Bulletin No. 607

Cost of Public Service

Sewage Collection and Treatment

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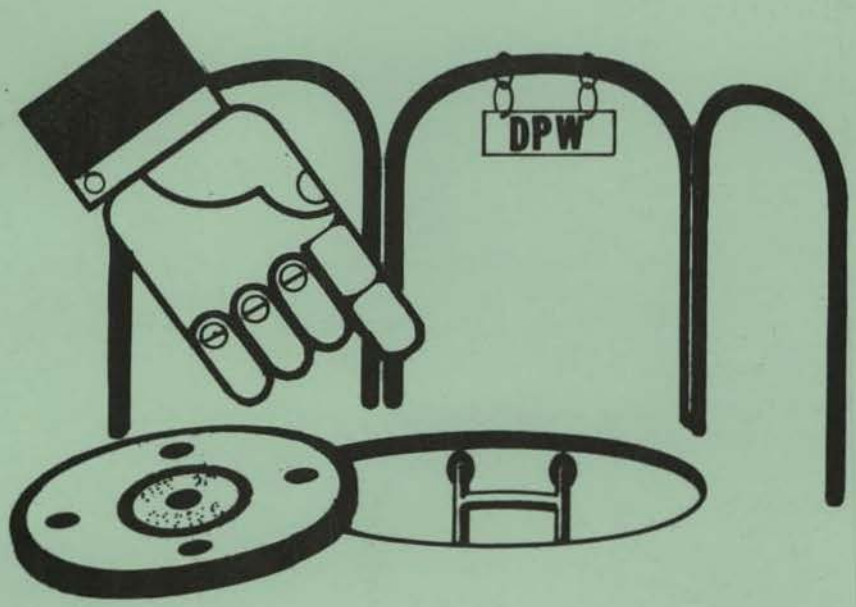

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Contents

This is one of eight bulletins supported by Title V of the Rural Development Act of 1972 on estimating costs of public service in Idaho communities of various size. The services covered in the series are:

- Education
- Fire Protection
- Police Protection
- Sewage Collection and Treatment
- Sheriff Protection
- Solid Waste Disposal
- Water Supply

A worksheet for estimating costs for each service area is designed to facilitate citizen use. Relationships are used to derive costs and are expressed in terms of state averages. You may use the standards as given to derive cost estimates for the services or change them to reflect the situation in your community.

Extension Bulletin 602, *Residential Growth: Its Benefits and Costs to the Local Community*, is used as a format for an overall look at what effects increases in the number of residential dwellings and people have on revenues for the public and private sector and on costs in the public sector. The estimation procedure is outlined for cities, counties and school districts.

This publication outlines a method of estimating your community's increased costs in sewage collection and treatment caused by population growth.

About the Authors

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Cost of Public Service: Sewage Collection and Treatment

N. R. Rimbey and N. L. Meyer

This publication presents a method of estimating expenditures for sewage collection and treatment and a method for estimating the impact of population growth on these expenditures. The cost estimates derived are based on relationships taken from various sources which approximate the actual situation in communities and counties. The relationships are based on state or national averages and can be changed to reflect the situation in your community. Worksheets are provided to help you in the estimation procedure.

Introduction

Idaho is currently one of the fastest growing states in the nation. This growth brings economic benefits such as increased tax revenue to the public sector, possibly more service-oriented jobs and increased spending in the private sector. This growth may also bring general social benefits such as meeting and interacting with people from different cultural backgrounds, more specialized health care and more cultural programs through schools and civic organizations.

However, this growth does not come without additional costs. Many communities and counties in Idaho are not prepared for this growth. The public sector (present residents) must handle the added costs of providing services to the new residents. For example, growth may create needs for a new sewage treatment plant, school buildings, fire and police facilities and equipment, water wells or reservoirs and garbage collection and disposal equipment. Sizable public expenditures may also be necessary for land acquisition and additional employees.

Areas can accommodate growth more easily if the public service infrastructure already exists. That means having excess capacity in the sewage treatment facility, school system and police department and that other services can absorb the population increases without the need for major capital expenditures. Excess capacity in public services does not exist in many rural areas.

