AN ABSTRACT OF THE THESIS OF

DONALD KENNETH FORD for the degree of MASTER OF SCIENCE

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Title: AN ECONOMIC ANALYSIS OF SEWERAGE SERVICES IN TILLAMOOK, OREGON

Abstract approved:

R. Charles Vars

This study presents an economic analysis of the sewerage service problems faced by the city of Tillamook and the adjoining North Highway 101 Sanitary District. The existing city system requires extensive remodeling and rehabilitation, and the district needs to find an alternative disposal system to replace its inadequate septic tanks. Since there are alternative solutions to these problems, the cost, financing, and pricing implications of each alternative were examined.

The study concluded that (1) the city of Tillamook could benefit from the inclusion of the North Highway 101 Sanitary District in its treatment system, and (2) a marginal-cost-based set of monthly charges, special assessments, and property tax levies is feasible and can provide an economically efficient and equitable distribution of costs on a benefits-received basis.

An Economic Analysis of Sewerage Services in Tillamook, Oregon

by

Donald Kenneth Ford

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Dean of Graduate School

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I. INTRODUCTION

Public decision makers are today facing situations more complex than ever before concerning the pricing of public services, and even whether to offer those services at all. Problems of the core city have been studied for the last several years, but normally in the context of the large metropolitan area. And the problems of suburbanization, overcrowding, lack of suitable room for development, and of course revenue generation for the large city are familiar to the sociologist, the political scientist, and the economist.

Today these problems are no longer the sole possession of the large metropolitan areas such as New York, Chicago, and Los Angeles. These critical issues are now also the concern of the smaller communities including semi-rural, and even some rural areas. These problems are often just as pressing and urgent for the smaller communities as they are for the more urbanized population centers.

This study will concern itself with one example of the problem of local decision making and public service pricing as it exists for a small community on the Oregon coast, the city of Tillamook. Some of the problems that are encountered in this example are unique to

Tillamook, but in general it is hoped that the overall analysis will be applicable to public service problems facing local governments, with special considerations taken into account, to tailor the analysis to the individual needs of the user. The general framework of the analysis should remain valid despite differing local circumstances.

Area Description

The city of Tillamook, located in the heart of Tillamook County, Oregon, is the economic center of activity, and is the most intensively urbanized area in the county. Most of the land surrounding the city is agricultural in nature with emphasis on timber and dairy production. Both of these activities require substantial amounts of undeveloped, open land, and as a result, most of the land is zoned either agricultural or forest land with the associated developmental restrictions. The forest lands are normally unsuited for intense development because they are usually mountainous or upland in nature. But dairy production requires fertile, somewhat flat grassland for its greatest efficiency. Much of the land around the city of Tillamook meets these requirements.

The city of Tillamook is situated in a large flood plain between the Wilson and Trask Rivers and is surrounded by mostly arable land. Flooding, which can pose grave threats to urban areas, presents little in the way of serious problems to lands used for forage and grazing.

It may even be true that organically rich silts deposited by flood waters may help maintain the fertility of the soil. It is also true that well-established grasslands have an increased ability to withstand the erosive effects of flood waters. It is when development occurs in the flood plain that the location becomes an issue of concern for planning bodies and other decision makers charged with the protection of health and property.

Another matter of concern, directly related to the developmental issue, is that of the trend towards the conversion of lands under agricultural use to other uses. In Tillamook county the decline in the number of acres under agricultural use has occurred at an alarming rate, especially during the 1950's. Much of the conversion was due to private timber and range lands, much of it nonarable, which was sold to timber companies. But there was also a significant loss of pasture and crop lands at the same time. As a result of the fear of continued conversion of agricultural lands to non-agricultural uses, zoning laws were adopted to restrict development. Today, the decline in agricultural lands has slowed to a considerable degree. This is due, in part, to the developmental restrictions imposed by the zoning laws, but also to the economic slowdown experienced by the country, as well as the continued strong position of agricultural prices in comparison to land values for alternative uses.

History

The late 1950's saw the beginning of an economic decline that was partly attributable to the reduction of salvageable wood in the Tillamook Burn, a source for a large amount of timber for the mills in the county. Population growth slowed, and population even decreased during the 1960's. In 1967 the growth resumed, although population growth rates have not been as great as in the rest of the state, including nearby counties. This has been attributed to the solid agricultural base that exists in the county. Agricultural lands all along the northern Oregon coast have been subjected to increasing developmental pressures, but Tillamook county has thus far managed to avoid much of this pressure due to improving market conditions for agricultural products generated by the county, primarily lumber, plywood, and dairy products. Homesite and recreational development has taken its toll in the county, but its impact has been tempered by the parity between farm incomes and agricultural land values.

The majority of development in the county has occurred within a narrow strip along Highway 101, a major interstate cordon popular with travelers as a scenic route along the coast. Large volumes of tourists travel this highway in the summer months placing tremendous recreational pressures on the coast. Again, the city of Tillamook has managed to avoid some of these pressures because the highway takes an inland turn through the center of the county. The most intense development near the city of Tillamook has occurred along Highway 101 just north of the city, between the city limits and the Wilson River, a mile further north. This development has become a topic of concern in this study.

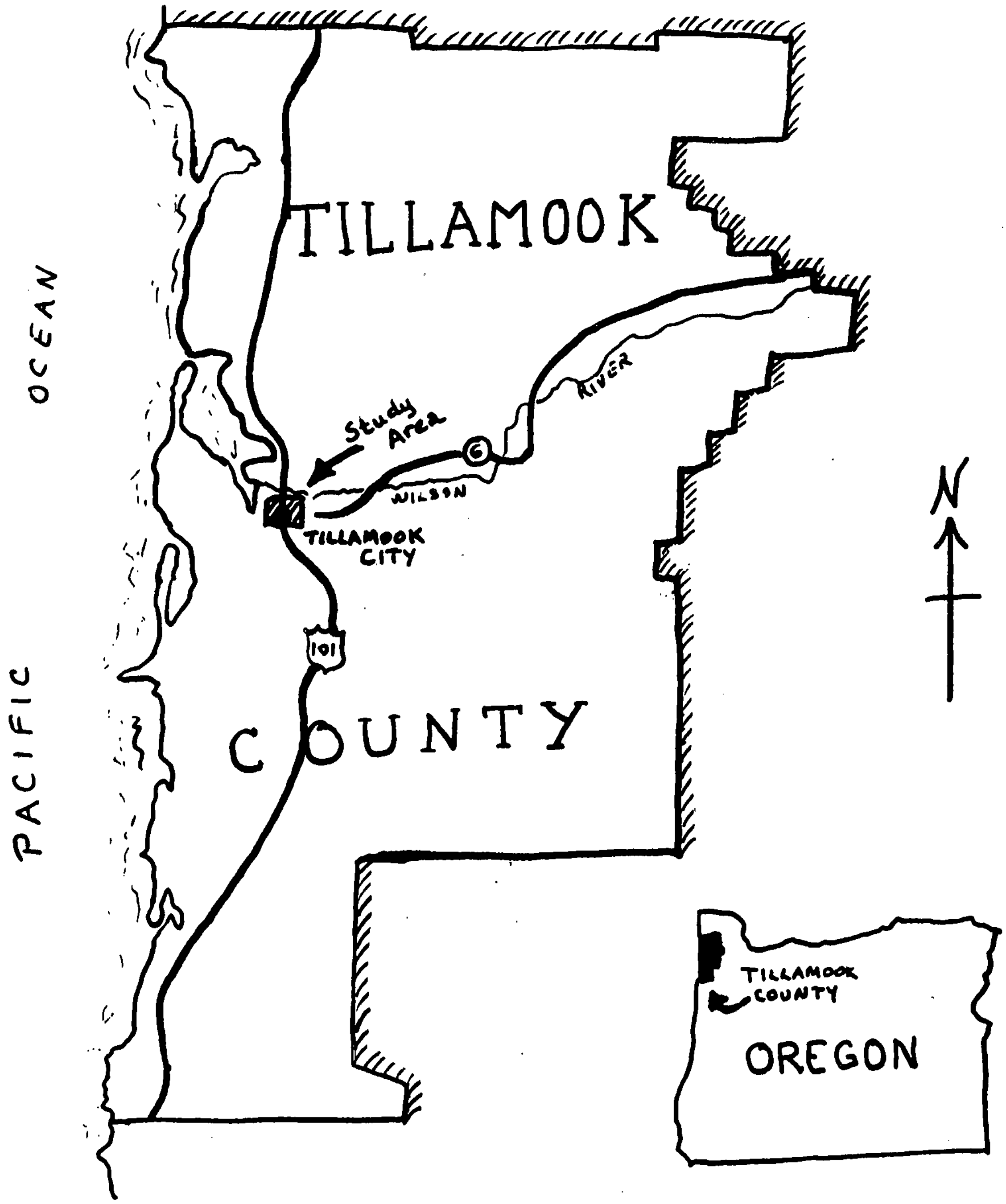
Scope of Study

Many communities today are faced with populations larger than some government service facilities were designed to handle. Population pressures and commercial and industrial interests have placed tremendous demands upon local services such as police and fire protection, hospital care, transportation systems, and sewerage systems. Several communities are also faced with the need to repair or replace facilities that are inadequate due to age and associated disrepair. It will be this study's intent to analyze the problems facing the city of Tillamook with regards to its sewerage system, which needs expensive remodeling and repairing, in conjunction with an outlying and adjoining special sanitary district, which needs to find an alternative sewage disposal system to replace the inadequate septic tank waste treatment process presently in use.

