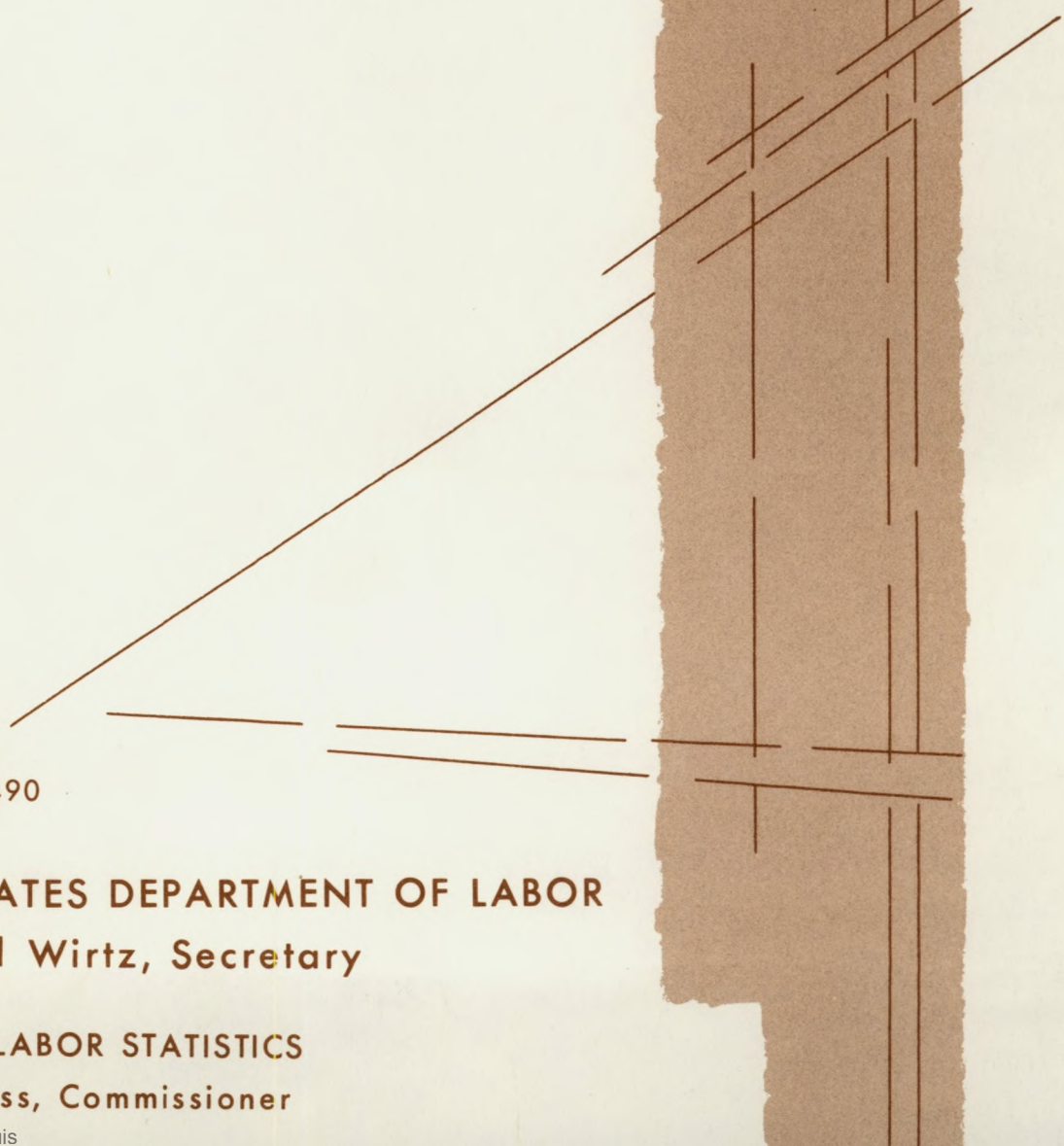
labor and material requirements for sewer works construction



Bulletin No. 1490

UNITED STATES DEPARTMENT OF LABOR
W. Willard Wirtz, Secretary

BUREAU OF LABOR STATISTICS
Arthur M. Ross, Commissioner

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Preface

This study of total labor and material requirements for the construction of sewer facilities is one in a series of Bureau of Labor Statistics studies of various types of construction that might be affected by future governmental action. Previously published studies examined the following types of construction: Schools, highways, Federal office buildings, hospitals, civil works activities of the Army Corps of Engineers, public housing, private one-family dwelling units, and college student housing.

The studies are being made by the Bureau's Division of Productivity Measurement, Lloyd A. Prochnow, Chief, under the general direction of Leon Greenberg, Assistant Commissioner for Productivity and Technological Developments. This bulletin was prepared under the supervision of James F. Walker, by Roland V. Murray, who also was responsible for compiling the data for on-site labor requirements. Claiborne M. Ball prepared the data on materials and off-site labor requirements.

The Bureau gratefully acknowledges the cooperation of officials of the Water Supply and Pollution Control Division of the Public Health Service, and of the Community Facilities Administration of the Housing and Home Finance Agency in supplying project payrolls on which most of the on-site requirements data were based. Mr. Peter P. Rowan, who was associated with the Public Health Service, was particularly helpful in this and related areas.

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Introduction

New construction is a major component of the Nation's output of goods and services and an important source of employment. Jobs are created not only at construction sites but also in many manufacturing, trade, service, and transportation industries which make, sell, and deliver materials and equipment required in construction processes. Because of its far-reaching employment impact, a vigorous construction industry is a significant aid in limiting unemployment.

To provide factual data on the more direct employment-generating effects of construction expenditures, the Bureau of Labor Statistics (BLS) has a continuing program of studies to measure labor and material requirements for various segments of the construction industry. Construction of sewer facilities was selected as particularly appropriate for study because of the continuing Federal interest and participation in water pollution control and the frequent prominence of this type of work in Federal employment-generating programs.

At the time to which this industry refers, 1962-1963, Federal assistance to local governments for sewer works construction took three forms, implementing three different purposes. One of these was the Water Pollution Control program, dating from the middle 1950's, administered by the Public Health Service of the U.S. Department of Health, Education, and Welfare. This program provides grants to local agencies for partial financing of construction of sewage treatment facilities, including intercepting and outfall sewers. The principal purpose is to provide an incentive to local communities to decrease the amount of untreated wastes discharged to water sources. The second continuing program was the Public Facilities Loan Program under the Community Facilities Administration of the Housing and Home Finance Agency. This is a loan program designed to assist small communities without established credit rating to acquire needed public facilities. Although loans were available for many types of facilities, they were used primarily for sewer and water works. Moreover, the sewer construction tended to be for collection lines rather than treatment facilities, thus complementing the pollution control program. The third program was the Accelerated Public Works Program which was aimed at helping people living in economically distressed areas by providing immediate employment on public construction. The program as a whole was under the direction of the Area Redevelopment Administration of the U.S. Department of Commerce, but grants were made through agencies already in the relevant fields, such as the two mentioned previously. Many different classes of public works were approved under this program, but sewer facilities, which accounted for over a quarter of the total dollar volume of approvals, made up the largest single group.