The increasing of service capability coupled with the movement toward government spending limitations poses a severe problem for many Idaho communities. "How can we accommodate the rapid population growth and additional service demands of residents and finance the services with reduced or 'frozen' revenues?" This is the most perplexing issue facing state and local government officials.

One possible alternative for local government officials is a program which would require new development to pay its "fair share" of the added service costs. Although this may seem to be a simple policy move, this action will require certain kinds of information. For example, information should be collected and analyzed to determine: the present costs of various services, the estimated costs for new residents, when expansion of which capital facilities will be needed (based on capacities of existing systems and projected growth rates), and what the existing policy of the governmental unit is concerning who should pay the additional costs.

Present costs of services are available in the annual audit report or annual budget of the unit of government. The policy aspect may require investigation of zoning regulations, building permit procedures or conversations with a city or county administrator.

The cost estimates presented here are based on relationships or standards that typify state or national averages. Standards for each service are

presented with the intention that you will change or modify them to fit the situation in your municipality. Worksheets, an abbreviated interest table and sources of information within the municipality are also given to help you in the estimation process.

A word of caution should be injected at this point. The cost figures presented here are **estimates** of actual costs and should be analyzed carefully before basing policies upon them. To help you critically evaluate costs, remember that the standards given should be changed when they prove inaccurate. Variations between actual and estimated costs may result from using average figures, topography of the area, the time lag between estimation and construction and a variety of other circumstances.

Be advised, then, to use care in using the cost figures presented.

This publication was designed to give you, as a concerned citizen or government official, a **framework** for estimating the current costs of a public service. A method to estimate the added costs of population growth is also given. The service covered is police protection.

Methods of Estimating Expenditures

You can estimate costs several ways. The procedure used most often in fiscal impact studies is known as the average cost method. This involves:

1. Using the existing budget or audit report to derive current costs of services.
2. Dividing these costs by number of people or households to determine a per capita or per household cost for each service.
3. Projecting this cost to new residents by multiplying the per capita or household costs by the number of new residents or houses.

This technique may be adequate for projecting the operation and maintenance costs of services but will severely underestimate the impact if capital expansion is needed. The problem lies in basing the estimates on past costs.

A more reliable method is using average cost figures and adding estimated capital costs. In other words, you can use average cost figures from the budgets as well as the estimated increases in capital costs to derive estimates of the impact on expenditures.

The most reliable (and costly) estimation method is conducting a detailed audit of each department within the municipality to determine the actual costs per household (or resident) and determining the anticipated date and cost of needed facilities expansion. This would involve a detailed study of each employee's duties, the anticipated equipment and personnel needs and the municipality's projected growth rates. This procedure is obviously very time consuming and expensive. However, it is the most reliable method to support local policies which require new development to pay for added service cost.

The following section outlines standards and procedures for estimating existing costs and added costs of development for sewage collection and treatment. This material should be used together with the information in Ext. Bull. 602, **Residential Growth: Its Benefits and Costs to the Local Community**, to derive estimates of the public benefits and costs of community growth.

Sewage Collection and Treatment

Public Law 92-500 requires municipalities operating sewage treatment facilities to treat sewage at the secondary level or better. Secondary treatment usually involves removing contaminants by sedimentation, reducing sludge by anaerobic digestion, drying the sludge by centrifugation or filtration and disposing of the sludge by incineration or land application.

Recent developments concerning a true definition of secondary treatment have clouded the issue and raised numerous questions relating to lagoon systems and other systems commonly used by smaller communities. This section presents facts relating to one form of secondary treatment. The following standards can be used to derive cost estimates for sewage collection and treatment.

Standard 1 — The average length of sewer pipe per capita decreases as population increases. The relationship can be expressed by the formula $Y = 114.54/X^{.19}$ where Y = length of sewer in feet per capita and X = community population. Table 1 presents length of sewer per capita and total length of sewer by community size. This relationship between population and per capita length of sewer is from data presented in Table 16 of Smith and Eilers (6). (A scientific or engineer's calculator is necessary to handle the exponent, i.e. $X^{-.19}$.)

Table 1. Length of sewer per capita in the U.S. (based on 1968 sewered population).