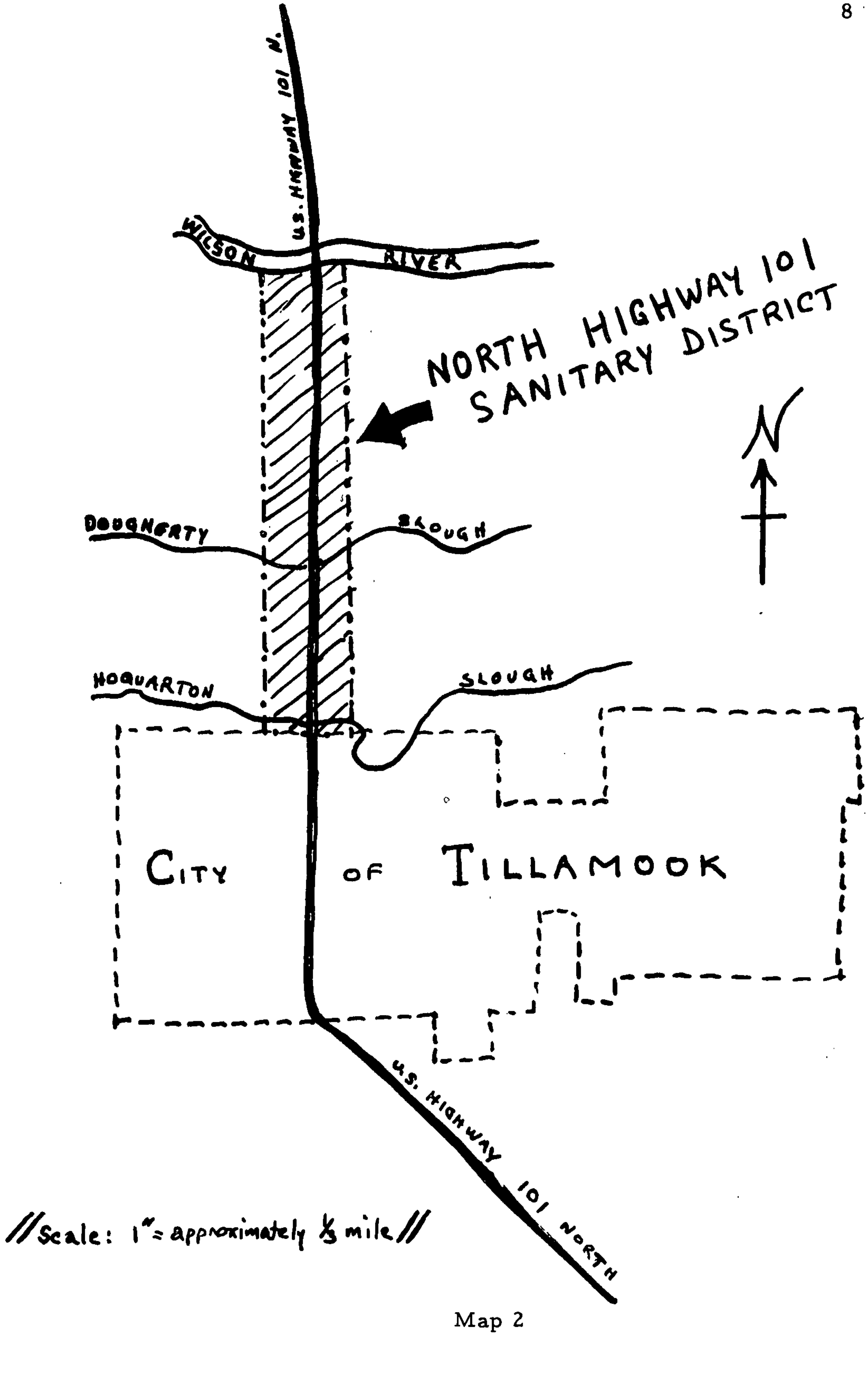
North Highway 101 Sanitary District

The conflict between the desire to keep as much land in agricultural production and the pressure to develop easily accessible lands is dramatically demonstrated in the political and economic problems of the city of Tillamook and the North Highway 101 Sanitary District, a special district 1,000 feet wide (500 feet on each side of Highway 101) and extending from the northern limits of the city of Tillamook to the Wilson River (see Maps 1 and 2). Approximately a third of the district is now developed, but due to normal speculation, it is apparent that future development is contemplated.

The Oregon State Department of Environmental Quality (DEQ) has been aware of the activity in the North 101 Sanitary District. In recent years, the threat to public health and safety in the Tillamook area had become serious enough to prompt a close look at the situation. The DEQ learned that the soils in the Wilson and Trask River floodplains have extremely poor drainage characteristics, being a "blue clay". This soil was determined to be unable to adequately handle the present septic tank drain field load being placed upon it, and the district was ordered to either find a suitable sewage treatment alternative such as connecting to the city of Tillamook's sewage treatment system, or to face public health hazard designation and closure


TILLAMOOK
COUNTY
PACIFIC
OCEAN
Study Area
WILSON
RIVER
6
TILLAMOOK CITY
101
N
TILLAMOOK COUNTY
OREGON

Map 1


U.S. HIGHWAY 101 N.
WILSON RIVER
NORTH HIGHWAY 101
SANITARY DISTRICT
N
DOUGHERTY SLOUGH
HOQUARTON SLOUGH
CITY OF TILLAMOOK
U.S. HIGHWAY 101 NORTH
//Scale: 1" = approximately 1/3 mile//

Map 2

of businesses in the district.[1] The problem is viewed by DEQ as acute.

The North 101 District approached the city of Tillamook in 1973 to ask for connection privileges to the city treatment system. The city of Tillamook was forced to deny the request, citing an already critical situation with their own sewerage operation.

Tillamook Waste Water Treatment

The Tillamook treatment plant capacity is rated approximately 1.05 million gallons of sewage per day MGD). During the summer months, at the time of the heaviest use of the system by local and summer residents as well as tourists, the system was able to operate within the design capacity of the plant, handling an average load of 0.7 MGD. But in winter, especially after a hard rain, a common occurrence in the northern Oregon coastal community, large volumes of water (often over two MGD) would infiltrate the aged transport system through cracks, holes, and disjointed sewer pipes, and pass through the treatment facility. Although this load is mostly water entering the system, the volumes encountered preclude the adequate treatment of the sewage that is originally present. Little more than chlorination and release is possible under these circumstances,

[1] Interview with DEQ District Engineer, Russell Fetrow, August 1974.

an environmentally unsound practice, and violation of state and federal water pollution control laws.

The city has begun a program of locating the most serious leaks into the system, and patching them, in order to qualify for a waste water discharge permit from the Department of Environmental Quality. These permits must be obtained by all agencies and firms who wish to discharge an effluent into a public body of water, including bays and estuaries. They involve strict monitoring of the contents and volumes of contaminants in the discharge.[2] Continual excess of prescribed maximum amounts of waste contaminants can result in the denial of the waste discharge permit.

Because the city was already struggling to maintain its sewerage system adequately, the city fathers did not regard it reasonable to incorporate additional volumes of sewage at the time of the request by the district. Another reason the request was denied was that the city really did not know what the impact of bringing the district on-line with the city's system would be, both in a physical sense and in terms of cost to the city. One additional point was mentioned concerning the fact that a portion of east Tillamook (city) was not presently served with the sewer, and was also on septic tanks. It was pointed out, however, that this section of the city was located in a soil with

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[2] Such as BOD, suspended solids, coliform bacterial levels, etc.

excellent drainage characteristics and there was no real problem there.[3]

Meanwhile, the promoters of the North 101 district had to develop some viable alternative, or face the prospect that serious steps would be taken by DEQ and other state bodies, with the accompanying heavy financial costs.

Alternate Waste Treatment

The district leaders conferred with a Salem firm which specialized in a relatively new, activated sludge waste treatment process called an aerobic waste treatment process. The firm, Sanitary Engineering Corporation (SECO), had not yet obtained DEQ approval of the system, and although it appears that the system has its merits, it is not an acceptable alternative for the district, under present state guidelines.[4] However, the system has been undergoing tests in conjunction with Oregon State University, initially under the leadership of the late Dr. Phillips in the Department of Civil Engineering. Even if the test results are favorable, and the system is approved by the DEQ, the results will certainly come too late for

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[3] Conversation with former Tillamook City Manager, Hans Paulson.

[4] Interview with Russell Fetrow, District Engineer, Oregon DEQ, August 1974.

implementation in the present situation. A solution must be found before the test results will be known. If the system is approved, however, it might bear consideration in other communities' alternative solutions to similar problems.

Another method of sewage treatment was mentioned by DEQ as having potential under certain conditions. This is known as evapotranspiration.[5] But this alternative had to be rejected, too, because it relies upon sunshine to carry on the evaporative portion of the treatment. Tillamook county with its exceedingly high rainfall levels would not qualify as a site for treatment of this nature until further refinements are made in this system.

Therefore, the sanitary district faces only two alternatives: connect with the Tillamook city sewerage system or reduce the level of development in the district.

The DEQ, who has direct authority and responsibility in this case, has conditioned approval of a city waste discharge permit on an effective remodeling of the city sewage treatment system, including an improved chlorine contact chamber and other improvements that will allow greater capacity for the facility. It is envisioned by the DEQ that the city will become a regional sewage treatment center in accordance with the state's philosophy concerning adequate waste

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[5] Conversation with Jack Osborne, DEQ administrator in Portland, Oregon office, September 13, 1974.

disposal. The State Emergency Board granted the city of Tillamook $25,000 to conduct an area sewerage study, including the area comprising the North Highway 101 Sanitary District. CH_2M-Hill, an engineering consulting firm, will conduct the study for the city.

Thesis Outline

This thesis will examine: (1) the costs relevant to the city of Tillamook in the remodeling and rehabilitation of its sanitary waste transport and treatment facilities; (2) the cost accruing to the North Highway 101 Sanitary District in order to obtain access to adequate waste treatment facilities; and (3) the alternative pricing and financing techniques available to the city and the district.

The analysis will include the concepts of both marginal and average cost pricing; and the implications of the various financing alternatives will be examined. Major emphasis will be placed on the principles of marginality in achieving economic efficiency in the operation of a public waste treatment system.

The facility design type will be determined first, followed by a discussion of the appropriate facility size in terms of meeting economic efficiency criteria.

Succeeding chapters will present cost data relevant to the system type and size determined previously, and finally a description of financing alternatives and pricing techniques appropriate to the analysis.

II. SELECTION OF WASTE TREATMENT FACILITY DESIGN

Benefit/Cost Analysis

In this chapter, the alternative waste treatment methods and plant designs that could meet the needs at Tillamook are analyzed. It is concluded that the lowest cost facility would use a trickling filter design.

Benefit/cost analysis can play a critical role in any public investment decision. Its greatest value exists in the event of limited resource availability and multiple investment alternatives since it can be used to establish priorities in investment decisions.

The standard approach in a benefit/cost analysis is to determine the maximum amount the beneficiaries of a proposed project or policy would be willing to pay for it, as well as the minimum amount that must be given to fully compensate those adversely affected by the proposal. When the former, or total benefits, exceed the latter, or the total costs, the proposed project would have a benefit/cost ratio greater than one and would have positive net benefits.

It should be noted that the fact that some project or policy passes the standard benefit/cost test is not sufficient by itself to justify undertaking the project or implementing the policy. In general, if one project or policy passes the standard test, so will others, and a social welfare function (or some substitute) must be introduced to rank the alternatives.