Another reason for the study is the current and prospective importance of this work. Expenditures for sewer facilities construction have risen steadily to a record $1,375 million in 1964. Although some decrease occurred in 1965 after the Accelerated Public Works Program's initial impact

of 1963 and 1964, expenditures are expected to continue to rise. The needs to be met arise not only from population growth and mobility, but also from deficiencies in existing waste disposal systems which are the subject of much current concern. These deficiencies are chiefly inadequate treatment of liquid wastes before their return to waterways, and the existence of combined storm and sanitary systems in many urban areas which dump untreated wastes into waterways during storms. Remedy of the latter situation alone, by separation of storm and sanitary sewers, would cost many billions of dollars.

Nature of Survey

The study was designed primarily to measure the total man-hours of labor required for each $ 1,000 of sewer facilities construction contract. These man-hours include both on-site and off-site employment in the construction industry, and the off-site employment in industries which produce and distribute the materials, supplies, and equipment used in the construction. Data for on-site labor include man-hours for supervisory, engineering, clerical, and custodial employees at the construction sites, as well as those for workers in the construction trades. Data for off-site employment cover not only the final stage of materials manufacture and transport to the site, but all other stages of production including the extraction of raw materials.

These labor requirements are thus the total of those generated by the construction contract. However, additional employment is generated by a construction project other than by the construction contract itself. This additional work includes preparation of plans and specifications, inspection by government agencies, installations by public utility employees, and other appurtenant work. These other sources of employment are not reflected in the estimates, which might differ slightly if total project man-hours were related to total project costs. Employment created by the respending and investing of the wages and profits arising from the construction--the multiplier effect--is excluded.

This study is based on data covering construction, chiefly in 1962 and 1963, on 138 sewer works contracts. Only new sanitary sewer facilities are covered; repair work and work on storm drainage systems are excluded, although six contracts cover work on features of combined storm and sanitary systems.

All of the projects were under one or more of the Federal assistance programs just described: 85 were administered by the Public Health Service and 53 by the Community Facilities Administration. Thus, the study did not include any projects financed without Federal funds. Of the 138 contracts, 86 were primarily for sewer line construction, and 52 primarily for plant construction. Data for these two groups are shown separately, where considered helpful, throughout the report.

General Survey Findings

Construction of sewer works in 1962-63 required an average of 222 man-hours of labor for each $1,000 of construction contract amount. Requirements for other types of construction studied in this series ranged from 204 to 236 man-hours.

Employment at the site of work on sewer facilities required 85 man-hours, and off-site employment, primarily to produce the materials used, required 137 man-hours. The total man-hours were distributed by industry groups as follows:

	Man-hours per $1,000 of construction contract, 1962-63	
	Number	Percent
Total	222	100
On-site construction	85	38
Off-site, total	137	62
Construction	7	3
Manufacturing	73	33
Trade	23	11
Transportation	11	5
Services	7	3
Other	16	7

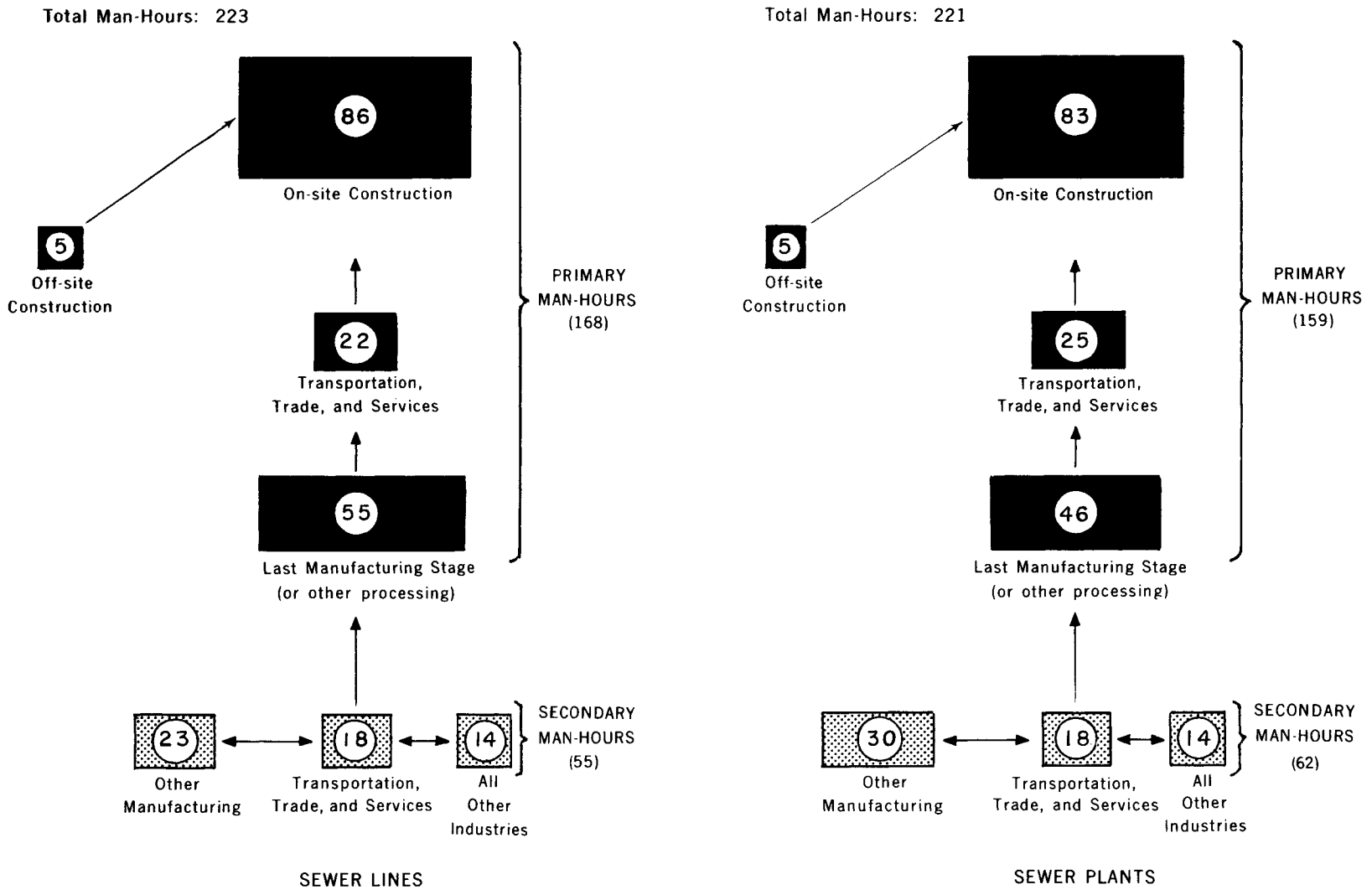
Man-hour requirements in the two major types of sewer works varied only slightly.

