include an appropriate penalty for late entering users. We are currently working on a system that would provide an efficient incentive to induce early entry.

[52] A 0% operating rate being equivalent to a year of calendar time is taken as implying that only operating time affects the life of the machine.

If B is the fraction of C, the initial cost of the machine, to be allocated according to the passage of time, and if the machine will last x years, P_t, the annual charge to a present or about-to-be user for the existence of a year's worth of capacity, must be such that:

$$BC = P_t K \sum_{i=1}^{x} (1 + r)^{-i} = P_t K [1 - (1 + r)^{-x}]/r \qquad (1)$$

where r is the interest rate used in discounting payments and K is the number of users the machine can serve when operated at full capacity. If machine use increases linearly with time from 0 to 100%, K/x users will be served during the first year of its life, 2K/x during the second year, ... and xK/x during its last year. P_u, the charge imposed only on users must, therefore, be:

$$(1 - B)C = P_u (K/x) \sum_{i=1}^{x} i/(1 + r)^i \qquad (2)$$

For a service life of x = 40 years and an interest rate of 4%, the right-hand sides of equations (1) and (2) respectively equal $19.793P_tK$ and $7.658P_uK$. Suppose that α equals 50% and, hence, that 50% of the cost of capacity should be allocated to users and the remaining 50% to present and prospective users. Suppose also that the machine costs $1,000,000, will last 40 years, and can serve a maximum of 1,000 users. Then

$19.793*1{,}000*P_t = \$500{,}000$ or $P_t = \$25.26$

and $7.658*1{,}000*P_u = \$500{,}000$ or $P_u = \$65.29$.

Thus, the total annual fee to a current user would be $P_u + P_t = \$90.55$. The connection fee for someone who begins to use the machine in the yth year of its life would be $\$25.26*[\{(1.04)^y - 1\}/.04]$, the amount to which an annual payment of $25.26 would accumulate in y years at a 4% interest rate.

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RESPONSE TO REGIONAL SEWER RATE STRUCTURE STUDY

The purpose of this study was to examine the social, economic and environmental effects on the metropolitan area resulting from (1) the allocation of current wastewater treatment costs to communities within service areas for which costs are attributable, versus (2) the allocation of current costs to communities uniformly throughout the Metropolitan Waste Control Commission (MWCC) service area.

The MWCC believes that this report, as an economic analysis, provides valuable information for policy discussions. We acknowledge the conclusion that there are different costs for providing sewer services to different areas, although we believe the differences are less than indicated. For example, we believe it is not appropriate to include capital monies received through federal grants as service costs. This approach exaggerates the cost differential between service areas. This service area cost differential was also acknowledged in a 1985 rate structure study that recommended the MWCC adopt a uniform rate. In response to this study, the 1987 Legislature created the uniform sewer rate structure currently in use.

The MWCC believes that this report focuses almost entirely on the economic efficiency of the current system and does not adequately consider the environmental, social and historical implications of a change in the rate structure. The MWCC was formed in response to major environmental problems in the metropolitan area. The current cost of the system are a result of a complex web of historical, environmental, and economic factors. The economic cost to the region was just one of several factors considered when deciding where and how to build the metropolitan sewer system.

The issue of sewer rate structure should be considered in a more holistic context. Current MWCC studies on the effects of centralization versus decentralization, and on the cost and benefit of removing phosphorus from the Metro Plant effluent, could have tremendous impact on wastewater treatment in the metropolitan area. To act on this report alone may lead to incomplete solutions, like the automatic selection of large plants that discharge in one location and do not adequately consider the social and environmental implications.

It should also be noted that the Commission does not believe that development patterns are affected by MWCC sewer rates. The MWCC is a wholesale supplier of sewer services, and does not set rates for individual communities. If the goal of the legislature is to influence development patterns, then the legislature should examine other ways to accomplish this.

This report should be viewed as one tool in examining several larger issues. The Metropolitan Waste Control Commission will incorporate this report when developing long range strategic plans for the agency. To make any decision regarding our rate structure based on this report, without waiting for more information from the phosphorous and centralization/decentralization studies, would not serve the metropolitan area well.

Lou R. Clark

Lou Clark, Chair
Metropolitan Waste Control Commission

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As adopted by the Metropolitan Council on Jan. 14, 1993.

DATE: January 14, 1993

TO: Metropolitan Systems Committee

FROM: Metro Systems Department, Bob Mazanec, Pat Pahl

SUBJECT: **Council Comments on Regional Sewer Rate Structure Study**

EXECUTIVE SUMMARY

The 1992 Minnesota Legislature directed the Metropolitan Council to contract with the University of Minnesota to conduct a study on whether development patterns in the Metropolitan Area are being influenced by the way sewers, highways and other infrastructure is provided and paid for. The study is being conducted in two phases: the first phase, just completed, deals with the effects of regional sewer rates on development. The second phase, to be completed in the first quarter of 1993, addresses the effects of infrastructure other than sewers.