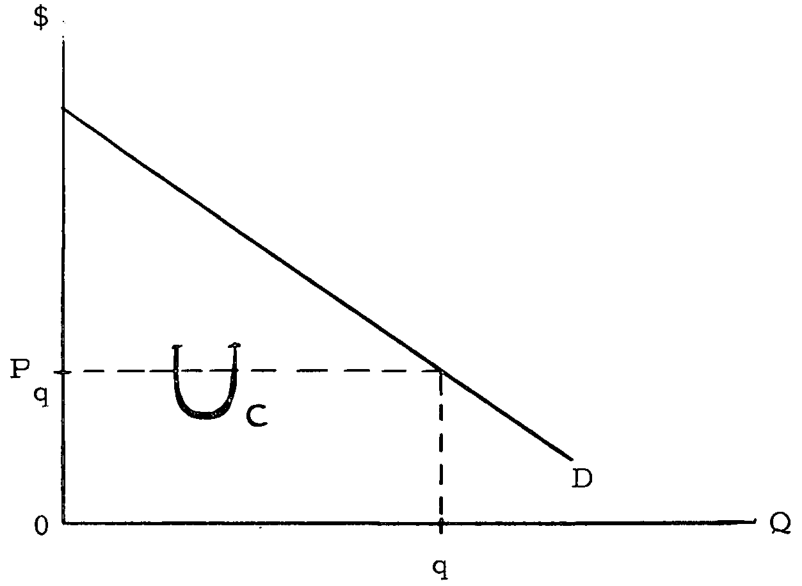
Also, since standard benefit/cost analysis relies upon hypothetical compensation tests to establish the existence of potential net gains to the groups affected by a project or policy decision, rational social decision-making requires consideration of both net benefits to affected groups and actual (as opposed to hypothetical) distributional consequences.

Benefit Measurement

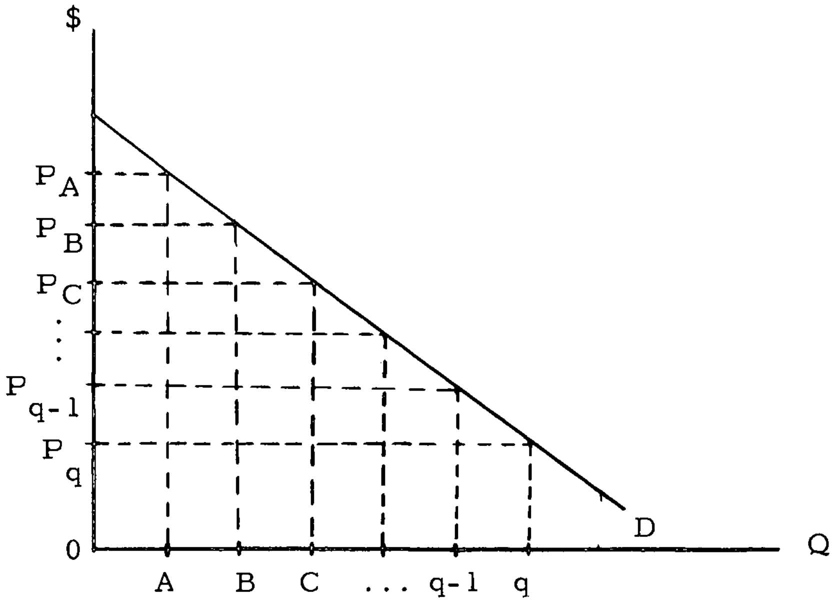
Using the Marshallian concept of consumer surplus to view benefits, we can refer to the area beneath the demand curve, up to the level of consumption, as a measure of the total benefits. In Figure 1(a), this area is shown as "U_c", the total benefits associated with a level of consumption at q^*.

This concept of consumer surplus is achieved by theoretically decreasing the price of the output in exceedingly small increments and considering the additional increase in total revenue associated with the new, lower price. See Figure 1(b). This implies that the new lower price has allowed more people to consume the product because they feel that there is now an opportunity for a positive increase in benefits over costs to themselves. By making these price decreases infinitely

[5a] Unless changes in well-being have the same social significance no matter where or to whom they accrue.



(a)



(b)

Figure 1.

small, the entire area beneath the demand curve could be extracted. This area can then be referred to as total benefits, and will be used in this study as the benefit side of the analysis.

It should be noted, however, that the net benefits that may be claimed for a specific project are limited by the costs of the best alternative project.

Referring to Figure 2, the area ACE represents the net benefits accruing from project I if there are no alternative projects with an average cost less than OC. If project II has average costs equivalent to OB, net benefits solely attributable to project I would be only the area ABDE because the benefits BCD are attainable without project I.

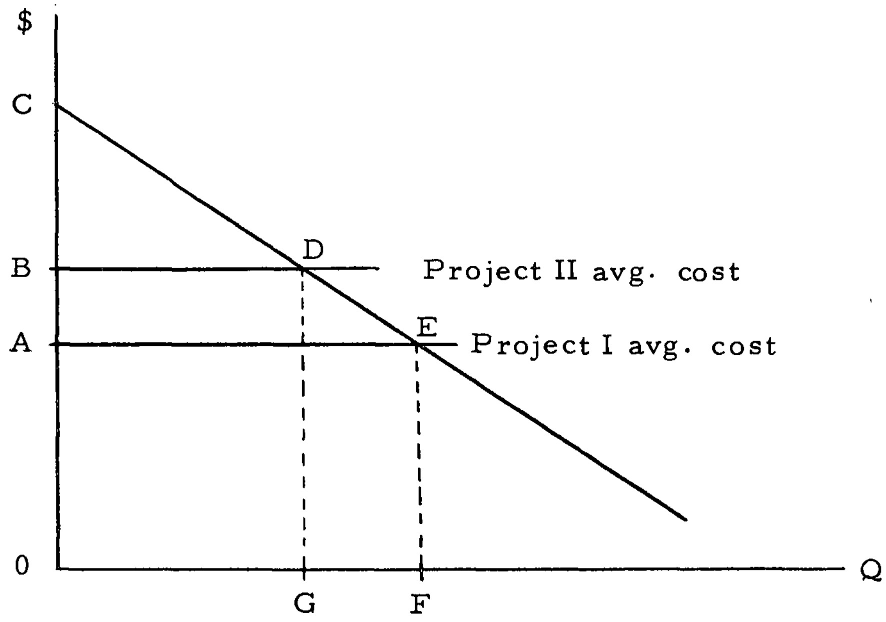


Figure 2.

Cost Measurement

Addressing the cost side of the analysis, we see that the costs of providing a service are comprised of two basic elements, fixed and variable costs. Fixed costs remain at a constant level as output varies, while variable costs are directly related to the level of output produced.

In a waste treatment facility, fixed costs include the capital costs of a particular plant while variable costs include items such as energy and chemical costs. Fixed costs exist only in the short run which is defined as the situation in which some costs are incurred that would exist even if no service was produced. Once capital expenditures have been invested in a particular plant, certain costs would have to be paid even if the facility were to close down its operations. These are short-run fixed costs.

Long-run costs can be controlled more easily than short-run costs. They are defined as existing when all costs are variable and can be made equal to zero if production were to cease. In the case of this study, all costs are viewed as long-run costs until a specific plant size is determined. This is to say that the size of the plant may vary continuously in the long run, until we choose a fixed plant size and actually build it. At that moment short-run costs become relevant. At all times, the distinction between the long and the short run will be made clear.

Treatment Method Alternatives

The first question to be answered in this analysis deals with the selection of the type of waste treatment facility that will meet the needs of the community at the least cost. The demand on the system will be composed of two elements: the population served within the limits of the city of Tillamook; and the demand imposed by the residents of the North Highway 101 Sanitary District, who represent all of the additional users of the system if and when it becomes a regional sewerage service. Any time a community is faced with public service investment decisions, it normally has several alternatives to consider. These alternatives must be compared and examined adequately so that the best service can be offered at the lowest cost.

Sewerage services are no exception. There are several alternate waste treatment systems available to communities, each with its own characteristic costs and effective treatment capabilities. Each system can provide, within certain limits, adequate waste treatment given treatment standards and density of development. Normally, there exists one system that meets the requirements of a community at a lower cost than other systems. If any of the critical parameters change, such as population, that particular system may no longer remain the least cost treatment method available.

Many of the waste water treatment systems in use today employ variations of two general designs, trickling filter and activated-sludge, to meet the specific needs of the community. These needs are imposed in the form of effluent discharge standards set by the Federal Environmental Protection Agency (EPA) and the Oregon State Department of Environmental Quality (DEQ). The trickling filter design and the activated-sludge process are described in the following sections, as are septic tanks which are the present waste treatment methods in use in the North Highway 101 Sanitary District.

Trickling Filter

Briefly, the trickling filter design is composed of biological treatment with chlorination and sand or mixed-media filtration. The design utilizes holding tanks to allow primary settling of the heavier waste materials and some bacterial decomposition of the waste. The remaining sewage liquors are then pumped to a sand or other media filter where the waste water is distributed and filtered, allowing for additional bacterial decomposition. The remaining materials are normally chlorinated and released, unless tertiary treatment is required.

Activated-Sludge

The activated-sludge design utilizes extended aeration of the sewage which permits flocs of bacterial organisms to develop. These flocs settle when the aeration is stopped, forming a sludge that is then brought into contact with new batches of sewage. This results in an increased level of bacterial activity speeding the process of decomposition and gives a highly effective degree of sewage decontamination. Activated-sludge systems are complex and expensive, but very efficient.

Septic Tanks

The most common rural treatment design is the septic tank. This is the system currently utilized in the North Highway 101 Sanitary District (North 101). Septic tanks are comprised of a holding tank in which residential wastes are detained for a period of time to allow some settling of heavier wastes and also for anaerobic bacterial action to take place. Then the remaining wastes flow into one or more drain fields to seep into the soil where naturally occurring bacteria can further reduce the waste before it contaminates the local water table. Septic tanks have severe limitations imposed by their design. They are also often subjected to neglect which results in a dangerous situation in many cases. Septic tanks require soils with good drainage characteristics as well as relatively large land areas to serve as drainfields. Once developmental pressures place too great a reliance on septic tanks, the system will normally fail to provide adequate waste treatment and become a hazard to the health of the community.

Relative Design Costs

Figure 3 shows hypothetical cost curves associated with each of the three systems described previously. The curves represent long run average costs imposed by a specific effluent if it were uniformly imposed on each system. The cost curve for septic tanks (ST) is an aggregate cost curve for the community. It becomes vertical at Q_1, which implies that is the maximum physical quantity of waste septic tanks could handle at any cost. The cost curves for both the trickling filter (TF) and the activated-sludge (AS) designs decline to show the economies of size inherent in the construction and operation of these systems.

It can be seen that each design represents a best (in the sense of least-cost) choice for a specific range of sewage volumes.