	Man-hours per $1,000 of construction contract, 1962-63	
	Lines	Plants
Total	223	221
On-site construction	86	83
Off-site, total	137	138

There were, however, some differences in the distribution of these hours, particularly in the pattern of on-site construction occupations. There were wide differences in total on-site man-hour requirements among individual projects, and a substantial difference between projects in the South and in the rest of the Nation.

The study developed, as byproduct, a rough breakdown of contractors' costs as between wages paid to construction workers, materials purchased, and overhead and profit. The percentages were, respectively,

Chart 1. Distribution of Man-Hours for Each $1000 of Sewer Works Construction Contract, 1962-63



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25, 56, and 19 for all projects covered. The wages percentages tended to be more uniform than the man-hours worked, by project and region, because high man-hour requirements frequently were associated with low wage rates and low man-hour requirements with high wage rates. However, the percentage for plants was somewhat higher than for lines--27 and 24, respectively. The materials ratios varied little in total between the two types, 56 in lines and 57 in plants. There were, however, great differences in the types of materials used.

The difference between total contract amounts and the combined sum of the wages paid and materials purchased amounted to 19 percent of the contract amounts. This residual represents the total of overhead and profit. In this report, overhead expenses are those which cannot be directly attributed to specific projects, as for example, expenses for the central office and yard, insurance, and taxes.

In the years 1962-63, the average expenditures per year for all types of local public sewer facilities were $1,131 million. This study indicated that at this rate of expenditure sewer construction provided about 125,000 full-time jobs, 48,000 on-site and 77,000 off-site.[1] Since full-time work is the exception, especially in heavy construction, the actual number of persons employed on-site was undoubtedly considerably greater.

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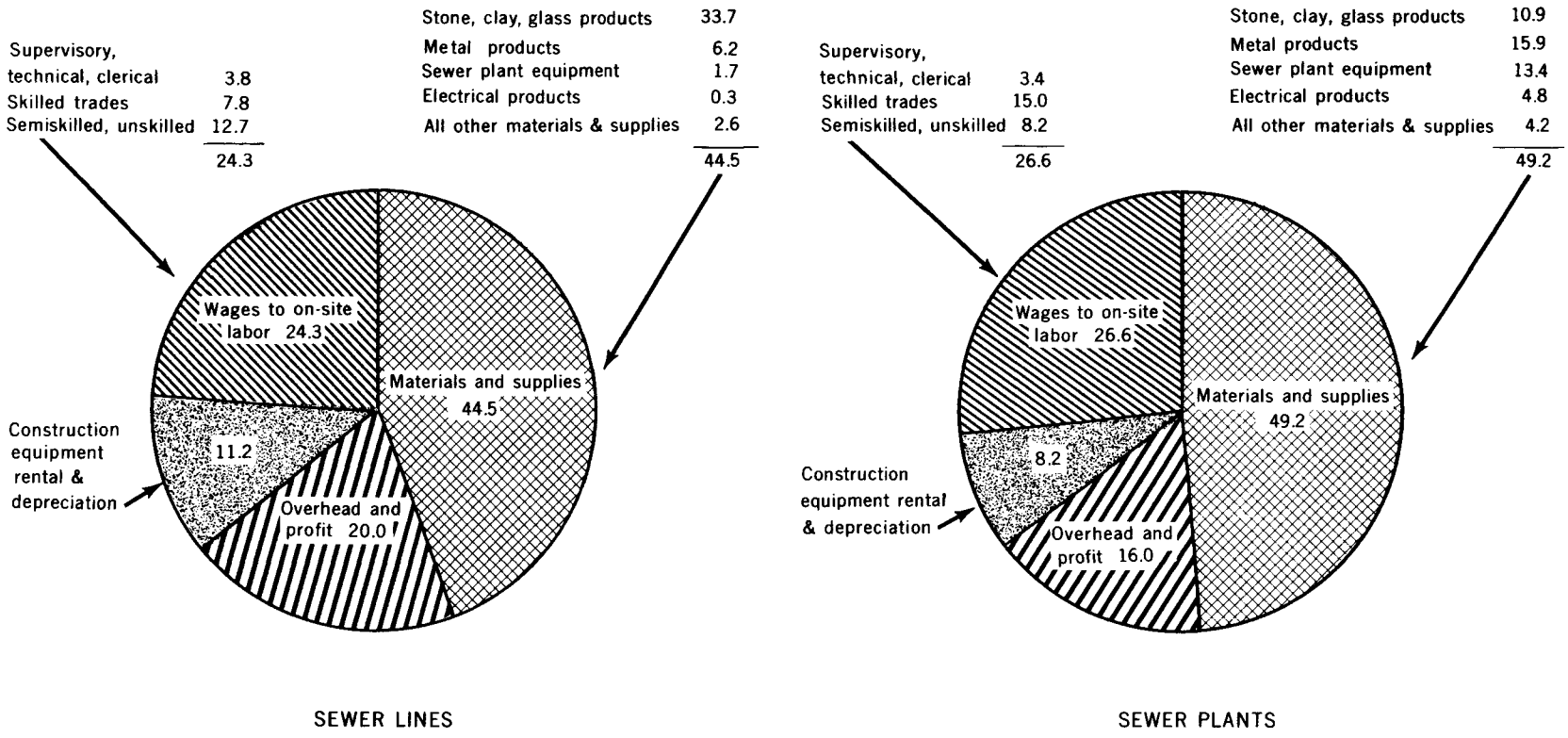
[1] The full-time work year for on-site work is taken as 50 times the average workweek of 39.9 hours in 1962 and 40.6 in 1963 as reported in the Bureau's employment and earnings series. For other types of employment 2,000 hours were considered a full year's employment.

Chart 2. Where the Sewer Works Construction Contract Dollar Goes 1962-63



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Project Characteristics

Today's urban society uses a wide variety of facilities for the collection, treatment, and disposal of human and industrial wastes. These facilities range from the small pipes collecting household wastes to the large trunk lines and interceptors; from the simple sewage lagoon to the intricate processing complex of the metropolitan treatment plant; and from the "packaged" lift station to the multimillion-dollar pumping station. The current study included all of these facilities insofar as they related to new sanitary sewer systems. Repair jobs were excluded and also work on storm sewer systems. Several relief sewer jobs, features of combined storm and sanitary systems, were included.

The 138 contracts [2] included in the study were distributed among types of facilities as shown in the following tabulation. (See appendix for additional details on sample selection and weighting.) Contracts are divided into two broad classes, according to whether they chiefly involved pipeline or plant construction.