The Council has strongly supported maintaining the vitality of the fully developed area and managing the costs of urban sprawl. It has well-established policies to do this in its *Metropolitan Development and Investment Framework, Water Resources Policy Plan, and Transportation Policy Plan.*

In the first phase of the university's study, the fundamental question addressed is the effect of sewer rates on the fully developed area, settlement patterns across the region, and cross-subsidies. Currently, rates to pay for metropolitan sewer service are uniform throughout the region.
To do the study, the university had to create a hypothetical rate structure, because data limitations prevented them from using the actual rate structure. Using this, they found that people living in the fully developed part of the region would theoretically pay $10 more a year than the average cost charged by the Metropolitan Waste Control Commission, which runs the regional sewer system, to provide service. Conversely, people in the developing area would theoretically pay $13 less a year than MWCC's average cost of providing the service to them. As a result, the study recommends charging the full cost of providing the service to all households in the region.

The Council's Metropolitan Systems Committee reviewed the study on Dec. 12 and raised many concerns about it. A Jan. 5 revision of study has addressed many of these concerns. The study and comments of the Council and Metropolitan Waste Control Commission are due to the legislature Jan. 18.

There are several reasons not to change the rates as the university study suggests.

1. The difference in costs to households is so small that, even if known, it would play no role whatsoever in a homeowner's decision to live in the developing area compared with living in the older, fully developed area.

2. Clearly, other factors, such as neighborhood quality, crime, schools and transportation accessibility, are far more fundamental to decisions about where people choose to live than a $13 annual sewer subsidy.

3. A uniform rate allows the Metropolitan Waste Control Commission and the Metropolitan Council to make investments throughout the region based on regional goals--i.e, closing down sewage treatment plants on Lake Minnetonka--without being limited by a concern about the cost impact on sewer service to households in that specific service area. The concept behind the creation of a regional sewer system was to solve sewage pollution problems throughout the region for the benefit of everyone in the region. The rate structure should facilitate this, not hamper it.

4. Costs to administer a more complex rate structure would increase.

The study does not provide an analysis of a differentiated rate system using regional costs that would give policymakers a basis to consider whether changes should be made to the existing MWCC rate structure. The Council is concerned that the study does not fully address this complex issue and further work is needed before changes in public policy are considered.

THE COUNCIL'S INTEREST IN THIS ISSUE

The Council has a long-standing policy interest in the issue of user fees and their relationship to development patterns in the region. The Council's policies are contained in the MDIF and made specific to the metropolitan sewer system in the Water Resources Policy Plan. The MWCC is required by the Environmental Protection Agency to impose user fees for its costs and is expected to develop a user fee structure that is consistent with the Council's development and investment policies.

Policies relevant to this issue include the MDIF's policies supporting the central cities and the fully developed area. Policy 11 states that: Maintenance of metropolitan systems serving the metro centers will receive the Council's highest investment priority. Policy 13 states that: Reinvestment for maintenance and replacement of metropolitan systems serving existing development in the fully developed area will take priority over investment for expansion in the developing area. The Council does not support unplanned Metropolitan Urban Service Area expansions (Policy 8) and promotes development in areas where system capacity already exists (Policy 2).

In addition, the Council's Economic Evaluation Criteria address investment questions of efficiency and equity. Efficiency is most important in determining whether the Council's policies or revenue-raising methods lead to better use of regional services by the public. Equity, as defined by the Council, is a concept that measures fairness in the provision of goods and services or in payment for goods and services. The Council measures benefits in terms of the availability, level and quality of service received; payments are measured in the relationship between the taxes or fees charged and the service received, or in service charges relative to ability to pay. Implicit in the Council's policy framework is a regional approach to the provision and pricing of all regional services.

The Council could use the information contained in the sewer rate study as input to its *Metropolitan Development and Investment Framework* (MDIF) revision, especially its fully developed area policy. The Council should also take it into account when laying out an action plan for dealing with the issues raised in *Trouble at the Core* and in establishing its principles for a human investment framework. In addition, the MWCC could further evaluate the practicability of implementing the university's recommendations, including the effects of taking federal and state grants into account and the administrative costs of changeover.