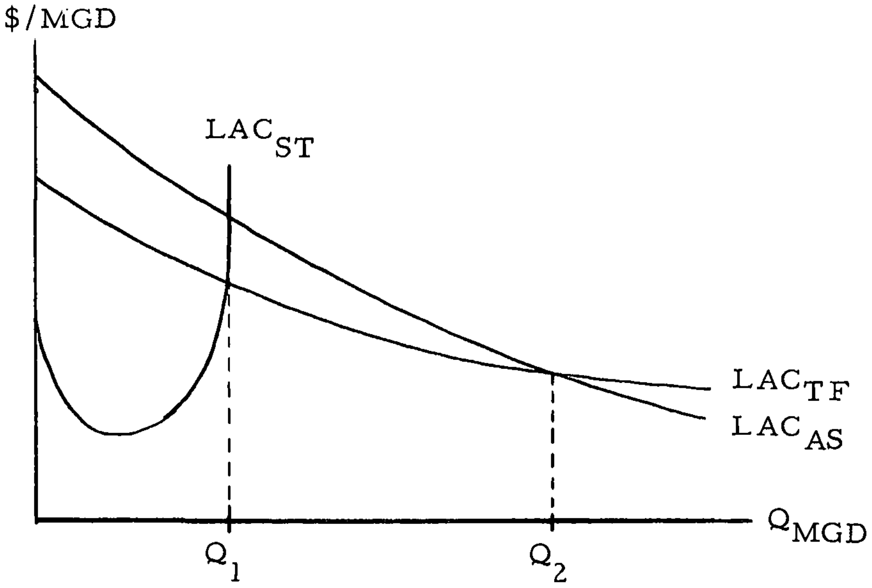


Figure 3.

Septic tanks are the lowest cost treatment method up to Q_1, at which point average costs dictate the use of a trickling filter design. At a volume Q_2, the activated-sludge process becomes the cost effective design.

After estimations of potential volumes of sewage have been made, and effluent standards have been established, engineers are able to select the facility design which will meet the needs of the community at the lowest cost. Once the design has been determined, a more detailed analysis of costs is possible. The short run costs associated with that particular design then become relevant, and the optimal size facility can be considered.

Figure 4 introduces the community demand curves. The community's level of demand (D) allows septic tanks to meet its needs. However, since growth is expected to push demand out to D' it is apparent that septic tanks will no longer be adequate, and a trickling filter design is indicated.

In the event the new demand curve had passed through the intersection of the cost curves, such as D'', the community would have to ask itself some other questions since either system design would meet its needs at the same average cost. The design selection would be based on other criteria such as developmental emphasis, aesthetics, and waste product utilization. Trickling filter systems sometimes experience slight odor problems, while activated-sludge systems operate entirely under water with few odors. But sludge generated by the trickling filter design has been used successfully as a fertilizer, while part of the sludge generated in an activated-sludge process must be retained as an integral part of the operation of the system.

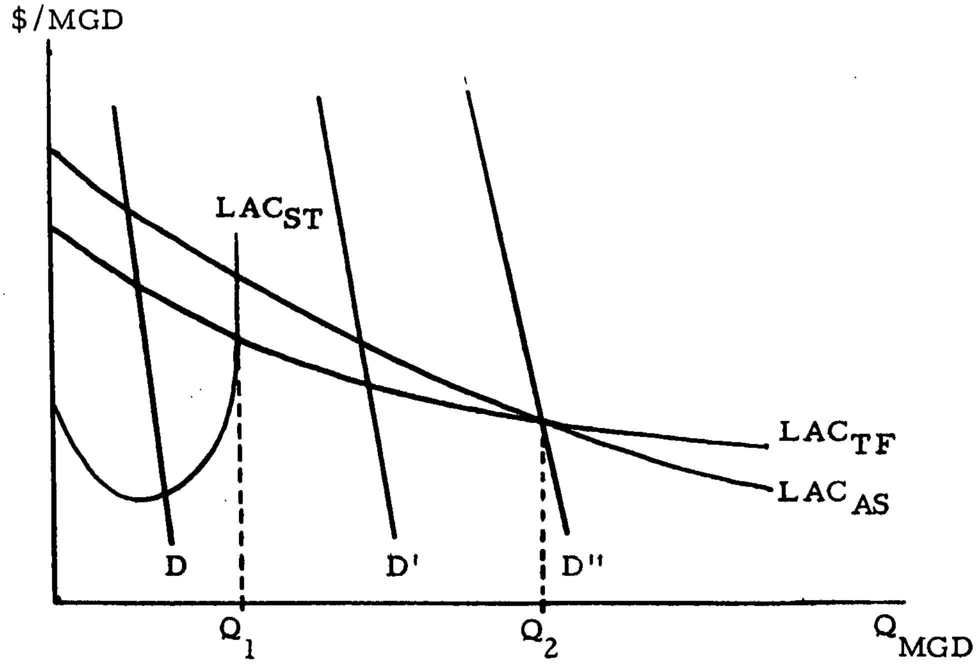


Figure 4.

Present Facility Design

Septic tanks do not generally meet the needs of the study area. A portion of the city of Tillamook, east Tillamook, is presently served by septic tanks, as is the North 101 district. But these areas, especially the North 101 district, will soon need a more advanced system to handle their wastes.

The present Tillamook waste water treatment facility is a 1.05 MGD trickling filter design. Estimates made by the city's engineering consultants, CH_2M-Hill, based upon growth data presented by the Tillamook County planning department, place demand in the next 20 years at a level of approximately 3 MGD exclusive of infiltrated waters, or 5 MGD, including infiltrated waters. This estimate will be the basis for the discussion of alternatives and costs facing the acting parties in this study.

Cost Data Sources

The cost data presented in this analysis represent the costs that must be incurred to obtain an effluent quality in compliance with the EPA's 1977 discharge standards. Two major sources of cost data are available: 1) the Federal Water Pollution Control Administration (FWPCA) cost index; and 2) the Engineering News-Record (ENR) index.

The ENR index is used in this study for two reasons. First, it is the index most widely used by engineering consulting firms. The ENR index is older and covers a wider range of sewerage system construction inputs than the FWPCA index. Secondly, by using one index throughout the study, some consistency is achieved in the data presented. (It should be noted, however, that estimates made with the ENR index will normally exceed those of the FWPCA which is based on data less sensitive to regional differences.) The higher estimate should be selected when a choice is indicated because none of the cost data presented in this study are particularly accurate because detailed engineering studies have not been completed. As a result, cost estimates made by engineering firms at this stage of the planning process are considered accurate within a range of -30 percent to +50 percent.

Conclusion

Based on demand projections and on the treatment standards imposed in the study area, a trickling filter design has been selected as the lowest cost system to meet the area's needs. The predicted total demand on the Tillamook system including the N. 101 district is estimated to be approximately 3 MGD (exclusive of infiltration) by the end of the century. The next chapter will consider the optimal size plant to be built.

III. DETERMINATION OF OPTIMAL FACILITY SIZE

The next question to be answered in this analysis deals with the determination of the optimal plant size needed to handle the demand imposed by the community. Initially, this demand will be considered to be composed only of the residents of the city of Tillamook. Once the optimal size plant for this level of demand has been selected, we will consider the impact of the added demand of the North Highway 101 Sanitary District upon the facility.

Studies (Downing, 1969) have shown that the demand for sewerage services is normally highly inelastic in both the long run and the short run. While Downing found that demand for sewer services may actually tend to become more elastic at lower prices, we will consider demand as a linear function of price for the sake of simplicity.

Long Run Analysis

Economic Efficiency

One of the primary concerns of economic analysis has been a determination of efficient useage of available resources given a particular production decision. Traditional production theory shows that the most efficient use of production resources is achieved when all factors and products are priced at a level equal to their marginal cost, if all the normal marginal conditions are met.[5b] In other words, the value of the marginal product should equal the price of that product.

Welfare theory also accepts the premise that marginal cost pricing results in an efficient, or Pareto optimal position. However, it should be noted that there are several efficient combinations of resources, each with a different welfare distribution, each a Pareto optimum. Therefore we cannot say that any particular efficient allocation is preferred to all others, or even to any other allocation without knowledge of the social welfare function and its associated interpersonal comparisons of utility--a difficult, if not impossible task. While there are some efficient (i. e., optimum) allocations of resources that represent welfare improving positions with respect to a non-optimum position, a movement to an optimal position is not necessarily a welfare improving move for everyone.

While efficiency should not necessarily be equated with welfare improvement, it is a valuable tool in the hands of the economist in using resources in a combination such that maximum output at least cost is achieved. As a result, marginal cost pricing will be the

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[5b] For a discussion of these marginal conditions, including constant utility of money, equal marginal rates of transformation and substitution, etc., see Henderson and Quant (Microeconomic Theory).

the primary pricing technique employed in this study in order to achieve economic efficiency in the offering of sewerage services.

Short Run vs. Long Run

Prior to discussing the appropriate short run operating level of a sewage treatment facility, it may be beneficial to view the interrelationships between the short and long run considerations of the problem.

Figure 5 shows both the long run and short run cost curves typically facing a community desiring to construct a sewage treatment facility. Based upon efficiency criteria already discussed, the optimal size plant would be built to handle a load of Q* MGD of waste water, the point at which demand interesects the long run marginal cost curve. At Q*, the appropriate short run and long run marginal costs are equal, and the short run average cost curve is tangent to the long run average cost curve.

The appropriate price to charge for the services would be equal to P_1, the price at which all long run marginal costs are covered. Any price lower than P_1 would result in marginal costs exceeding marginal revenues, thus implying that the facility cannot be operated efficiently at that price level.

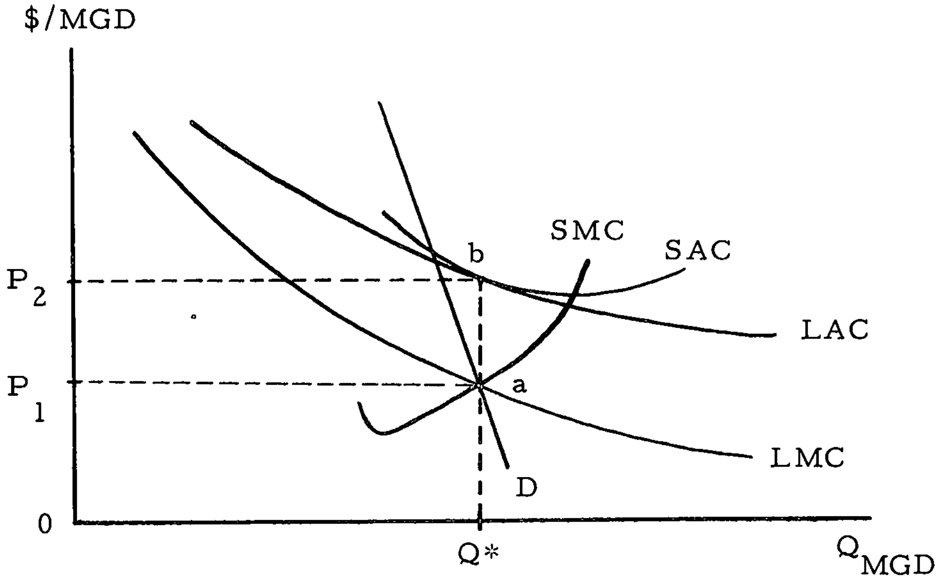

Figure 5.