	Number of contracts	Actual (unweighted) contract amounts, 1962-63	
		Thousands of dollars	Percent
All contracts	138	$45,465	100
Principally pipelines	86	24,717	54
Lines exclusively	61	15,932	35
Lines and other (chiefly lift stations)	25	8,785	19
Principally plants	52	20,748	46
Sewage treatment plants ...	29	14,493	32
Pumping stations.....	9	3,578	8
Waste stabilization ponds ..	9	910	2
Mixed	5	1,767	4

[2] Because of the dispersed nature of the work, "project" and "contract" do not always have identical meanings in sewer construction. However, in this report, either word may be used to designate a single prime general contract (or, rarely, a general and one or more specialty primes) for construction of a specified feature or group of features of a sewer system.

The 86 sewer line contracts were chiefly collection and trunk (or interceptor) lines in about equal numbers; in addition, there were a relatively small number of outfall and relief sewers. (Outfall sewers conduct the effluent from the treatment plant to a river or other disposal area; relief sewers in combined storm and sanitary systems divert excess storm waters directly into a river to prevent overloading of the treatment plant.)

The pipelines primarily were concrete, vitrified-clay, or cast iron. Smaller amounts of steel, asbestos-cement, and corrugated metal pipe were used. In addition, one job used cast-in-place reinforced concrete pipe, and another used brick masonry for lining a sewer constructed by tunneling.

The "other" element in "lines and other" in the previous tabulation is almost entirely lift stations. These are the pumping facilities, usually small, required in lines where the terrain is such that gravity alone will not insure adequate flow. In addition, of course, all sewer lines require such structures as man-holes and junction chambers, to facilitate the operation and maintenance of the lines.

Trenching almost universally was used for placing pipe below ground. However, in one entire job and in portions of two others, tunneling was used. These examples do not include the many cases where relatively short sections of the line had to be bored under such obstacles as highways and railroads.

Of the 52 plants covered in the survey, about half included some external pipeline work, usually for interceptors or outfalls, in addition to the necessary within-plant piping connections. In each case, however, the plant construction predominated.

Seven of the treatment plants, representing half of the contract amount in this category, were to provide primary treatment only--the separation of liquids and solids, with digestion of the solids, and disposal of liquids without further treatment. The other 22 plants provided so-called secondary treatment--conversion of the liquid wastes through biological processes to comparatively inoffensive effluents before their disposal. Eleven of these, representing a third of treatment plant contract amount, used the activated sludge process, and 11, representing a sixth of contract amount, used the other principal processing method, the trickling filter system.

Most treatment plants were of small or moderate size, including several of the small packaged equipment type, requiring hardly more on-site construction than for a foundation and a shell. However, 8 contracts of over $500,000 each accounted for 70 percent of the total contract amount for treatment plant construction. These large contracts were for processing complexes using a variety of facilities. Modern large-scale sewage treatment consists of a series of physical, biological, and chemical processes and therefore requires several distinct types of structures (tanks, lagoons, buildings, mechanical installations), and of course, appurtenant piping, and electrical and other related work.

The pumping station category was dominated by a single very large contract for a plant which included installations for pumping storm water as well as sanitary sewage. The other eight contracts were for relatively small lift stations.

Waste stabilization ponds are shallow ponds acting as natural sewage treatment "plants" through the action of micro-organisms on the raw sewage. They usually involve no more construction work than excavation and diking, and inlet and outlet structures. Such ponds usually serve small communities--each of the nine sample projects was in a nonmetropolitan area.

The five projects designated as "mixed" in the previous tabulation were contracts with multiple features. The two largest represent complete systems, with sewer lines, lift stations, and treatment facilities.

On-Site Man-Hour Requirements

On-site man-hour requirements averaged 85 per $1,000[3] of contract amount of sewer facilities construction but varied widely by project characteristics. (See table 1.) Some of the variations are consistent with those noted in previous studies in this series. A chief example of this is the consistently higher employment generated by a dollar of construction in the South compared with the remainder of the country. To a smaller and less consistent extent, higher requirements also are evident for projects outside of metropolitan areas, and smaller projects. It usually is assumed that the availability of labor at comparatively low hourly rates in the South and in smaller communities reduces the incentive for mechanization, and that smaller projects reduce the opportunity for it.

The range in requirements for individual projects was extremely wide--from 23 to 249 man-hours per $1,000 in sewer line projects, and from 31 to 159 in plant projects. In some instances, these wide ranges reflected financially very profitable, or virtually disastrous, jobs as explained in the wage portion of this study. This is typical of high-risk operations such as sewer facilities work. In other instances, these wide ranges reflect individual project characteristics.

However, the ranges radically differ for the South and the rest of the country. Most of the contract value of the sample for the South was in projects with requirements over 100 man-hours per $1,000; for the remainder of the country, most of the value was in projects with requirements under 100.

	Percent of contract amount			
	Lines		Plants	
Man-hours per $1,000	South	Other U.S.	South	Other U.S.
Total	100	100	100	100
Under 50	0	33	5	4
50 and under 100	30	64	35	95
100 and under 150	51	3	58	1
150 and under 200	15	0	2	0
200 and under 250	4	0	0	0

[3] The "man-hours per $1,000" concept cannot be used for productivity comparisons because of the different physical quantities which the $1,000 may represent, owing to differences in prices of construction. Price differences reflect not only differences in productivity, but also differences in profits, and costs of materials, labor, etc.

Table 1. On-Site Labor Requirements for Sewer Works Construction, by Selected Characteristics, 1962-63

