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ENERGY, WATER AND TELECOMMUNICATIONS DEPARTMENT

GUIDELINES SERIES

ECONOMIC EVALUATION AND FINANCING OF SEWERAGE PROJECTS

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i. This paper considers the particular problems that arise in applying the usual tools of economic evaluation to sewerage projects and recommends a systematic approach to deal with project justification and pricing. It is intended as a supplement to Economic Evaluation of Public Utilities Projects (GAS 10) and assumes the reader is familiar with the issues discussed there.

ii. Sewerage projects present special difficulties in each of the three main components of economic evaluation: the demand forecast, the least-cost solution and the benefit-cost comparison. Forecasting demand, or willingness to pay, is difficult because many projects are designed for areas which currently lack sewerage facilities and where the alternative has been to do without. This has obvious health and environmental costs but few quantifiable financial ones. Thus in practice the demand for sewerage service (or lack of it) will usually have to be inferred from the water usage of the area, the extent of environmental pollution, local wage levels and whatever information can be gathered on householders' priorities and needs.

iii. Closely tied to the demand question, of course, is the selection of the least-cost method of providing sewerage.1/ Conventional waterborne systems are usually subject to economies of scale which make the initial investment per user quite high. In addition, since the least cost size is generally large enough to satisfy demand well into the future, the risk of overly optimistic demand projections is especially expensive. More flexible, individual disposal systems or non-waterborne community collection are usually much less costly to construct but often provide a lower level of service which may entail health problems and/or consumer rejection. Thus it may be necessary to prepare separate demand forecasts for the various alternatives (since both the cost and the service differ significantly) in order to determine which is the most cost-effective. The capability of the community as a whole to afford the investment must be considered as a final check. In capital-short developing countries it is especially important that the entire range of sewerage technology and corresponding service levels be considered in the least-cost decision.

iv. Coupled with the selection of the appropriate technology is the benefit-cost comparison. Unfortunately, however, in most cases it is not possible to resolve the problem of benefit measurement.

1/ A research project to explore alternative, low cost methods of waste disposal is currently underway within the Bank under the supervision of the Energy, Water and Telecommunications Department.

projects approved contained a sewerage component whereas in the previous decade (FY 64-74) sewerage was provided for in only 30% of the Bank's water supply projects. With this increasing demand for sanitation assistance the need for specific guidelines on the economic evaluation of such projects has become evident: in only two of the FY 75-76 projects surveyed in Annex 1 was any attempt made at an economic justification, and even in those cases the results were admittedly inadequate.

1.02 The theoretical problems involved in determining economically optimal pricing and investment rules for sewerage projects are the familiar ones of capital indivisibility, unquantifiable benefits, metering and so forth which have been extensively discussed in the context of water supply project evaluation.1/ In the case of water supply, the general recommendation is to set price equal to marginal cost to enable the consumer to reveal the value he places upon incremental output, and thereby provide a signal for investment and project justification. The internal rate of return calculation, which is based on data identical to those needed to calculate average incremental cost (AIC),2/ supplies a rough cross check on the adequacy of pricing policy and project viability.

1.03 In sewerage projects, however, major difficulties arise in applying these basic techniques of public utility project evaluation. Conventional sewerage technology3/ usually requires a relatively large investment per user which implies that charging connection fees to cover the cost of network extensions would effectively exclude most of the poor from receiving service even though the largest environmental benefits may result from serving low income areas.4/ In addition, since non-incremental costs are often large, the economically optimal policy of setting prices equal to short-run marginal costs is likely to result in financial deficits during the life of the project.5/ Even pricing at average incre-

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1/ See for example, Economic Evaluation of Public Utility Projects (GAS 10), September 1974, Urban Water Supply and Sewerage Pricing Policy (PUN 11), March 1974 and The Definition and Role of Marginal Cost in Public Utility Pricing (RES 6), July 1976.

2/ AIC is defined below (para. 4.08). For a discussion of the role of the internal rate of return calculation see L. Squire and H. van der Tak, Economic Analysis of Projects, John Hopkins University Press, 1975.

3/ The research project to explore alternative, low cost methods of waste disposal which is being undertaken by EWT could have major implications for the availability and pricing of sewerage services.