Pricing Criteria

Meeting efficiency criteria in pricing does not necessarily mean that all costs are recovered. Referring again to Figure 5, it can be noted that a price of P_1 would yield revenue in an amount equal to the area $(0P_1aQ^*)$, while costs are equal to the area $(0P_2bQ^*)$. There would then exist a long run deficit equal to $(0P_2bQ^*) - (0PaQ^*)$, or (P_1P_2ba). The deficit would have to be recovered through the means of other revenue sources such as property assessments, sewer connection charges, etc. Of course, a price higher than P_1 could be charged to help reduce the deficit at the cost of economic efficiency if political expediency so requires.

Figure 6 demonstrates the relationships between average and marginal cost pricing. Q^* is the economically efficient optimal size plant, with a price charged equal to P_1. At this price long run marginal costs are just recovered, with a deficit equal to the area $(P_1 P_2 ab)$.

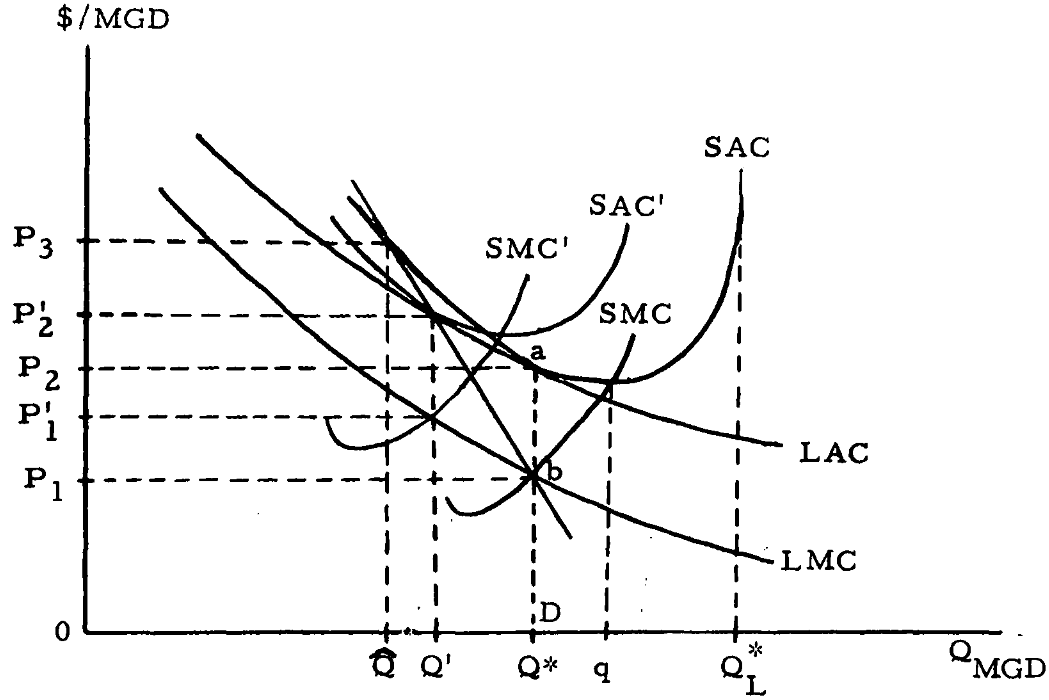

Figure 6.

It would be possible to eliminate the deficit for a plant scaled at Q^* by then charging a price equal to the short-run average cost, P_3, with a decline in the use of the system from Q^* to $\hat{Q}$. But it should be recognized that we are then operating with a nonoptimal plant.

If policy dictates the avoidance of incurring a deficit, even at the cost of economic efficiency and a reduced level of facility use, the plant should be scaled at Q' and a price equal to P'_2 charged, as shown in Figure 6. Q' then becomes an optimally scaled, though economically inefficient, plant based upon average cost pricing: output Q' being larger than the $\hat{Q}$ level experienced under non-optimal average cost pricing, and price P'_2 being lower than the P_3 price resulting from average cost pricing with a plant scaled to Q^*.

Short-Run Analysis

Cost of Expanding Output

The previous discussion has suggested that the short run cost curves become the relevant curves when quantities different than the design capacity of the facility are to be treated. Referring again to Figure 6 it can be seen that short run average costs decline as the quantity increases from Q^* until q is reached. After q has been reached, short run average costs begin to increase at an increasing rate until the SAC becomes vertical at Q_L^*, which implies that the physical capacity of the facility has been reached.

The fact that short run average costs decline and short run marginal costs increase can be useful to decision makers faced with increases in demand the plant was not originally designed to handle due to unexpected peak load situations, or unexpected new users of the facility not included in the original growth estimates.

Price Discrimination

When demand shifts beyond D as shown in Figure 7, price discrimination can be utilized for an assignment of the share of the burden. The original users of the system could still be charged P_1 for waste treatment service while the additional users of the system responsible for demand growth from D to D' would be charged P_2 to cover the short run marginal costs they have imposed upon the system. In fact, with discriminatory marginal cost pricing, an increase in demand through the addition of new users can reduce the average deficit.

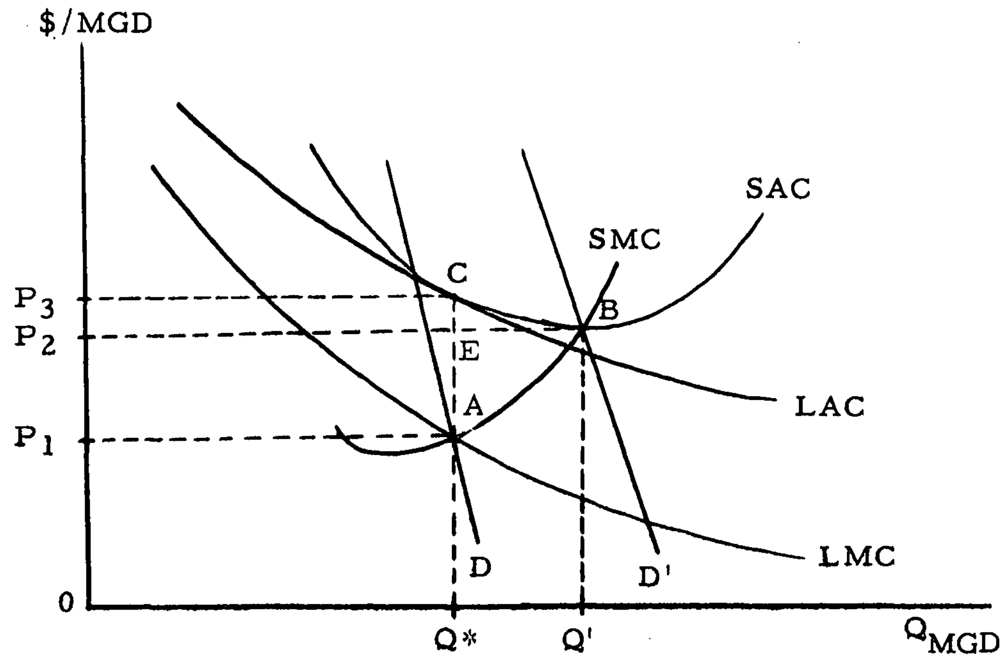

Figure 7.

In Figure 7, Q^* is the optimal plant size when demand is equal to (D), and the short run costs curves shown are those applicable to plant size Q^*. At a price of P_1, the revenue generated would be equal to the area $(0P_1AQ^*)$. The costs would equal $(0P_3CQ^*)$, with the resulting deficit equal to (P_1P_3CA). The new demand is represented by D'. Let these new users of the system be charged according to the marginal costs of their inclusion, P_2, while the original users are still charged at P_1. The revenues now generated consist of the area $(0P_1AQ^*)$, as before, plus the area (Q^*EBQ'). The costs are now $(0P_3CQ^*)$ plus (Q^*ABQ'). Since the new costs are less than the new revenues, $(Q^*ABQ') < (Q^*EBQ')$, the average deficit declines as more users now share in the smaller deficit that results. This is a benefit to the original users of the system.

Application of the Analysis

Alternatives for City of Tillamook

Turning to the long run considerations of the situation facing the city of Tillamook and the North Highway 101 Sanitary District, we can continue the analysis. As noted in the introduction, the city's sewage collection system suffers from a serious infiltration problem. Since the city must increase its sewage treatment capacity, it would be important to consider the effects of various alternatives.

The city could leave its infiltration problem unchecked, and build a new plant large enough to handle the extra load, without the inclusion of the North 101 Sanitary District. Or, it could correct its infiltration problem, ignore the N. 101 district, and construct a smaller treatment facility. The last two alternatives resemble the first two, with the exception that they include the residents of the North Highway 101 Sanitary District.

Figure 8 shows each of these alternatives. In Figure 8(a), D_1 represents the demand by residents of the city for waste treatment and D_2 represents the shift in demand from the addition of the N. 101 district. Infiltration is assumed to have been eliminated.

The marginal cost-determined optimal plant size, Q_1^* is the no-infiltration facility size for the residents of the city alone. Q_2^* is the no-infiltration facility size for the combined use of the city and district residents.

Figure 8(b) then demonstrates the effect of not correcting infiltration. Once again, D_1 is the city demand and D_2 is the combined demand for the city and district. The distance 0I represents the amount of peak infiltration and inflow into the system. These infiltrated waters must be treated whether the city provides joint waste treatment with the district or decides to treat only its own wastes.[6]

[6]There is no additional shift in the II' axis with the addition of the N. 101 demand because it is assumed that any sewer lines extended into the district area would be relatively free of infiltration.