Characteristics	Man-hours per $1,000 of contract					Wages as percent of contract amount					Average hourly earnings				
	United States	North-east	North Central	South	West	United States	North-east	North Central	South	West	United States	North-east	North Central	South	West
Total, all contracts	84.5	70.8	66.6	109.5	63.2	25.3	25.5	24.6	26.3	23.8	$3.00	$3.60	$3.70	$2.41	$3.77
Lines	85.9	68.6	61.9	117.4	61.7	24.3	25.7	23.8	24.5	23.5	$2.83	$3.75	$3.84	$2.09	$3.81
Plants	82.7	72.4	71.9	99.8	66.1	26.6	25.3	25.6	28.6	24.4	3.22	3.49	3.56	2.87	3.70
All contracts:															
Metropolitan area	78.2	70.5	63.0	99.4	59.6	25.9	25.4	24.2	28.4	23.5	3.32	3.60	3.84	2.85	3.95
Nonmetropolitan area	93.1	71.2	70.6	122.4	69.8	24.5	25.6	25.1	23.8	24.4	2.63	3.59	3.56	1.94	3.50
Lines:															
Metropolitan area	74.7	60.6	57.0	98.5	58.2	23.0	23.2	22.2	23.2	23.1	3.08	3.83	3.90	2.36	3.96
Nonmetropolitan area	103.8	75.5	68.1	145.5	74.5	26.4	27.9	25.7	26.5	25.3	2.54	3.69	3.78	1.82	3.39
Plants:															
Metropolitan area	83.1	75.1	70.7	100.7	65.5	30.0	26.4	26.7	35.8	25.5	3.61	3.52	3.78	3.56	3.89
Nonmetropolitan area	82.1	64.4	73.1	98.8	66.4	22.6	21.9	24.5	21.0	23.8	2.75	3.40	3.36	2.13	3.58
All contracts:															
Under $50,000	92.0	77.6	83.4	106.4	(1)	25.7	27.9	26.2	24.4	(1)	2.79	3.60	3.13	2.29	(1)
$50,000-$99,999	94.8	52.4	71.8	131.1	75.7	26.1	18.4	25.6	26.6	28.6	2.76	3.50	3.56	2.03	3.77
$100,000-$299,999	95.8	67.2	75.1	132.8	67.6	25.4	25.2	28.0	24.0	24.3	2.65	3.75	3.73	1.81	3.59
$300,000-$499,999	84.6	66.1	65.4	107.3	(1)	23.2	21.9	23.9	23.2	(1)	2.74	3.31	3.66	2.17	(1)
$500,000-$999,999	64.7	65.2	(1)	(1)	47.6	21.5	25.0	(1)	(1)	18.6	3.31	3.84	(1)	(1)	3.90
$1,000,000 and over	84.9	(1)	64.2	99.6	70.0	28.4	(1)	24.4	30.8	26.1	3.34	(1)	3.80	3.09	3.73
Lines:															
Under $50,000	93.3	77.6	84.3	(1)	(1)	27.5	27.9	30.0	(1)	(1)	2.94	3.60	3.56	(1)	(1)
$50,000-$99,999	99.3	(1)	74.1	127.0	78.4	26.7	(1)	27.1	25.9	29.9	2.69	(1)	3.66	2.04	3.81
$100,000-$299,999	104.1	68.5	71.8	147.1	73.1	26.7	25.8	28.4	26.2	25.7	2.56	3.77	3.95	1.78	3.51
$300,000-$499,999	88.4	64.6	62.4	123.9	(1)	23.6	22.6	23.2	24.6	(1)	2.67	3.49	3.72	1.98	(1)
$500,000-$999,999	55.4	(1)	(1)	(1)	41.7	20.2	(1)	(1)	(1)	16.3	3.65	(1)	(1)	(1)	3.90
$1,000,000 and over	81.3	(1)	(1)	(1)	(1)	24.1	(1)	(1)	(1)	(1)	2.97	(1)	(1)	(1)	(1)
Plants:															
Under $50,000	90.7	(1)	82.9	97.2	(1)	24.0	(1)	23.5	24.4	(1)	2.64	(1)	2.83	2.51	(1)
$50,000-$99,999	83.2	(1)	(1)	(1)	(1)	24.6	(1)	(1)	(1)	(1)	2.96	(1)	(1)	(1)	(1)
$100,000-$299,999	81.0	64.4	81.1	100.2	62.8	23.0	23.9	27.4	19.0	23.0	2.84	3.71	3.37	1.90	3.67
$300,000-$499,999	78.4	(1)	(1)	86.5	(1)	22.5	(1)	(1)	21.6	(1)	2.88	(1)	(1)	2.49	(1)
$500,000-$999,999	75.2	(1)	(1)	(1)	(1)	22.8	(1)	(1)	(1)	(1)	3.04	(1)	(1)	(1)	(1)
$1,000,000 and over	87.7	(1)	66.2	(1)	(1)	31.6	(1)	25.5	(1)	(1)	3.60	(1)	3.74	(1)	(1)

[1] Fewer than 3 contracts in category.

The Cost of Direct Wages

Wages paid to on-site construction workers constituted about 25 percent of total construction contract amount, and this figure tended to be quite constant by region and other characteristics (table 1). This reflects a tendency observed in previous studies in this series; high man-hour requirements tend to be associated with low average hourly earnings and vice versa. For example, man-hour requirements in the South are double those for the other regions for lines constructed in nonmetropolitan areas, but average hourly earnings are almost one-half as much. The result is a wage requirement differing only slightly from the national average.

This tendency of variations in hours and rates to offset one another is illustrated further in the following tabulation, which shows that half of all the projects (with somewhat more than half of the weighted contract amounts) have wage percentages within 5 percentage points of the national average.

	Lines		Plants	
Wages as a percent of contract amount	Number of projects studied	Percent of contract amount	Number of projects studied	Percent of contract amount
Total	86	100.0	52	100.0
Under 10	2	2.5	1	1.1
10 and under 20	23	30.8	13	8.7
20 and under 30	40	47.2	29	61.5
30 and under 40	16	15.8	8	28.4
40 and under 50	5	3.7	1	.3

In addition to reflecting possible differences in productivity, the extremes in this table tend (since contract amounts are fixed) to represent unusually profitable or unprofitable jobs. The extremes may also reflect large differences in percentages of material costs in contract amounts, due to job characteristics. Sewer facilities construction tends to be one of the more speculative types of construction, chiefly because of the below-ground-level nature of much of the work. Unexpected encountering of water may increase costs greatly by requiring extensive pumping; rock may require drilling and blasting; unstable soils may require heavy shoring. In the present study, field representatives heard numerous complaints of losses on contracts in the course of data collection, with unfavorable soil conditions most commonly being blamed. (The speculative nature of sewer work contributed to one of the chief problems encountered in data collection--the difficulty of obtaining information on work performed by prime and subcontractors since gone out of business. Four projects in the sample studied were reported to have bankrupted the prime contractors.)

The portion of table 1 showing average hourly earnings illustrates the differences in earnings between the South and the rest of the country

(particularly the West), and between metropolitan and nonmetropolitan areas. The extreme range in this average in individual projects was from $ 1.48 to $ 4.74 for sewer line construction and from $ 1.61 to $ 4.31 for plants. The lower figure in each case represents a project in a small southern community; the larger figure, a project in a metropolitan area--one in the Northeast and one in the West.

The wages discussed in this section, and the average hourly earnings based on them, represent total gross earnings, including overtime premiums, before any deductions for social security, health insurance, etc. The wages do not represent total labor costs, which would include travel and vacation allowances, contractors' legally required or voluntary contributions to health and welfare funds, and other fringe benefits.

Requirements by Occupation

The principal skilled trades required in sewer facilities construction are operating engineers and carpenters (table 2).

Operating engineers cover employees operating all types of construction machinery except powered handtools (jackhammers, drills, saws, and the like), the operators of which are separately shown. For somewhat over a half of all man-hours reported for operating engineers, the type of equipment was specified. Following is a distribution of these specified man-hours:

	Percent
Total	100
Backhoe	16
Crane-shovel-dragline	19
Dozer	17
Tractor (attachments, if any, not reported)	5
Pump and compressor	13
Loader	12
Pile driver	8
Scraper	3
Trencher, ditcher	3
All other	4

Primarily, the equipment operated was of the type required for trenching and other excavation, and backfilling. Pile driving and pumping equipment were associated with these operations--the former was extensively used for installing sheet piling, and the latter for excavation dewatering.