BACKGROUND

Legislative Directive

The legislation requires that the sewer rate structure component of the university's study together with comments on it from the Council and the Metropolitan Waste Control Commission (MWCC) be transmitted to the legislature by Jan. 4, 1993. Because of problems with the study discussed at the Dec. 12 Systems Committee meeting, the deadline for transmittal was extended by the legislature to Jan. 18, 1993 to allow the university an opportunity to revise its study to address Council and MWCC concerns. The university submitted a revised study on January 5 that met many of the major concerns of the Council and the MWCC. The comments provided below address remaining issues.

Summary of the Study

The University of Minnesota designated the Humphrey Institute to conduct the study under the direction of Professor Tom Luce. The legislation requires that the study examine the social, economic and environmental effects on the fully developed area resulting from (1) the allocation of current costs to communities within service areas for which the costs are attributable, versus (2) the allocation of current costs to communities uniformly throughout the Metropolitan Area (the current practice).

The study conducted by the Humphrey Institute does not analyze the current uniform rate structure used by the MWCC, which charges for annual operating and debt service costs. The authors of the study were not able to trace debt service costs back to individual municipalities or policy areas. Instead of using the MWCC's current rate structure, the study uses the asset value of treatment plants and interceptors and allocates the "full cost" of those facilities to municipalities within the metropolitan area. To obtain costs by policy area, the study aggregates costs for each municipality within a policy area. These costs are then measured against average costs to determine whether each policy area is paying the full costs of receiving MWCC service. If some areas pay less than the full cost, other areas must pay more. In using asset values to determine cost, the study ignores the significant share of costs that were paid in the past with federal and state grants. In so doing, the "full cost" rate structure would charge users for costs the MWCC did not incur and would also create a surplus, two issues of concern to the Council.

The study is based on the economic theory that users should pay the "full costs" of service to ensure that the most efficient use is made of the service (that it is not over-consumed) and that no unwanted incentives are provided by charging more or less than cost. The study, therefore, attempts to answer the following question: What would the effects be of a rate structure based on "full costs" that charges each user the same fee even though the cost of providing service to that user is higher or lower than the fee charged?

The study finds that a uniform rate structure that is based on the "full cost" or asset value would result in households in the fully developed area paying $10 per year more than the MWCC cost for providing them service. Taking this annual "extra" cost into account, a purchaser of housing in the fully developed area would discount the purchase price of the home by $250 to account for the excess sewer charges. Conversely, households in the developing area would receive a subsidy of $13 per year, resulting in purchasers being willing to pay $350 more for housing in the developing area. The largest subsidy would occur in the freestanding growth centers where households received a subsidy of $46 annually, increasing the value of homes by $1,150. The "efficiency" question is whether this difference is large enough compared to other variables to influence housing location choice.

ANALYSIS

User fees

1. *Study*: User costs vary significantly across the region. The cost variations discovered by the authors are great enough to affect settlement patterns in the region.

   Response: The variation in user costs found by the authors is not great. If a uniform rate structure based on full costs were put in place, the fully developed area would pay an average of $10 annually per household (100,000 gallons) for a present value of -$250. The developing area would receive an average subsidy of $14 annually per household for a present value of +$350. Only in the freestanding growth centers would the subsidy become more significant at $46 annually per household for a present value of $1,150. As a share of the cost of purchasing a home it is difficult to see how these variations in sewer fees would affect a location decision. In addition, as the authors note, home buyers would have to be aware of these fee differentials. Since regional sewage collection and treatment charges are billed to municipalities which pass them on to home owners as part of a local sewer bill, it is unlikely that home owners, much less home buyers, would be aware of regional sewer service costs and charges.

   Even the authors recognize that effects on settlement patterns might occur only at the margin, in Hastings, for example where costs are substantially higher than charges. Because the study does not address other, possibly competing values, such as proximity to jobs, the relative importance of differential sewer fees in the location decision is not assessed.

2. *Study*: Uniform fees generate subsidies flowing from the inner part of the region to outer portions.

   Response: Staff agrees that the uniform rate structure as assumed by the study would result in cross-subsidies among policy areas. This results not so much from uniform fees themselves but from the economies of scale provided by the metro plant and by the exclusion of federal and state grants from the costs incorporated into the rate structure. In other words, because of its size the metro plant is far more efficient than other plants, thus, areas served by the metro plant have far less costs to pay.

   If the study's conclusions were implemented, all municipalities in the region would seek to be served by the metro plant. For environmental and historical reasons, the MWCC has not centralized all sewer service. Whether residents served by plants other than metro should pay higher rates today because of past decisions made by the Council and the MWCC is a policy issue that involves more than the economic concept of efficiency.