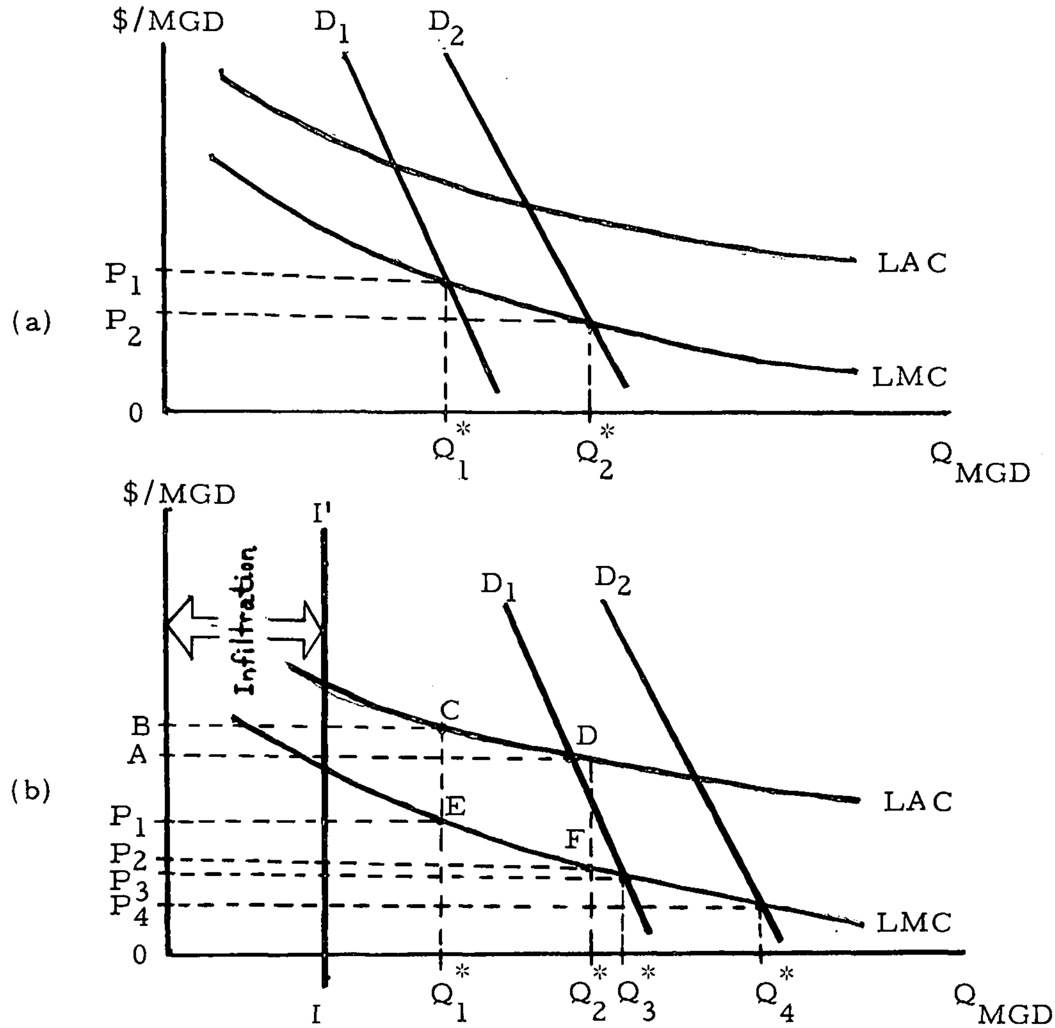

Figure 8.

The optimal size facilities with the presence of infiltration then become Q_3^* for the city, alone, and Q_4^* for the combined treatment of wastes from the city and N. 101 district. P_1, P_2, P_3, and P_4 are the marginal cost prices associated with each alternative discussed.

Plant Expansion Costs

Shown in Figure 8(b) is the effect on costs when plant size is increased. In this diagram it can be seen that as we move from

Q_1^* to Q_4^*, costs increase at a decreasing rate (declining marginal cost). This implies that everyone benefits from a larger sized facility based on an increase in actual demand.[7]

This can be demonstrated by considering the size of the deficit in Figure 8(b). With marginal cost pricing in effect, and the treatment facility scaled to size Q_1^*, the deficit is the area (P_1BCE). The per unit share of the deficit (average deficit) is equal to (P_1BCE/Q_1^*). With a plant scaled to Q_2^*, and again utilizing marginal cost pricing techniques, the deficit becomes the area (P_2ADF), and the average per unit share of the deficit is (P_2ADF/Q_2^*). It can be seen that $(P_2ADF/Q_2^*) < (P_1BCE/Q_1^*)$, due to the fact that we are operating in the declining portion of the average cost curve. Since per unit costs are lower, the city benefits from the inclusion of the N101 in its treatment system. This conforms with the previous theoretical discussion.

Summary

This chapter has shown that there are distinct advantages for the city of Tillamook in building the increased waste treatment

[7] It should be noted that plant sizes Q_3^* and Q_4^* are based on an inflated demand caused by the infiltration/inflow problems, and these waters do not represent an increase in the revenue base that will have to pay the costs of expansion and treatment.

capacity necessary to include the North Highway 101 Sanitary District in its sewerage system. These benefits accrue regardless if the city corrects its infiltration problem. They are (1) expanded use of the system at a lower uniform marginal price and (2) a reduced average share of the deficit that occurs with economically efficient marginal cost pricing techniques.

Chapter IV will measure these benefits with relevant cost data.

Pages 38-41 have been removed from the thesis.

IV. TREATMENT FACILITY AND SEWER EXTENSION COST ESTIMATES

Introduction

When considering the optimal design capacity of a waste treatment facility, planners must know the future population and demand growth expected in the planning period.

Once future demand estimates have been made, it is possible to examine the capital costs of the various alternatives, as well as the treatment costs associated with each alternative.

This chapter will examine the functional relationships of the appropriate capital and treatment costs associated with the proposed Tillamook city waste water treatment facility. Included is a discussion of the costs of extending sewer lines into the North Highway 101 Sanitary District.

Basic Design Data

Population Estimates

Based upon estimates made by the Tillamook County Planning Commission, population levels in and around the city of Tillamook are not expected to grow significantly in the next 25 years. This prediction is supported by current economic problems as well as the characteristics of the Tillamook County economy. Therefore, on the assumption that population levels will change little over the time horizon appropriate to planning a new waste treatment facility, attention can turn to an analysis of the existing situation.

Required Facility Size

Estimates of expected sewage loads by 1985 show that the new treatment facility for the city of Tillamook should have a design capacity of 3-5 MGD. The range was determined by engineers from CH_2M-Hill based on anticipated population levels in the service area, and the volumes of infiltrated waters in the system at the present time during the rainy season. It is assumed that the normal wet weather infiltration is approximately 2 MGD. The rest of the increase in the load (from .7 MGD to 3 MGD) takes into account the entire local area surrounding the city, since DEQ envisions the city treatment facility as an area sewage treatment plant in the future.

N. 101 Population Load

The present population of the N. 101 district is less than 100 full-time residents. As a consequence, even allowing for the retail customers of motels and restaurants, as well as some reasonable developmental growth, the maximum N. 101 district load should not exceed 50,000 gallons per day.

Tillamook City Demand

The residents of the city of Tillamook presently inpose a load of approximately 700,000 gallons per day. Preliminary estimates place the 1985 demand on the system at approximately 3 MGD. This figure includes the entire proposed service area around the city, including the N. 101 district, as noted earlier. With an average winter day infiltration rate of approximately 2 MGD, and without correcting its infiltration problem, the city would require a facility of approximately 5 MGD design capacity. By correcting the bulk of the infiltration, the proposed area-wide system would need to treat approximately 3 MGD average sewage flow.

Capital and Treatment Costs

Capital Costs

The costs associated with the alternatives presently faced by the city of Tillamook can be compared in terms of the framework presented in Chapter III.

The functional forms of costs associated with the type of trickling filter design that would satisfy the required effluent standards that must be met by the city are shown in Table 1, below.

Table 1. Capital and treatment cost equations, city of Tillamook waste treatment plant.

Total Capital Cost	$\log TC_K = .04 + .78 \log Q$
Average Capital Cost	$\log AC_K = \frac{.04 + .78 \log Q}{Q}$
Marginal Capital Cost	$MC_K = .86\ Q^{-.22}$
Total Treatment Cost (annual)	$TC_T = \$15,000 + \$65,000\,Q$
Average Treatment Cost (annual)	$AC_T = \frac{\$15,000}{Q} + \$65,000$
Marginal Treatment Cost (annual)	$MC_T = \$0.065$

Source: Water and Wastes Engineering, March 1974.

From the perspective of this study, the city of Tillamook has four alternatives regarding its sewerage planning. These include: (1) to leave all but the most serious (in a health or safety capacity) infiltration unchecked, and treat only city-generated sewage with the infiltrated waters; (2) to leave the infiltration problem unsolved, but to treat sewage from the N. 101 district together with the city's waste and the infiltrated waters; (3) to reduce the infiltrated waters to negligible levels and only treat city-generated sewage; and (4) to reduce infiltration and treat sewage from the N. 101 district together with the city's waste.

Table 2 presents the estimated capital and treatment costs, based on the equations in Table 1, for each of the alternatives described.

Table 2. Estimated capital and treatment costs, alternatives 1-4.[a]

Alternative	Design Capacity MGD	Capital Cost	Treatment Cost
1	2.95	$2,550 million	$271,750/year
2	3.00	2.583 million	275,000/year
3	4.95	3.818 million	401,750/year
4	5.00	3.848 million	405,000/year

[a]Cost estimates based on equations given in Table 1.

Local Capital Costs

A portion of the capital costs of a waste water treatment facility may be paid with a 75 percent federal grant. Table 3 shows the federal and local sharing of the capital costs with federal grants made available.

Table 3. Estimated total, local, and annual capital costs of alternative Tillamook city waste water treatment plants.

Design Capacity	Total Capital Cost (million)	75 Percent Federal Grant (million)	Local Share	Annual Amortization Cost[a]
2.95 MGD	$2.550	$1.913	$637,000	$59,500
3.00 MGD	2.583	1.936	647,000	60,500
4.95 MGD	3.818	2.864	955,000	89,300
5.000 MGD	3.848	2.886	962,000	89,900

[a]With a 20 year amortization rate at 6-7/8 percent interest.

Although 30 year amortization rates have been used for many public service projects, a 20 year rate is presented in this study in accordance with accepted engineering practice in dealing with the sophisticated equipment used in modern advanced sewage treatment. The current federal discount rate of 6-7/8 percent is used as the interest rate throughout this presentation.

Sewer Extension Costs

The next costs to be estimated are those related to the extension of interceptor main and lateral sewer lines into the North Highway 101 Sanitary District, complete with pump station costs, engineering and legal fees, and other associated costs.

A preliminary study, completed in 1972 by CH_2M-Hill, estimated the total cost of extending sewer lines approximately 2,200 feet from the north city limits at Hoquarton Slough to Dougherty Slough to be $106,000. An update of that estimate based on the EPA sewer construction cost index, would place the total cost at approximately $140,000.

The remainder of the district has not had a comparable cost estimate. However, another study by CH_2M-Hill in 1969 estimated the cost of extending sewer lines[8] from Dougherty Slough to the Wilson River at $49,000 as compared with a cost of $70,000 from Hoquarton Slough to Dougherty Slough. If this 49/70 ratio is assumed to apply in 1975, the cost of serving the area from Dougherty Slough to the Wilson

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[8]This study did not include engineering, administrative, or contingency fees, nor did it include pump station costs.

River would be estimated to be $98,000.

The $140,000 estimate for the first portion of the district includes the following costs: (a) necessary interceptor main pressure sewer line; (b) three lateral main sewer lines; (c) two highway cross borings;[9] (d) one pump station; and (e) engineering, legal, administrative, contingency, and other costs.