Table 2. On-Site Labor Requirements for Sewer Works Construction, by Occupation and Region, 1962-63

Occupation[1]	United States		Northeast		North Central		South		West	
	Man-hours per $1,000	Per-cent	Man-hours per $1,000	Per-cent	Man-hours per $1,000	Per-cent	Man-hours per $1,000	Per-cent	Man-hours per $1,000	Per-cent
Total	84.5	100.0	70.8	100.0	66.6	100.0	109.5	100.0	63.2	100.0
Superintendents and general foremen	6.8	8.1	6.1	8.7	5.6	8.4	8.3	7.6	5.7	9.0
Professional and technical	.7	.8	.4	.6	.8	1.2	1.0	.9	.2	.3
Clerical	.6	.8	.7	1.0	.2	.3	1.0	1.0	.2	.4
Operating engineers	14.7	17.4	11.2	15.9	12.5	18.7	17.9	16.4	13.5	21.3
Carpenters	6.5	7.7	6.8	9.6	5.5	8.3	7.1	6.5	6.1	9.7
Plumbers	2.1	2.4	3.6	5.0	2.7	4.0	1.3	1.2	1.7	2.7
Ironworkers[2]	1.6	1.9	1.6	2.2	2.4	3.6	1.6	1.4	.8	1.3
Bricklayers[3]	1.4	1.6	1.0	1.4	1.3	2.0	1.9	1.7	.5	.8
Electricians	1.3	1.5	1.6	2.3	1.5	2.3	1.3	1.2	.6	1.0
Cement finishers	1.1	1.3	.9	1.2	1.2	1.8	1.3	1.1	1.0	1.6
Painters	.6	.7	.6	.8	.6	1.0	.5	.5	.6	1.0
Other (skilled) trades[4]	1.2	1.4	1.1	1.5	1.0	1.5	1.6	1.5	.8	1.2
Truckdrivers	2.7	3.2	3.1	4.4	1.6	2.5	3.1	2.9	2.6	4.1
Oilers	2.4	2.9	3.2	4.5	1.7	2.5	1.8	1.7	3.9	6.2
Helpers and tenders	1.5	1.8	.3	.4	1.0	1.5	2.1	1.9	1.8	2.9
Power tool operators	1.2	1.4	.8	1.2	.8	1.1	1.6	1.5	1.1	1.8
Labor foremen	1.4	1.7	1.3	1.8	1.4	2.1	1.6	1.5	1.1	1.7
Pipelayers	5.1	6.1	4.0	5.6	2.0	3.0	7.8	7.1	4.0	6.4
Laborers	31.3	37.0	22.2	31.3	22.2	33.4	46.5	42.4	16.8	26.6
Flagmen, watchmen	.2	.3	.3	.5	.6	.8	.1	.1	(5)	(5)

[1] Skilled occupations include apprentices and working foremen.
[2] Primarily reinforcing ironworkers; also includes structural and ornamental ironworkers.
[3] Includes manhole block layers.
[4] Covers primarily mechanics (construction equipment repair and process equipment installation) and minor building trades.
[5] Less than .05.

Note: Because of rounding, sums of individual items may not equal totals.

Carpenters were employed as extensively in sewer plant construction as in some types of building construction previously studied. They were employed primarily for concrete form work on buildings and tanks. However, carpenters were also employed to a significant extent in sewer line construction for installing wood shoring in trenches and building forms for cast-in-place concrete pipe and appurtenant concrete sewer structures such as manholes and outlet works.

Regional differences in the distribution of man-hours by occupation should be interpreted with caution. They result from a variety of factors, among which are the different proportions of lines and plants in the region's projects, the chance occurrence of jobs presenting unusual features, and local differences in job classification. Perhaps the most striking variation, and one which has been observed in previous studies in the series, is the high proportion of common laborers in the South.

Table 3, which shows the occupational distribution of man-hours separately for sewer lines and plants, illustrates the relative complexity of the two types of construction.

The pattern for lines reflects the comparatively simple operations of excavating, pipe handling, and backfilling. Skilled construction workers account for only a quarter of total man-hours, and these skilled workers are chiefly operating engineers. On the other hand, common laborers alone account for 43 percent of total on-site man-hours. This ratio is far higher than the corresponding ratios found in previous studies in this series. This fact might be a consideration when assigning priority to projects in programs for alleviating unemployment.

The occupational pattern for sewer plants reflects the greater and more varied skills required to construct the many different types of facilities in and around treatment and pumping plants. The skilled construction trades account for nearly a half of all on-site man-hours, whereas common laborers account for only 30 percent. These ratios approach those observed in studies of building construction.

Apprentice Man-Hours

Apprentices in formal, registered programs accounted for only 2 percent of the total man-hours worked by the skilled production workers on all sewer facilities projects. The percentage for line construction was much lower than that for plants, where, as has been seen, there is a larger percentage of workers in trades with strong apprenticeship traditions. (National apprenticeship standards for heavy equipment operators and mechanics were not established until 1963.)

Table 3. Percentage Distribution of On-Site Man-Hours for Sewer Line and Plant Construction, by Occupation and Region, 1962-63

Occupation [1]	Lines					Plants				
	United States	North-east	North Central	South	West	United States	North-east	North Central	South	West
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Superintendents and general foremen	8.9	11.0	9.3	8.6	8.6	7.0	7.0	7.6	6.1	9.9
Professional and technical	.8	1.5	1.8	.6	.3	.8	0	.5	1.3	.2
Clerical	.4	.7	.1	.4	.6	1.2	1.2	.6	1.8	(2)
Operating engineers	19.6	19.9	25.6	16.7	23.8	14.6	13.0	12.0	15.8	16.5
Carpenters	2.4	.7	.9	1.3	8.8	14.3	15.9	15.5	13.9	11.4
Plumbers	.4	(2)	.3	.4	.6	5.1	8.6	7.6	2.3	6.9
Ironworkers	.4	(2)	.8	.2	.6	3.9	3.8	6.4	3.2	2.5
Bricklayers	1.3	.6	.9	1.7	.5	2.0	2.1	3.0	1.8	1.2
Electricians	.1	(2)	(2)	.2	.2	3.3	3.9	4.4	2.7	2.4
Cement finishers	.5	.1	.7	.3	1.3	2.3	2.0	2.8	2.3	2.1
Painters	(2)	(2)	(2)	.1	(2)	1.5	1.4	1.9	1.1	2.8
Other (skilled) trades	.7	1.4	.6	.5	1.4	2.3	1.6	2.3	2.9	.9
Truckdrivers	4.1	5.2	3.7	3.6	5.5	2.1	3.8	1.3	1.9	1.5
Oilers	3.2	5.0	3.4	1.5	7.7	2.5	4.2	1.7	2.0	3.3
Helpers and tenders	1.8	.4	1.8	1.7	3.0	1.8	.5	1.1	2.3	2.8
Power tool operators	1.2	.7	1.9	.9	1.9	1.7	1.5	.5	2.3	1.7
Labor foremen	1.5	1.3	1.9	1.5	1.0	2.0	2.1	2.4	1.5	3.1
Pipelayers	9.6	12.9	5.8	10.7	7.1	1.6	.4	.3	1.9	4.9
Laborers	42.7	37.4	38.8	49.2	27.0	29.9	27.0	28.1	32.5	25.9
Flagmen and watchmen	.4	1.2	1.7	(2)	(2)	.1	(2)	(2)	.3	(2)

[1] Skilled occupations include apprentices and working foremen.
[2] Less than .05.