Community population	Length of sewer (ft/capita)	Total length of sewer (ft)
500	35.17	17,585
1,000	30.83	30,830
1,500	28.54	42,810
2,000	27.02	54,040
2,500	25.90	64,750
5,000	22.71	713,550
10,000	19.90	199,000
15,000	18.43	276,450
30,000	16.15	484,500

Standard 2 — The two types of pipe most frequently used for main sewage lines in Idaho are polyvinyl chloride (PVC) and iron.

Standard 3 — The cost per foot of 8-inch pipe at trench side is PVC — $2.93 and iron — $10.00 (2).

The minimum size for main sewage lines in Idaho is 8 inches (1). To analyze costs of sewage treatment and collection here, 8-inch pipe costs will be used. Also, please note that topography and community lay-out may determine the size of the sewage lines. For example, the flat terrain of many parts of southern Idaho may allow for larger mains. However, the rolling hills and mountains in other parts of the state may dictate smaller lines.

Another factor is the way a community has developed, and this development plays a role in determining sewage line sizes. One community may use the 8-inch mains solely as "feeder-type" lines that dump into a large main line. Another may use the small lines to service the entire system because there is no feasible location for the larger line because of the community's development pattern. The possibility that various sizes of sewage lines may be used in a community is a difficult engineering problem and must be handled on a case-by-case basis. For these reasons, the 8-inch line is used for all communities in this publication.

Standard 4 — Table 2 shows the total sewer investment. The different components are given as percentages of total cost. For example, construction of lateral sewers is 64.1 percent of total investment.

Table 2. Component costs as percentages of total sewer investment (2).

Investment	Percent of total
Planning	9.1
Land	2.4
Construction	
- Lateral sewers	64.1
- Pumping	12.6
- Oxidation pond	7.7
- Contingency	4.1
Total	100.0

Standard 5 — Table 3 lists the costs of lateral sewers.

Table 3. Component costs as percentages of total construction cost of lateral sewers (4).

Pipe at trench	17%
Pipe handling and joining	3%
Trench labor and construction	80%
Total	100%

Standard 6 — The annual operating and maintenance cost per capita is expressed by:

$Y = 8.44X^{-.175}$

where Y = annual operating cost per capita
X = design population (6)
(A scientific or engineer's calculator is necessary to handle the exponent, i.e. $X^{-.175}$.)

Table 4 on page 6 gives the annual operating costs per capita for various population sizes.

Standard 7 — The population to sewer hookup ratio is 3.2:1 (Idaho averages 3.2 persons per household). Therefore, there is one sewer hookup for every 3.2 people in the community (7).

Table 4. Annual per capita operating and maintenance costs of sewer system by community population.

Design population	Cost per capita
500	$2.84
1,000	2.52
1,500	2.35
2,000	2.23
2,500	2.15
5,000	1.90
10,000	1.68
15,000	1.57
30,000	1.39

Standard 8 — The average length of house connection is 60 feet (6). Pipe used for connection from main sewage line to house is 4-inch polyvinyl chloride (PVC), and the cost is $.75 per lineal foot (5). The pipe is 20 percent of total hookup cost (5). The average household hookup cost is $225.

Estimating Sewage Collection and Treatment Costs

Using the eight standards given, you can estimate total sewage investment, annual operating and maintenance costs and other annual expenses for various community populations. As an example, consider a community with a population of 1,000 people.

Construction

Step 1 — Determine the length of the sewage lines needed (Standard 2) (Table 1):

30.83 ft of line/capita × 1,000 population = 30,830 ft of sewage line

Step 2 — Determine the total cost of the pipe (Standards 2 and 3):

30,830 ft × $2.93/ft (PVC pipe) = $90,332

Step 3 — Determine the total cost of installing the sewage line (Standard 5). Total cost of the pipe is 17 percent of construction cost. Therefore, total construction cost is:

$90,332 ÷ 0.17 = $531,364

Step 4 — Other costs of the lateral sewers are:

Pipe at trench 17 percent of total or	$ 90,332
Pipe handling and joining 3 percent of total or	$ 15,941
Trench labor construction 80 percent of total or	$425,091
Total	$531,364

Step 5 — Determine the total sewer investment cost (Standard 4). The construction cost of the lateral sewers is 64.1 percent of the total sewer system investment. Therefore, total sewer investment equals:

$531,364 ÷ 0.641 = $828,961

Step 6 — Determine the annual cost of the system by amortizing the total sewer investment by the appropriate amortization rate (in this case, it is assumed to be financed for 20 years at a loan rate of 10 percent). Other amortization rates for various interest rates and time periods are listed in Table 5.