The remaining portion of the district may require: (a) necessary main interceptor pressure sewer lines; (b) two highway cross borings; (c) possibly one pump station; (d) three lateral main sewer lines; and (e) engineering, legal, contingency, administrative and other costs. As of May 1975, an adequate engineering study has not determined whether a second pump station would be required at the Wilson River. However, because the 4,300 foot distance from the Wilson River to the pump station at Dougherty Slough includes a relatively high spot near what is presently the end of the intensive development in the district, a second pump station may be required. On the basis of this fact, the cost of extending lines into the second portion of the district may well approach the $140,000 estimate made for the first portion. Thus, an estimate of $280,000 to serve the entire district will be used as the appropriate cost estimate.

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[9]Oregon law prohibits cutting across a major highway such as Highway 101, which makes it necessary to bore under the highway in order to serve the other side of the district.

Table 4 presents a compilation of the costs of the two alternatives under discussion: (1) the termination of sewer line extension at Dougherty Slough; and (2) extending sewer lines throughout the district, to the Wilson River.

Table 4. Alternate sewer expansion costs for North 101 Sanitary District.

	Total Cost	Front Foot[a]	Area (ft^2)[b]	Per $1000 TVC
Total expansion cost:				
Case #1	$140,000	$31.82	$0.0636	$ 69.20
Case #2	280,000	21.54	0.0430	138.40
Annual cost (20 year @ 6-7/8%):				
Case #1	$ 13,087	$ 2.97	$0.0059	$ 6.47
Case #2	26,174	2.01	0.0040	12.94

[a]Total front footage: Case 1 = 4,400 feet; Case 2 = 13,000 feet.

[b]Area = front foot x depth in feet. District is 4,400 x 1,000 (Case 1) or 13,000 x 1,000 (Case 2).

The total front footage involved in the first case, including both sides, is approximately 4,400 feet, and in the second case it is approximately 13,000 feet. The costs based on area are computed using a depth of 1,000 feet (500 feet on either side of the highway). The appraised true cash value of all properties in the district in 1974-75 was $2,023,460.[10]

[10]A conversation with Mr. Morton Meyers, Tillamook County Assessor, indicates that the presence of sewer lines in the district would increase property values an average of 20 percent.

Total Cost Estimates

Table 5 presents a compilation of the estimated costs of the various alternatives available to the city of Tillamook. These costs do not include the district's cost of extending sewer lines into the N. 101 district (see Table 4), nor do they include the city's cost for infiltration corrections (not determined at this writing).

The treatment cost figures in Table 5 for the 4.95 MGD and 5.0 MGD facilities are not based upon the full capacity figures, but are based instead upon those volumes of waste water directly attributable to the entities generating sewage.

Since 2MGD of the volumes included in the capacity figures are wet-weather infiltration that occurs for about half a year and has no supporting revenue base, per gallon treatment costs that include infiltration would be misleadingly low. The cost of treating these waters must be paid by the users of the system.

Table 5 attempts to accomplish this by presenting the cost figures for both a 4.95 MGD and a 5.00 MGD waste water treatment facility with adjustment made for these considerations. These figures more accurately describe the situation as it exists in terms that are more relevant to the decision maker.

Table 5. Local costs of Tillamook city waste treatment plant alternatives.[a]

	2.95 MGD	3.00 MGD	4.95 MGD	5.00 MGD
Capital Costs:				
Total Capital Cost	$637,000	$647,000	$955,000	$962,000
Average Cost/Gallon Capacity[b]	0.2159	0.2157	0.3237	0.3207
Marginal Cost/Gallon Capacity	0.1695	0.1688	0.1505	0.1500
Total Annual Capital Cost	59,500	60,500	89,300	89,900
Avg. Annual Capital Cost/Gal. Cap.[b]	0.202	0.0200	0.0303	0.0300
Marginal Ann. Capital Cost/Gal. Cap.	0.0157	0.0157	0.0141	0.0141
Treatment Costs (Annual):				
Total Treatment Cost	206,750	210,000	271,750[c]	275,000[c]
Avg. Cost/Gallon Capacity	0.0701	0.0700	0.0940	0.0917
Marginal Cost/Gallon Capacity	0.0650	0.0650	0.0650	0.0650
Total Costs (Annual)				
Total Annual Cost	266,250	270,500	361,050	364,900
Avg. Cost/Gallon Capacity	0.0903	0.0902	0.1224	0.1216
Marginal Cost/Gallon Capacity	0.0807	0.0807	0.0791	0.0791

[a] Cost estimates based on equations given in Table 1.

[b] Includes only water volumes with resource base, determined by subtracting 2 MGD infiltrated water water from design capacity.

[c] Most infiltration occurs November to April. These costs are determined by adding one-half the annual treatment costs of 2MGD (infiltration) to the annual treatment costs of 2.95 MGD and 3.0 MGD facilities, respectively.

Summary

This chapter has presented data concerning the construction costs of a waste water treatment facility for the city of Tillamook, as well as cost data for an extension of sewer lines into the North Highway 101 Sanitary District.

Techniques for financing these costs are described in Chapter V and the concluding chapter of this study will discuss an appropriate financing formula.

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V. CURRENT AND PROPOSED FINANCING ALTERNATIVES

Preceding chapters in this study have dealt with general principles of public service offerings and their associated costs. Turning now to the sources of revenue available to municipalities and special districts, a discussion of general pricing criteria and techniques is in order.

Current Financing Practice

Capital costs of waste treatment facilities and collection systems are normally paid initially with revenues generated from the issuance of general obligation bonds. These bonds are backed by the full faith and credit of the issuing authority, and are normally 20 or 25 year term bonds retired through the use of special assessments and connection charges, property taxes, and less commonly, through the use of sinking funds that may be replenished with planned excess revenues from connection charges, system development charges, and a portion of the monthly sewer service charge.

The operating costs of the treatment system are normally paid through the use of a periodic sewer service charge paid by those who actually use the facilities.

Current financing programs are based upon an average cost-determined set of prices, designed for full cost recovery. In the interest of economic efficiency certain revisions in current practices are suggested.

Proposed Revisions in Financing Practices

Monthly Service Charge

A monthly sewer service charge is normally assessed against those in the service area who actually use the treatment facility. This charge is designed to cover the variable operating and maintenance costs of the facility, which are incurred in the waste treatment process.

In order to arrive at the appropriate service charge level, total operating and maintenance costs are first determined. These costs are then apportioned among the users of the system.

Under average cost pricing principles, this change is determined by dividing total costs by the number of users (if their use is fairly homogeneous), or as a percentage of the water bill where water service is metered.

With the use of marginal cost pricing, the monthly charge would be a flat-rate charge designed to cover the strictly variable costs (personnel, maintenance, chemicals, power, etc.) of waste treatment. Again, waste loads can be estimated either through historical averages, or as a percentage of the water bill.

Any deficit that results from this change would then become a part of the annual assessment financed through the property tax, as discussed later.

Connection Charges and Special Assessments

Connection charges and special assessments are made to finance costs that directly benefit individual users of the system, such as the provision of lateral sewer lines, and system access connections. According to the benefits-received principle of taxation, users of the system should be required to pay the entire cost of extending service to them, since cost is assumed to be a measure of the benefits received.

Some benefits may be collective in nature, though not system-wide, such as interceptor sewer lines, lift stations, manholes, etc. It may be that certain areas impose some costs on other users, that would not be incurred in their absence, such as a lift station that becomes a necessary part of the collection system to pump wastes from outlying areas. In this event, average cost pricing would not reflect the benefits received accurately since incremental, or marginal costs imposed by some individuals are averaged over all users. Therefore, marginal cost pricing is necessary in the interest of equity.

Even though some costs can be shown to benefit individual users directly, e.g., the costs associated with the provision of connections to the property lines, such costs are normally sufficiently homogeneous to allow for average cost pricing, since average cost equals marginal cost. However, if it can be shown that a particular property will cause costs significantly different from other properties, the individual property should be assessed the total cost incurred in providing it with a connection.

Once again, if a deficit develops through the use of marginal cost pricing of these system-wide costs, it becomes a part of the general property tax assessment.

The costs of the collection system are then assessed against the properties which benefit directly from it, on an equal basis, under Oregon state law.

Upon individual property owner's application these special assessments can be financed through the sale of Bancroft bonds. The Bancroft Bonding Act, ORS 223.205-223.300, enables municipalities and special districts to assess a portion of the cost of sewers and other improvements against the properties that directly benefit from these improvements.

A problem that may develop from the use of Bancroft bonds stems from the legal restriction limiting the sum of all assessments against an individual property to 1.2 times it appraised true cash value. As a result, owners of very low valued properties may be required to make substantial cash payments to cover their share of expansion costs.

Also, since Bancroft bonds can take up to ten years for complete repayment, an interim form of financing may be necessary for the service authority, such as general obligation bond sales.

Property Taxation

Property taxes are a means of distributing system-wide collective costs among all property owners in a service area. This can be regarded as consistent with the general principles of taxation according to the benefits received.

The deficit that can result from the use of marginal cost pricing is assumed to represent costs associated with the provision of system-wide benefits. These benefits are the public good that results from the existence of sanitary waste treatment. The public good is a collectively shared benefit in the form of public health, welfare, and safety that occurs from the elimination of the public bad. This good may be the prevention of the breeding and spread of disease, the removal of possible contaminants of the local water table and surrounding bodies of water, and other environmentally and aesthetically sound occurrences that may result from the prevention of inadequate waste water treatment. Whether the inadequacy takes the form of failing septic tanks or a treatment facility required to operate beyond capacity, the public bad affects everyone in the community. Therefore, the public good that results from the elimination of the public bad is also shared by everyone in the community.

The property tax appears to be the best single way to allocate system-wide costs, since everyone shares in the public good, and it can be argued that property valuation gives an indication of the relative share of the benefits received. Property owners, tenants, and indirectly, transients, would all share in the deficit.

Federal Grants

All the methods of financing the capital costs of the waste treatment system discussed here deal of course with local costs. The actual capital costs of constructing a sewerage system may qualify for federal and state aid in the form of construction grants.

These grants are available to aid municipalities in the construction of sewerage systems, and will pay 75 percent of the eligible costs for waste treatment facilities, interceptor sewers, and pumping stations, if the service area request is accepted.

Important sources of federal funds include the Federal Water Pollution Control Act of 1972 (FWPC), the Environmental Protection Agency (EPA), the Farmers Home Administration (FHA), and the Department of Housing and Urban Development (HUD)--supervised

Housing and Community Development Act of 1974 (HUDCD).

The city of Tillamook should qualify for federal funding of 75 percent of its eligible expenses. Therefore, cost estimates presented later in this study are made with this federal help assumed.

While it may be true that the North Highway 101 district will also have some expenses qualify for federal funding, this eligibility is not clear at this time, and the cost estimates for the district do not include the assumption.

Conclusion

This chapter has demonstrated how marginal cost pricing techniques can be used to finance sewer services. To do this, it is only necessary to calculate and set monthly service charges, connection fees, and special assessments on a somewhat different basis than is currently done. This difference results primarily from the recommended reliance on marginal cost pricing, with the planned deficit financed with an annual assessment against all properties within the service area.