   The relative subsidies that are identified in the study do occur but the level of subsidy is affected by the methodology employed in defining "full costs". If the costs of regional facilities that were financed by federal and state grants were deducted from asset values proportionally across all facilities, the amount of subsidy provided by municipalities in the fully developed area would decrease substantially as would the amount of subsidy received by the developing area. The result would be subsidies from one area to another probably too small to justify the administrative costs of a rate structure such as that proposed in the study.

Deducting federal and state grants from the full costs would also eliminate the problem of surplus created by the study's proposed rate structure.

3. *Study*: SAC charges (regional connection charges) may be low but the difference between actual costs and the fee charged are not significant enough to affect the overall density of the region. SAC cost variations across the region are also not likely to be substantial enough to translate into significant housing cost differentials.

   Response: Because of methodological problems in addressing marginal or incremental costs, the analysis of SAC fees is very limited. It is possible that the higher costs of treatment required for future development served by the Blue Lake plant may result in capital costs significantly greater than the current regional connection charges. This would seem to be an area where pricing based on full costs might be worthwhile exploring as a development management tool.

Further Work

The Council is about to undertake a revision of the *Metropolitan Development and Investment Framework* (MDIF). The issues raised in the university's study are highly relevant to the issue discussions currently underway. The MDIF work group is talking about the basic values that will need to be balanced in the MDIF policy (environmental quality, economic growth, effective and efficient services and healthy communities). The value of efficiency is well illustrated by this study: those who benefit should pay the cost of services, maximizing economies of scale, higher cost services for lower density development, life-cycle costs taken into account in investment decisions.) However, this study also is a good example of what can happen when one value--efficiency--is considered without balancing it with other values. One good example is environmental quality. It may be good public policy for the region as a whole to bear some of the cost of transporting sewage away from Lake Minnetonka rather than allowing the lake to be polluted. If the costs are placed only on the sewer users in the area, the environment may suffer because those users may not be able to afford the costs of correcting the problem. The region then loses the benefits of improved water quality on a major regional recreation resource.

A major concern with the study from an MDIF perspective is its limited analysis of equity from the standpoint of benefits received. Examples of benefits not included in the study are the use of MWCC interceptors as local trunks by downstream communities and subsidies provided to Minneapolis, St. Paul and South St. Paul for separation of sewers.

Also, the analysis of subsidies to the freestanding growth centers misses the role of the communities in the Council policy structure. Each of the freestanding growth centers is a microcosm of the metropolitan urban service area and has within it developed and developing areas. The conclusions in the study may lead one to find that services to the freestanding growth centers are not economic but that ignores the role of and history of the centers in the Council's policy framework for metropolitan development.

CONCLUSION

The university's study of the economic implications of a uniform rate structure for the regional sewer system based on the full costs of the system has the following limitations:

1. Because of data limitations, the study was not able to analyze the existing MWCC uniform rate structure system established in statute; the rate structure created for the purpose of the study uses asset values and, therefore, does not account for costs paid for previously by federal and state grants. If the costs funded by federal and state grants were deducted proportionally across the system, many of the study's findings regarding incentives for location decisions, efficient use of services and the amount of cross-subsidies by policy areas would be substantially modified.

2. The study is limited to the MWCC rate structure. Many other infrastructure costs in the form of fees and taxes influence location decisions. To look in isolation at regional sewer fees distorts the effect of sewer rates on the home buyer's decision. In addition, the study makes the unlikely assumption that home buyers are aware of and take into consideration in purchasing a home the extent to which their regional sewer charge differs from the full cost of providing the service. The MWCC charges municipalities for sewage collection and treatment; municipalities in turn bill homeowners for sewer services without distinguishing between regional and local charges, making it highly unlikely that the home buyer would know and act based on regional sewer charges.

3. The study acknowledges that economies of scale for treatment plants drive the conclusions with respect to subsidies. In essence, users served by the metro plant subsidize users served by other, smaller plants. Because the metro plant includes all of the fully developed area municipalities within its service area, the study concludes that the fully developed area is subsidizing the developing area and the freestanding growth centers. But there is nothing inherent in the delineation of policy areas that leads to one subsidizing the other, such as older areas versus newer areas. The subsidy is solely a function of the size of the metro plant.

4. The conclusion that, under the proposed full cost rate structure, the fully developed area would unfairly be required to subsidize sewer service for the developing area illustrates the shortcomings of focusing on a single service. The MWCC services are regional in nature and decisions about services provided and fees charged must be made in a regional context. If each regional service is costed out on a municipal basis, the concept of a metropolitan area working together as a single region with a common interest will be seriously damaged.

RECOMMENDATION

That the Metropolitan Council adopt this report as its comments on the Regional Sewer Rate Structure Study prepared by the Humphrey Institute.

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