Annual cost = $828,961 × .117460 = **$97,370**

Operation and Maintenance

The annual operating and maintenance costs can be determined by multiplying the cost per capita by the community population (Table 4):

$2.52 per capita × 1,000 population = **$2,520** annual operating and maintenance cost

Connection charges for this sewer system can also be determined. They do not need to be calculated to determine the system cost. However, the hookup cost, usually borne by the system users (homeowners, schools, businesses, etc.), is here for illustration:

Step 1 — Estimate the number of households in the community (Standard 7):

1,000 population ÷ 3.2 people per household = 313 households

Step 2 — The house connection pipe cost can be estimated by multiplying the feet of pipe per household by the cost of pipe per foot (Standard 8):

60 feet per house × $0.75/ft. = **$45.00**

Step 3 — Since pipe cost is 20 percent of the total hookup cost (Standard 8), hookup cost per household can be estimated by:

$45.00 ÷ 0.20 = **$225.00**

The total annual sewer costs for the sewage system for a community of 1,000 people can now be calculated by adding the annual sewer investment cost ($97,370) and operating and maintenance cost ($2,520) for a total annual cost of **$99,890**, or about $320 per household. The cost of sewer connections has not been added to the annual cost of the sewer system because it is a cost which is usually paid by users when their house is connected to the system. It is a "one-shot-deal" which is not paid every year.

Cost estimates for other population sizes are given in Table 6.

Estimating Population Growth's Impact on Sewer Expenditures

The standards can also be used to estimate the costs of extending sewage lines to "new" population that has immigrated into a community of a given size. It is assumed that the community in this example has excess capacity in the treatment plant to absorb the new population without having to make capital expenditures to alter the existing

Table 5. Amortization rates for different interest rates and loan periods.

Interest rate	Years					
	3	5	10	15	20	30
7	.381052	.243891	.142378	.109795	.094393	.080586
8	.388034	.250456	.149029	.116830	.101852	.088827
9	.395055	.257092	.155820	.124059	.109546	.097336
10	.402115	.263797	.162745	.131474	.117460	.106079
11	.409213	.270570	.169801	.139065	.125576	.115025
12	.416349	.277410	.176984	.146824	.133879	.124144
13	.423522	.284315	.184290	.154742	.142354	.133411
14	.430700	.291200	.191700	.162800	.150900	.142800
15	.437900	.298300	.199200	.171000	.159700	.152300

This table will help you calculate the annual payments on investments for community services. For example, the annual payments for a $40,000 loan at 10 percent interest rate for 15 years can be calculated:

Loan amount × amortization rate = annual payment
($40,000) (.131474) ($5,259)

An annual payment of $5,259 would pay the principal and interest on this loan and retire the debt in 15 years. If an interest rate and the time period for a loan are not listed in this table, your local bank can provide the figures.

Table 6. Estimated sewer costs by community size.

Population	A Length of sewer[1] (ft/capita)	B Cost of 8" PVC pipe/ft	C Total sewer pipe cost[2] (1 × 2 × 3)	D Total cost of construction[3]	E Total sewer investment[4]	F Total amortized sewer investment[5]	G Annual oper. cost/ capita[6]	H Annual oper. cost[7]	I Total annual cost[8]	J Cost of service/ household[9]
500	35.17	$2.93	$ 51,524	$ 303,082	$ 472,827	$ 55,538	$2.84	$ 1,420	$ 56,958	$364.53
1,000	30.83	2.93	90,332	531,365	828,963	97,370	2.52	2,520	99,890	319.65
1,500	28.54	2.93	125,343	737,841	1,151,078	135,206	2.35	3,525	138,731	295.96
2,000	27.02	2.93	158,337	931,394	1,453,033	170,673	2.23	4,460	175,133	280.21
2,500	25.90	2.93	189,718	1,115,988	1,741,011	204,499	2.15	5,375	209,874	268.64
5,000	22.71	2.93	332,702	1,957,071	3,053,153	358,623	1.90	9,500	368,123	235.60
10,000	19.90	2.93	583,070	3,429,824	5,350,739	628,498	1.68	16,800	645,298	206.50
15,000	18.43	2.93	809,499	4,764,700	7,433,229	873,107	1.57	23,550	896,657	191.29
30,000	16.15	2.93	1,419,585	8,350,500	13,027,301	1,530,187	1.39	41,700	1,571,887	167.67