4/ The low income areas of a city are not necessarily those most in need of public sewage disposal since their use of water may be much lower than that of other residential areas where house connections are more common. However, they may be the areas where the general level of sanitation is the lowest and where an investment to improve sanitation would have the highest return.

5/ For a discussion of the issues concerned in the appropriate trade-off between financial objectives and economic efficiency see A. Ray "Cost Recovery Policies for Public Sector Projects," Bank Staff Working Paper No. 206, July 1975.

2.03 In higher income areas forecasts can sometimes be based on the usage rates of similar consumers in other cities. However, if the prospective new consumers have already installed septic tanks which adequately serve their needs then their demand for piped sewerage may be much lower than in similar areas where sewerage connections have been available for a long time. In lower income areas where some system of nightsoil collection or individual transport and dumping is practiced, the cost of these alternatives can indicate consumers' minimum willingness to pay. If the proposed new system will cost significantly more to construct and operate than the present system (say, five to ten times as much) then one should be extremely cautious about forecasting a large or rapidly growing demand.

2.04 In new markets or other areas where the demand forecast has a high degree of uncertainty attached to it the least cost decision should reflect this risk by preferring more flexible systems over those requiring one-time investments of predetermined size. In some places, of course, the choice of technology will be clear-cut regardless of the likely variation in demand. But in many other cases the least-cost method will be highly dependent on system size (which is a function of expected demand). Suppose that the demand for sewerage connections in a particular area is estimated to be X over the next 10 years. If that forecast is fulfilled the internal economic rate of return (IER) on the project will be 8%; if demand exceeds X the IER will be 9% (since capacity is reached sooner) and if it is less than X the unutilized capacity will depress the IER to 3%. If an alternative technology which can be initiated in stages and expanded gradually (e.g., occasional vacuum truck collection from pit privies) yields a 7% IER over the entire feasible range of demand, then the likelihood attached to the demand estimate will determine which is the least-cost alternative. If the probability of demand being X is 40% while there is a 30% chance of it being either more or less than X, then the expected value[1/] of the IER for the first alternative is less than the 7% which the second alternative will produce. The general conclusion that the choice of technology may be influenced by the degree of certainty of the demand estimate is, of course, true for all types of projects. However, it is more likely to make a signficant difference in sewerage projects both because the range of technology is so wide and because of the exceptional difficulty of making precise demand forecasts.

III. MEASURING SEWERAGE BENEFITS

3.01 The cost-benefit comparison is closely tied in with the problem of identifying the least-cost technology. As is true of other utility projects, however, the effective use of cost-benefit analysis is frustrated by the difficulty of benefit measurement. This problem is compounded by the importance of external benefits which accrue to persons

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1/ The expected value (E) is the sum of the probabilities of each possible outcome multiplied by the value of that outcome. Thus for the first alternative:

$$E = 0.40\ (8\%) + 0.30\ (9\%) + 0.30\ (3\%) = 6.8\%$$

while for the second alternative E = 7%.

indicator of beneficiaries' willingness to pay for environmental improvement. Since investments in public sewerage frequently result in a dramatic improvement in the well-being of the households connected to the system, one might expect that landholders would often place a value upon their land being served by a public sewerage system that is in excess of the amount they actually have to pay for that service. This implies that, other things being equal, the value of land that has access to the service would be greater than that of land that does not. In contrast to the sewerage "market", which does not work very well because there is not a host of suppliers able and willing to compete effectively with the sewerage authority, the property market often consists of large numbers of competitive buyers and sellers, in which case there is opportunity for the effective willingness of people to pay for sewerage facilities to be revealed.

3.05 An effort was made in the Sao Paulo Pollution Control Project to measure the benefits of a sewerage interceptor, which would effectually transform an open sewer into a relatively clean river, by estimating the impact that this would have on riparian land values. A similar attempt was made in the Tunisia Pollution Control Project where the benefits included enhancement of the value of undeveloped land. However, such analyses are not easily transferable to the typical Bank sewerage project where the new system primarily influences the values of existing developed properties. In such cases it becomes much more difficult to disentangle the sewerage related changes from the multitude of other factors influencing community property values.