Note: Because of rounding, sums of individual items may not equal 100 percent.

	Percent of skilled trade man-hours worked by apprentices		
	Total	Lines	Plants
All skilled trades	2.2	1.1	2.9
Operating engineers	.2	.4	0
Carpenters	2.0	4.6	1.5
Plumbers	8.9	18.9	8.0
Iron workers	1.4	0	1.6
Bricklayers	1.5	0	2.7
Electricians	14.1	8.3	14.5
Cement finishers	1.0	0	1.2
Painters	1.7	0	1.8
Other skilled trades	5.2	.4	7.1

In the aggregate or in percentage of total, apprentice man-hours were significant chiefly in the plumbing and electrical trades.

Overtime Man-Hours

For 102 (of the 138) projects, which accounted for over 80 percent of the total man-hours worked in the sample projects, data were available for measuring the proportion of these hours which were paid for at overtime rates. For all projects, this amounted to 7.5 percent. The ratio for sewer line construction, however, was much higher than for plant construction, 10.3 and 4.2 respectively. On several sizable line projects, this proportion approached a quarter of all hours worked.

The higher proportion of overtime hours on line construction probably is due to the more exposed conditions under which this work is done and to the location of the work on public rights-of-way. Both these conditions require intensive activity when weather conditions are favorable (particularly to make maximum use of heavy construction equipment) and when traffic will be disrupted the least.

Construction Time

On the average, the jobs covered in this survey required a little over 33 weeks to complete. The sewage plants, however, required a substantially longer period for construction than the lines--41 weeks as compared with 28. The difference was not due to variations in the distribution of the projects, for example by cost class. The relationship held for all sizes and locations of projects; on the average, sewer plant construction requires about 50 percent longer than comparable sewer line projects. These figures cover the total elapsed time from the start of site operations to the substantial completion of the contract. They do not include the sometimes extensive period of testing and remedial work, but they do include periods during the course of construction when, for various reasons, no work was performed.

To measure the distribution of employment over the period of construction, the construction time for each project was divided into 10 equal intervals, and data were tabulated on the number of man-hours worked in each interval. This procedure permitted the combination of man-hours for projects of various sizes in order to obtain typical employment patterns. The results for the two major groups of projects revealed little difference in the timing of employment:

	Tenths of construction period										
	Total	1	2	3	4	5	6	7	8	9	10
Percent of man-hours:											
Sewer lines	100	5	10	13	15	14	13	11	8	7	4
Sewer plants	100	5	10	13	14	13	13	11	10	7	4

Off-Site Employment

For each man-hour of work performed at the construction site of sewer facilities construction, an additional 1.6 man-hours of work were required elsewhere to produce and distribute the materials, supplies, and equipment used at the site. The ratio was about the same for lines and plants. These are rather high ratios compared with the same ratio in other types of construction. This results in part from the fact that site workers are able to place relatively large values of work per hour on this kind of construction--in the case of lines, by the use of heavy construction equipment; in plants, by the installation of process equipment.

This off-site activity directly affects a substantial number of industries; indirectly it affects virtually all industries as the impact of the initial purchases spreads throughout the economy. These effects are shown in table 4, which presents by industry the total man-hour requirements for sewer works construction. Primary man-hours are defined as those worked at the construction site and in activities closely related to the site: off-site employment in the construction industry, employment in the last stage of materials manufacture, and employment in the industries distributing the final product to the site. Secondary man-hours are those required prior to final manufacture in all activities involved in producing and distributing materials and equipment, including the basic extraction and processing of raw materials. The distinction between the two areas may be useful in gaging the immediacy of the impact of a construction proposal.

Primary man-hours largely reflect materials usage. Thus, the substantial employment in the stone, clay, and glass products industry will be seen to reflect in large part the usage of concrete and clay sewer pipe. Secondary man-hour requirements, by their definition, could be analyzed only with reference to the basic data on interindustry relationships.

Table 4. Man-Hour Requirements Per $ 1,000 of Sewer Construction Contract, by Producing Sector and Stage of Manufacture, 1962-63

Sector	Total man-hours	Primary man-hours	Secondary man-hours
All sectors	221.9	163.8	58.2
On-site construction	84.5	84.5	--
Agriculture	2.2	.2	2.0
Mining	4.8	1.1	3.7
Other construction	7.2	5.5	1.7
Manufacturing	72.6	46.8	25.8
Lumber and lumber products	1.6	.7	1.0
Paper and paper products	1.5	--	1.5
Printing	1.1	--	1.1
Chemicals	1.6	.2	1.4
Stone, clay, and glass products	26.2	22.8	3.4
Primary metals	11.7	5.7	6.0
Fabricated metal products	6.6	3.9	2.6
Machinery	14.1	10.5	3.6
Electrical products	4.0	2.1	1.9
Transportation equipment	1.0	.2	.7
Other manufacturing	3.2	.7	2.5
Transportation	10.6	4.7	5.8
Trade	23.3	16.5	6.8
Services	7.3	1.6	5.8
Other industries	9.3	2.8	6.6

Note: Because of rounding, sum of individual items may not equal totals.

Total off-site man-hour requirements per $ 1,000 for construction of the two principal types of sewer works--lines and plants--show little difference:

Type of facility	Man-hours per $ 1,000 of contract for sewer works construction						
			Off-site				
	All industries	On-site: construction	Total	Construction	Manufacturing	Transportation, trade, and services	Other
Total hours:							
All sewer facilities.....	222	85	137	7	73	41	16
Lines.....	223	86	137	7	74	40	16
Plants	221	83	138	7	72	43	16
Primary hours:							
All sewer facilities.....	164	85	79	5	47	23	4
Lines.....	168	86	82	5	51	22	4
Plants	159	83	76	5	42	25	4
Secondary hours:							
All sewer facilities.....	58	--	58	2	26	18	12
Lines.....	55	--	55	2	23	18	12
Plants	62	--	62	2	30	18	12

In the primary off-site category, lines require more man-hours than are required by plants, because of the use of materials, such as pipe, of a relatively low order of fabrication, requiring more hours in the final stage. Plants use a greater value of items, such as process and control equipment, requiring more processing prior to the final manufacturing stage.