[1]See Standard 1
[2]See Standards 2, 3 (Population × A × B)
[3]See Standard 5, (C ÷ .17 = total construction cost)
[4]See Standard 4, (D ÷ .641 = total sewer investment)
[5]Annual amortization (E × amortization rate)
[6]See Standard 6, Table 4
[7]Annual operating cost = population × G
[8]Total annual cost of sewage service = (F + H)
[9]Annual cost per household of sewage service = I ÷ number of households, or I ÷ population ÷ 3.2.

facility. The only expenditures necessary, then, would be for sewer line extensions and added operation and maintenance costs. Comparisons of capital costs for different population sizes will give rough estimates of added capital costs.

Assume that a community of 1,500 people is experiencing growth expected to bring in an additional 1,000 people and that the growth is taking place on the outskirts of town where there is presently no sewage service. What will be the estimated impact on sewage expenditures for the community?

Let us assume that the community develops in a pattern similar to that in Table 1. The length of sewer per capita will decline from 28.54 feet to 25.90 feet. This assumes that the growth on the outskirts of the community will be somewhat more compact (i.e., houses will be closer together and not require as much sewage line as the development pattern within the existing community boundaries).

The community of 1,500 people would require about 42,810 feet of sewage line (1,500 population × 28.54 feet per capita). The community of 2,500 people would require 64,750 feet of sewage line (2,500 population × 25.9 feet). Therefore, an estimated 21,940 feet of new sewage line will be needed to serve the 1,000 new people.

Determine the cost per household for sewage collection and treatment in this example community of 1,500 that experiences a population growth of 1,000. Follow these steps.

Step 1 — Estimate the total cost of installing the sewage lines by using Standards 3 and 5.

21,940 ft of line × $2.93/ft (Standard 3) =
$64,284 cost of pipe at trench;
$64,284 ÷ .17 (Standard 5, Table 3) =
$378,142 total cost of installing sewage line

Step 2 — Calculate the annual cost of the sewage line extension.

$378,142 × 0.117460 (amortization rate for 20 years at 10 percent) = $44,417 annual sewer line cost

Step 3 — Estimate the increase in annual operating and maintenance costs by taking the difference between total operating and maintenance costs for the two population sizes (Standard 6).

$5,375 (2,500 population × $2.15/capita) - $3,525 (1,500 population × $2.35) = **$1,850** increase in annual operating and maintenance cost

Step 4 — The estimated total annual increase in sewage expenditures is the sum of the sewage line costs, annual operating and maintenance costs.

$44,417 Annual sewer line cost
1,850 Increase in annual operating and maintenance costs
$46,267 Total increase in sewage expenditures

Divide this figure by the estimated number of new households (Standard 7) to derive the anticipated effect per new household.

$46,267 ÷ 313 households =
$147.82 per "new" household

If the added cost is allocated to all households in the community (2,500 population, 781 households), the impact would be $59.24 per household. Connection costs of new houses to the sewer system can also be added to come up with the total cost of the growth per "new" household.

$147.82 + $225 = $372.82 per new household

Remember, the connection cost is a first-year cost and is not paid by users in subsequent years.

This analysis of the added sewer costs of population growth has explored only sewage line extensions, operating and maintenance costs. Growing communities that are at or near the capacity of their treatment facilities must also consider the added costs of modification or building new treatment plants. Many communities require developers to pay for line extensions. These communities must therefore be concerned with plant expansion and increased maintenance and operation costs.

Community Information Sources

- The city or county sanitation officer should be able to provide answers to many of the technical questions concerning sewage collection and treatment.
- City and county budgets may have helpful information on expenditures and receipts.
- Local banks and financial institutions will be able to provide information on loans, interest rates and other questions concerning financing a sewage system.
- Local plumbing supply outlets will be able to provide information concerning sewage pipe costs and suitability.
- Local or state ordinances concerning the type of sewage treatment allowed in the area may also be explored.
- The local council of government, planning association or community development organization will be able to answer questions concerning federal or state grant sources and eligibility criteria for these programs.