3.06 Empirical testing of the hypothesis that investments in sewerage have a positive impact on property values would require data both on the "project area", which is the site of the investment, and a "control area", which would be used to help isolate project effects from all other factors that might influence land values. A fairly rigorous econometric trial of the land value hypothesis has been made in the Bank using data from such areas in Nairobi and Kuala Lumpur.[1/] However, even in such a case where maximum effort was made to isolate causal effects, a number of difficulties common to most such studies frustrated a clear conclusion. The more important of these were the anticipation of property value rises, the treatment of property taxes, changes in zoning and other controls, site improvements, externalities, information problems and the effects on property values outside the project area.

3.07 In view of the lack of success that has characterized most of these attempts to quantify the benefits of sewerage that accrue to the consumer, only one reliable datum is generally left upon which to base a benefit estimate: the amount that the consumer has demonstrated he is willing to pay for the service. The usefulness of the pricing mechanism stems from its ability to translate the unquantifiable contribution to

1/ For a complete description of the study, see Estimation of the Economic Benefits of Water Supply and Sewerage Projects, Public Utilities Department, IBRD, October 1973.

difficulties of applying this rule to sewerage projects are discussed below. First the most frequently used pricing methods are reviewed along with their respective advantages and weaknesses.

4.02 There are four types of charges that are used, separately or in combination, in the vast majority of sewerage systems. A very common one is a flat periodic (e.g. monthly) fee paid by each connected household, sometimes varying with a usage related characteristic such as the water service pipe diameter, or varying according to type of consumer (residential, commercial, etc.), or with lot size, property value, etc. The popularity of this billing system probably stems from its simplicity and ease of administration. The disadvantage is that it provides no direct link between charges and system usage and may also influence the initial decision to connect by discriminating among consumers whose service costs would be the same although the charges would differ.

4.03 Another common payment scheme involves a surcharge on water billings. A periodic payment is determined by metered water consumption, and may vary with usage blocks, seasons, sewage strength, property value or other consumer related characteristics. This method is based on a recognition of the interdependence of water use and sewerage needs and has the advantage of apportioning costs according to demands placed upon the system, at least as long as the relationship between water use and sewerage flows is constant across consumers. Where this is not the case (e.g. houses with gardens vs. apartments, industries which incorporate water into their products), such a method will be inequitable and may distort water use.2/ This method has also been used in cities where water usage is not metered, but under such circumstances its major advantages are lost.

4.04 A third financing technique, which is generally found in conjunction with one of the others, consists of direct transfers from the government budget. Whether applied to capital or operating costs or both, such an approach, which might also involve cross-subsidies from one part of the country to another, provides no guideline on consumer willingness-to-pay and may remove financial incentives for the sewerage authority to operate efficiently. If these problems can be minimized, however, by earmarking a specific local property tax rate for sewerage, then this is one way to collect from people who are not connected to the sewerage system but benefit from the general environmental improvement.

1/ For a discussion of the practical problems involved in this, see RES 6, The Definition and Role of Marginal Cost in Public Utility Pricing: Problems of Application in the Water Supply Sector, July 30, 1976.

2/ This could be overcome by giving consumers the option of installing their own effluent meters to directly monitor sewage flows as an alternative basis for charges.

the economic solution most often recommended for public utility projects involving large capital indivisibilities: setting prices equal to average incremental cost (AIC). In the case of sewerage the AIC would be defined as the sum of the present value of the stream of capital and operating costs of the proposed system divided by the sum of the present value of the annual volumes of wastewater to be disposed and/or treated. Since no satisfactory method has been found to quantify the cost of different levels of pollution, the quality of the waste disposal method enters the calculation only indirectly through the definition used in the denominator. Thus the AIC becomes an important quantitative input into the selection of the appropriate level of sewerage service but it cannot provide the final answer alone.1/

4.09 For example, suppose two levels of sewerage service are being considered for a particular city: Alternative A which provides for waterborne sewerage with full secondary or tertiary treatment, and Alternative B which recommends a mixture of private and waterborne collection with treatment through settling tanks. Both A and B would have associated cost streams and annual levels of processed wastewater (where the latter would be of different quality). Thus the AICs of each could be calculated and then compared. If the incremental cost of A is three times as high as that of B (per volumetric unit) then the choice between the two should be based upon whether the social benefit provided by A's "cleaner" treated effluent is more than three times as high (per volumetric unit) as that of B's. While this is a difficult and necessarily subjective question, the use of the AIC has simplified the original many-dimensional comparison into a single-variable test.