VI. SUMMARY AND RECOMMENDATIONS

Summary

The purpose of this study was to establish a theoretical framework for public service financing and determine the implications of marginal cost pricing for a waste treatment facility for the North Highway 101 Sanitary District and the city of Tillamook, Oregon.

Chapter I presented background information describing the study area and the problems to be considered. Chapter II then discussed benefit and cost measurement in general terms based upon conventional secondary waste water treatment methods, as well as the effects of demand on the appropriate facility size and type.

Economic efficiency and optimal plant size were the topics of Chapter III, where short and long run considerations relevant to pricing on both an average and marginal cost basis were investigated. This was followed by a general discussion of the alternatives open to the city of Tillamook in order to meet its sewage treatment expansion and rehabilitation needs. The theoretical analysis demonstrated that it was to the city's advantage to expand plant capacity to serve the North 101 district, regardless of whether the city decided to eliminate its infiltration problem. This was supported by the estimated cost data presented in Chapter IV.

Although greater accuracy in the data would be required prior to the actual determination of property assessments, the size of bond issues, or the establishment of monthly sewer rates, presently available data provide reasonable estimates of approximate costs. The implication of the study should not be impaired by the lack of precision in the cost data presented in Chapter IV.

Four alternatives for the city were presented in Chapter IV:

1. Correct its infiltration problem, build a 2.95 MGD treatment facility, and not serve the North Highway 101 Sanitary District.
2. Correct the infiltration problem, and build a 3 MGD facility, to include the N. 101 district.
3. Leave the infiltration basically unchecked, build a 4.95 MGD facility, and not serve the N. 101 district.
4. Not correct the infiltration, but build a 5 MGD facility in order to also serve the N. 101 district.

Based upon the presentation of cost data, it would appear that not only would it be advantageous for the residents of the city of Tillamook to include the North 101 district in their waste water treatment system, but it may well be to their advantage to solve their infiltration problem.

Even though infiltration elimination costs have not been determined as of November 1975, certain data is available that will be useful in the decision-making process once those costs are made available. Then a comparison of the costs of infiltration upon the treatment system and the costs to society to eliminate the infiltration problem will be possible.

Chapter V considered pricing techniques and financing alternatives available to both the city of Tillamook and the North Highway 101 district. It was indicated that the bulk of the initial funds for capital costs must come from the sale of general obligation bonds, with the principle and interest payments made from any existing reserve funds, ad valorem taxes, property pre-assessments, and a portion of the sewer service charge. Property owners facing sewer assessments could elect to use Bancroft bonding to pay the assessments, but general obligation bonds may still be required as an interim financing method since assessments for Bancroft bonds can be made only after exact costs have been determined.

The North Highway 101 Sanitary District must decide how far it wishes to extend sewer lines into the district. Two alternatives have been discussed: (1) extending lines to the approximate end of present development within the district (Dougherty Slough); and (2) extending sewer lines throughout the district to the Wilson River. This decision will undoubtedly reflect the economic factors of costs and benefits received, as well as political and developmental factors such as flood plain and agricultural land use goals.

Recommendations

Two recommendations based upon data presented in this study can be made. First, it is recommended that the cost associated with the correction of the infiltration problem in Tillamook be determined in order to facilitate a comparison with the cost of treating the infiltrated waters. Secondly, a recommended allocation of sewerage system costs within the North Highway 101 Sanitary District is presented based upon marginal cost pricing principles. It is felt that this allocation of costs more nearly reflect the benefits-received principles of taxation and pricing than methods commonly employed.

Total Cost of Treating Infiltrated Waters

By referring to data presented in Tables 3 and 5, an estimate of the cost to society imposed by the presence of infiltrated waters may be calculated. This estimate is derived by adding the cost of expanded facility size and increased treatment costs made necessary by the presence of infiltration.

The approximate annual cost of treating infiltrated waters can be determined by subtracting the annual treatment costs of 3 MGD facility ($210, 000 from Table 5) from the annual treatment cost of a 5 MGD facility ($275, 000 from Table 5), which yields a cost of $65, 000. The present value of $65, 000 over 20 years at an interest rate of 6-7/8 percent would amount to approximately $695, 000.

Referring to Table 3, the increased capital costs of treating infiltrated waters is approximately $1.265 million ($3.848 million-$2.583 million). Therefore, the total estimated social cost of treating infiltrated waters is approximately $1.96 million.

The importance of this estimate is as follows. If the costs of infiltration elimination do not exceed $1.96 million, it would become economically efficient to correct the problem. However, if the cost of infiltration elimination exceeds $1.96 million, the decision to leave the problem unchecked may be appropriate, providing that the environmental costs remain negligible. If they are not negligible, the elimination of infiltration at a cost exceeding $1.96 million may be justified.

<u>Monthly Charges</u>

In accordance with the marginal cost pricing techniques previously discussed, the total monthly charges in Table 6 are determined by adding the marginal treatment cost and the marginal operating and maintenance costs. Any deficit that develops as the result of marginal cost pricing should then be made up through some form of annual assessment as indicated in the property tax portion of Table 6.

Table 6. Cost apportionment in North Highway 101 Sanitary District

	Area 1 [(a)]	Area 2 [(b)]
<u>Monthly Charge</u>		
(1) Treatment (e.g. chemicals)	$r_i \Delta\,\text{Treat.}_1$	$r_i \Delta\,\text{Treat.}_2$
(2) Operating & Maintenance	$\Delta\,OMC_1$	$\Delta\,OMC_2$
Total Monthly Charge	Σ lines 1, 2	Σ lines 1, 2
<u>Special Assessments</u>		
(3) Pipeline Costs	$ff_i\,(\Delta\,TPLC_1)$	$ff_i\,(\Delta\,TPLC_2)$
(4) Excavation Costs	$TEC_1/\Sigma\, ff_i$	$TEC_2/\Sigma\, ff_j$
(5) Connection Costs	TCC_1/n_1	TCC_2/n_2
(6) Pump Costs	$r_i(\Delta\,TPC_1)$	$r_i(\Delta\,TPC_2)$
(7) Facility Capital Costs	$r_i(\Delta\,TFC_1)$	$r_i(\Delta\,TFC_2)$
Total Special Assessment	Σ lines 3,4,5,6,7	Σ lines 3,4,5,6,7
<u>Property Tax</u>		
(8) Facility Capital Cost	deficit TFC_1	deficit TFC_2
(9) Pipeline	" $TPLC_1$	" $TPLC_2$
(10) Pumps	" TPC_1	" TPC_2
(11) Treatment (e.g. chemicals)	" Treat._1	" Treat._2
(12) Operation & Maintenance	" OMC_1	" OMC_2
Total Property Tax	$\frac{AV_i}{\Sigma AV_i}\,[\,\Sigma \text{ lines } 8,9,10,11,12]$	$\frac{AV_j}{\Sigma AV_j}\,[\,\Sigma \text{ lines } 8,9,10,11,12]$
Property Tax Rate	$\frac{(\Sigma \text{ lines } 8,9,10,11,12)}{\Sigma AV_i}$	$\frac{(\Sigma \text{ lines } 8,9,10,11,12)}{\Sigma AV_j}$

(continued)

Table 6. continued

(a) Area 1 includes the area from Tillamook city limits north to approximately Dougherty Slough.

(b) Area 2 includes the area from Tillamook city limits north to the Wilson River.

Key to Table 6:

OMC	=	operation and maintenance costs (lines 2, 12)
TPLC	=	total pipeline costs (lines 3, 9)
TEC	=	total excavation, fill and paving cost (line 4)
TCC	=	total connection cost (line 5)
TPC	=	total lift station and pump costs (lines 6, 10)
TFC	=	total treatment facility capital costs (lines 7, 8)
Δ	=	marginal cost
r	=	residential unit of waste
ff	=	front footage of a property in area described
i	=	1, . . . , n potential connections in area 1
j	=	(n+1), . . . , m potential connections in area 2
AV	=	assessed valuation in area described

Special Assessments

Capital costs are treated individually in Table 6 in order to assign them on a marginal cost basis to properties in the district.

Treatment Facility. Marginal capital costs imposed on the city by the expanded treatment facility size required to serve the residents of the district are apportioned on a "residential unit" basis, and then amortized over the financing term, normally 20 years for G. O. bonds, to become a portion of the total annual assessment.

Since the increased capacity of the treatment facility is required only to handle the potential waste volumes generated by the district, total marginal capital costs are apportioned among district property owners according to the potential waste volumes that their properties are anticipated to generate. Waste volumes are measured in residential units to allow flexible application of this basic cost allocation principle. The basic result presented in the formula itself is derived from Littlechild's famous article, "Marginal Cost Pricing with Joint Costs": joint costs are efficiently allocated according to the value of the service received by users. In this instance, it is assumed that the marginal value of sewer service is about equal among potential connectors within the N. 101 Sanitary district.

Main and Lateral Interceptors. The marginal cost of sewer pipe and associated material is allocated on a front footage basis in Table 6, under special assessments. Of course, marginal cost allocation of the pipeline costs implies a deficit equal to total cost less marginal cost accumulated on a front footage basis could result. This deficit then becomes a part of the property tax section of Table 6.

Excavation. Excavation costs are based entirely on footage because excavation is a constant cost activity. Thus these costs are allocated on a front footage basis.

Connection Charges. Under normal conditions it is appropriate to base the allocation of total connection costs on the average cost of providing the service connection to the property line. Since most connections vary little in cost, this approach is generally sound. However, in the event of unusual connections where cost varies significantly from normal, properties should be charged a price equal to their actual cost.

Pumps. Since users of the system would benefit from pumps in accordance with the potential load they impose upon the system, marginal pump costs would be apportioned on a residential unit basis. Any resulting deficit would again become a part of the property tax to reflect the benefits society as a whole gains from the use of the pumps.

Property Tax

The property tax is recommended to recover the cost deficits incurred with the applicaton of marginal cost pricing, for reasons stated in chapter five. Thus, in Table 6, the deficits associated with the treatment facility capital costs, pipeline and pump costs, and the operating, maintenance, and treatment costs are all components of the general property tax for sewerage service. The tax on each property is based upon the assessed valuation of the property, with the rate equal to the sum of the deficits in Table 6 divided by the total assessed valuation of properties within the district.

Areas for Further Study

Areas for further study include the determination of the cost of eliminating infiltration and inflow from the city of Tillamook sewerage system. Once this cost is known, planners will have the information necessary to decide whether to correct it.

A more complete assessment of the economic and environmental questions regarding development in the Wilson River flood plain specifically, and along the Oregon Coast in general, is indicated by this study. One specific difficulty in the Tillamook area concerns the lack of coordination between the various governmental planning units. Improved communications between the various levels of government, coupled with more accurate information, should help eliminate some future problems.

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