Bibliography

1. Brinkley, Marlin. Telephone conversation. March 1978. Environmental Services Division, Idaho Dept. of Health and Welfare, Lewiston.
2. Klindt, T. and W. Burgmann. 1973. Costs and revenues of waste disposal systems in selected rural communities of Louisiana. Agr. Exp. Sta. D.A.E. Research Report No. 459, Louisiana State Univ., Baton Rouge.
3. Lawrence, Charles. 1967. Economic considerations of sanitary sewers. Public Works, Ridgewood, NJ.
4. Mackey, R. Bruce. 1977. Costs for rural community services in Nevada — an economic-engineering approach. Agr. Exp. Sta. Bull. T21, Univ. of Nevada, Reno.
5. Materials Distributors. Telephone conversation. August 1980. Costs of sewage pipe. Lewiston, ID.
6. Smith, Robert and Richard Eilers. 1972. Cost to the consumer for collection and treatment of wastewater. Advanced Waste Treatment Laboratory, Office of Research and Monitoring, U.S. Environmental Protection Agency, incinnati, OH.
7. U.S. Department of Commerce, Bureau of the Census. 1970. Census of the population, characteristics of the population, vol. 1, part 14, Idaho.

WORKSHEET
Estimating Sewage Collection and Treatment Costs

A. _____
Community population

B. _____ = (_____ × _____)
Length sewer pipe (ft) | Standard 1 | (A) Population

C. _____ = (_____ × _____)
Total pipe cost | (B) Length sewer pipe | Pipe cost per foot or Standard 3

D. _____ = _____ ÷ .17
Total installation cost | (C) Total pipe cost | Standard 5

E. _____ = _____ ÷ .641
Total sewer investment cost | (D) Total installation cost | Standard 4, Table 2

F. _____ = (_____ × _____)
Annual sewer investment cost | (E) Total sewer investment cost | Amortization rate (Table 5)

G. _____ = (_____ × _____)
Annual operating cost and maintenance | Standard 6, Table 4 | (A) Population

H. _____ = _____ + _____
Total annual cost | (F) Annual sewer investment cost | (G) Annual maintenance and operation costs

I. _____ = _____ ÷ _____
Annual cost per capita | (H) Total annual cost | (A) Population

J. _____ = _____ ÷ _____
Annual cost per household | (H) Total annual cost | Number of households or connections

WORKSHEET
Estimating Population Growth's Impact On Sewage Collection and Treatment Costs

A. _____
Number of new residents

B. _____ = (_____ × _____)
Feet new sewage line — Total new population — Standard 1

- (_____ × _____)
Total previous population — Standard 1

C. _____ = (_____ × _____)
Total cost new pipe — (B) Feet new sewage line — Pipe cost per foot (Standard 3)

D. _____ = _____ ÷ .17
Total new sewer line installation cost — (C) Total new pipe cost — Standard 5

E. _____ = (_____ × _____)
Annual cost new sewage line — (D) Total new sewer line investment cost — Amortization rate (Table 5)

F. _____ = (_____ × _____)
Annual alteration or new treatment plant construction — Alteration or new treatment plant construction — Amortization rate (Table 5)

G. _____ = (_____ × _____)
Increased annual operating and maintenance costs — Total new population — Standard 6, Table 4

- (_____ × _____)
Previous population — Standard 6, Table 4

H. _____ = _____ + _____
Total annual costs for new population — (E) Annual cost new sewage line — (F) Annual alteration or new treatment plant construction costs

+ _____
(G) Increase in annual operating and maintenance costs

I. _____ = _____ ÷ _____
Annual cost per new resident — (H) Total annual new costs — (A) Number new residents

J. _____ = _____ ÷ _____
Annual cost per new household — (H) Total annual new costs — Number new households

K. _____ = _____ ÷ _____
Annual cost per resident — (H) Total annual new costs — Total number community residents

Cost of Public Service: Sewage Collection and Treatment is the fifth in a series of bulletins on estimating costs of public service in various size Idaho communities. Other bulletins in that series available from the University of Idaho Agricultural Information Department are as follows:

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