4.10 In addition, once the quality of the waste disposal method has been selected, setting the sewerage charge equal to the AIC will ensure that, given that quality, the water consumer is provided with an incentive to use the facilities up to the point where the marginal benefit to him from so doing equals the marginal cost of expansion of the means of disposal. The AIC is also the appropriate guideline for price discrimination among consumers whose service costs differ. For example, per capita costs of collection/transmission are generally higher in areas of lower density population. Operating and possibly capital costs of treatment vary according to the composition of effluents, and collection/transmission operating costs increase with distance from the treatment plant and/or eventual outlet. If these cost variations are significant, separate AIC calculations should be made for those unusual customers or groups of customers2/ (e.g. for industries with noxious wastes).

1/ Once the level of service is selected, however, the AIC will provide the appropriate pricing guideline.

2/ In all of these calculations any marginal "downstream" benefits from the project such as providing treated waste water for irrigation should be netted out of the AIC even if no financial recovery of these benefits can be expected.

4.14 This kind of situation, which is common in LDCs, is one in which a reduction in environmental pollution is an important part of the authority's task, but either because of overemphasis on financial objectives or simply a lack of alternative means of finance, the basic objective is not being met most efficiently. Even though the shadow cost of transferring funds from the general revenue may exceed the nominal value, such a course of action will frequently be more efficient than using real resources in building certain elements of a sewerage system when they are not really justified, simply as a means of raising revenue.

4.15 One element of pricing policy remains to be discussed: the connection charge. The general rule for most public utilities is that connection charges should equal connection costs, but since such costs are usually relatively high in the case of sewerage it may be necessary to subsidize them for poorer consumers. Because private benefits are increased when others connect to the sewerage system, there may be considerable justification for cross-subsidization of connection charges either directly or through the municipal tax system. In addition to cross-subsidies, another possibility is to annuitize most of the connection cost so that it can be paid in monthly installments along with the fixed charge.

4.16 Thus the charges for a typical waterborne sewerage system would probably include:

(1) A one time fee based on connection costs with the option to pay only a small amount initially with the rest annuitized under (3).

(2) A surcharge per cubic meter of water use equal to the AIC of sewerage times the proportion of water which is returned as wastewater.

(3) A flat fee which includes:

(a) the annuitized portion of connection costs;

(b) an additional charge to meet financial requirements <u>if</u> the revenue from (2) above is insufficient. This charge may be varied among consumers if cross-subsidization is desired, and may well be extended to households and community enterprises that are not connected to the sewer system.

SURVEY OF SEWERAGE CHARGES

A review of thirteen appraisal reports representing Bank lending for sewerage in FY75 and FY76 provides a fairly broad, if unscientific, cross-section of information on sewerage charges of cities in developing countries. As shown in Table 1, excluding the two cases where information is unavailable or irrelevant, seven of the cities use some form of water surcharge, six use either earmarked taxes or municipal transfers and one incorporates a flat fee (some cities use more than one method). Information on connection charges was lacking in most reports.

Of the seven cities which use water surcharges, one (Hodeida) charges more per cubic meter for sewerage than for the water consumed. Most of the other sewerage rates are around one-half the unit water rates with the exception of Swaziland where the fraction is one-eight to one-sixth (depending on consumption levels). The relationship between sewerage and water rates, of course, will vary with hydrologic conditions as well as financial and economic considerations.

By way of comparison, a 1970 survey of wastewater charges in 72 US cities[1/] yielded the pattern of financing shown below in Table 1.

Table 1 - US Wastewater Charges in Sample Cities

Type of Financing	% of Cities
Taxes	18
Water surcharge	47
Flat fee	28
Combination or n.a.	7
	100

Again the most common method is the water surcharge although most US cities in this category levied varying surcharges for different consumption levels (some progressive, some regressive, some mixed). Nearly all of the cities use betterment levies (generally on front footage) to pay for system extensions so that the periodic charges or transfers from municipal revenues are generally used to cover only operating and maintenance costs. This system might be difficult to apply in developing countries, of course, where homeowners' ability to pay a lump sum amount for the extension of sewer lines is more limited.

1/ E.E. Dupre, Jr., "Survey of Wastewater Rates and Charges," Journal Water Pollution Control Federation, January 1970.

ECONOMIC EVALUATION AND FINANCING OF SEWERAGE PROJECTS

SUMMARY AND CONCLUSIONS

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