Cost of Materials Used

The cost of materials used in construction of the sewer works under study amounted to 56.5 percent of the contract amount. For the lines it was 55.7 percent and for plants, 57.4. Included in these figures are the value of the materials incorporated into the various structures; the value of processing equipment and other types of installed equipment; the value of supplies consumed; and costs of construction equipment rental or estimates of depreciation allowances. They do not include costs of purchases of overhead goods and services.

The proportion of materials cost to contract amount varied widely depending on peculiarities of individual jobs or their relative profitability. Thus, high proportions often were associated with unprofitable jobs, or with jobs which by their nature required little on-site construction, as for example, the installation of a small treatment plant using packaged equipment. Three-quarters of the contracts, however, showed materials proportions within approximately 15 percentage points of the average:

Percent materials cost of contract amount	Lines		Plants	
	Number of projects studied	Percent of contract amount	Number of projects studied	Percent of contract amount
Total.....	86	100.0	52	100.0
Under 40	10	5.7	2	1.0
40 and under 50 ..	25	21.4	7	11.0
50 and under 60 ..	28	36.5	24	55.1
60 and under 70 ..	13	23.8	10	29.6
70 and under 80 ..	7	10.8	8	2.4
80 and over	3	1.8	1	.9

Table 5 presents the costs to the contractors of major materials and groups of materials used in each $ 1,000 of sewer facilities construction. Minor items are included in group totals but are not listed separately. Data are shown for all projects by region, and for lines and plants separately.

The table shows quite different patterns of materials usage for lines and plants. For lines, nearly one-half of total materials cost is accounted for by concrete and clay pipe and an additional one-fifth by the estimate for construction equipment usage. On the other hand, plant construction uses a wide variety of materials, many of a high degree of fabrication, as might be expected from the varied structures involved. In this respect, the two materials patterns parallel the two construction occupational patterns previously discussed.

Some apparent anomalies in the table are explained by the design and techniques of sewer facilities construction. For example, the greater relative use of brick and "other precast concrete products" in lines reflects the production of sewer manholes. The high requirements of sand and gravel relative to cement, in reverse of the usual pattern, suggest its use as a pipe bedding material in lines, and as a filter medium in plants.

Each of the broad categories--lines and plants--includes elements of the other. This explains expenditures for pumps and motors on line construction. Where slopes are such that sewage cannot flow properly by gravity alone, lift stations are required. Finally, in view of the great differences between the line and plant material patterns, the regional variations shown are as much a reflection of differences in product mix as in local usage. The breakdowns are thus applicable only to situations where the mix is assumed to be similar.

Table 5. Cost of Materials per $ 1,000 of Sewer Works Construction Contract, by Type of Materials, Region, and Type of Project, 1962-63

Item	All projects					United States: lines	United States: plants
	United States	North-east	North Central	South	West		
Total, all materials	$564.70	$530.40	$533.00	$570.50	$621.30	$557.20	$573.90
Stone, clay, and glass products	$234.60	$156.10	$227.90	$214.70	$355.40	$337.30	$109.30
Cement, concrete, and gypsum products	130.20	79.80	131.20	103.80	231.50	179.90	69.60
Concrete pipe	88.00	33.20	75.20	65.60	201.40	147.40	15.70
Ready mixed concrete	29.80	30.80	38.30	29.70	18.60	16.30	46.30
Concrete block	2.50	3.20	2.10	2.10	3.30	2.40	2.70
Other precast concrete products	7.80	10.90	13.40	3.90	7.00	11.50	3.30
Cement	1.60	1.40	1.70	2.00	1.00	2.00	1.20
Clay products	77.40	55.50	67.00	95.20	69.90	124.30	20.20
Clay sewer pipe	67.80	50.70	57.30	80.40	67.80	113.40	12.20
Brick	8.20	2.70	8.80	13.00	1.70	10.80	5.00
Other stone, clay, and glass products	27.00	20.80	29.70	15.70	54.00	33.10	19.50
Sand and gravel	17.70	10.20	24.20	10.80	31.60	22.80	11.50
Asbestos cement pipe	6.00	6.10	--	2.50	21.00	7.20	4.50
Miscellaneous aggregate	1.80	3.30	3.00	1.10	.80	2.90	.50
Fill dirt	.60	.30	.90	.60	.30	.20	1.00
Metal products (except plumbing and heating)	105.70	112.90	90.30	133.00	58.20	62.30	158.60
Primary metal products	56.00	64.60	32.60	77.60	30.10	47.80	66.20
Cast iron pipe	34.10	33.20	17.90	53.80	11.70	28.50	41.00
Steel pipe	8.00	11.40	6.20	7.70	7.70	9.00	6.70
Steel sheet piling	5.60	7.40	.40	8.50	3.80	1.30	10.70
Cast iron manholes, etc.	5.50	5.30	3.60	6.50	5.60	8.80	1.40
Aluminum sheet metal	1.70	5.40	3.20	(1)	.10	(1)	3.60
Copper sheet and pipe	.70	1.20	.80	.40	.80	(1)	1.60
Fabricated metal products	49.70	48.30	57.70	55.40	28.10	14.50	92.40
Reinforcing rods and bars; joists	15.30	13.70	20.80	15.30	10.00	4.70	28.20
Structural steel	8.80	8.40	9.80	8.90	7.80	.70	18.70
Valves and fittings	8.30	9.30	10.90	9.10	2.50	2.30	15.70
Steel plate products	4.20	3.40	6.70	4.60	1.10	1.70	7.30
Fabricated sheet metal products	3.40	.60	1.40	6.40	1.70	.60	6.70
Corrugated metal pipe	3.30	6.20	.30	4.90	.80	2.90	3.70
Fencing	1.80	2.30	2.60	1.70	.60	.50	3.40
Metal doors and frames	1.40	1.20	1.60	1.30	1.50	.30	2.80
Metal windows and frames	1.10	.90	1.60	.70	1.60	.50	1.80
Prefabricated buildings	.60	--	.40	1.00	.20	--	1.20
Sewage plant equipment	69.90	89.90	76.50	71.20	41.40	17.40	134.00
Pumps and motors	27.20	24.00	23.40	39.70	7.30	15.80	41.20
Mechanical collectors	15.40	32.00	31.70	5.50	2.20	--	34.10
Digesters, clarifiers	10.00	16.10	8.50	4.00	19.70	.10	22.10
Diffusers and distribution equipment	5.10	11.70	4.70	4.00	2.50	--	11.40
Laboratory equipment and instruments	2.10	1.50	2.20	2.90	.70	.60	3.90
Electrical generating units	1.40	2.10	1.20	1.10	1.90	.20	3.00
Chlorinators	1.10	1.40	1.50	.90	.70	--	2.40
Elevators	.90	.30	--	2.10	--	--	2.10
Unspecified equipment	6.70	1.00	3.30	11.00	6.30	.70	14.00

See footnote at end of table.

Table 5. Cost of Materials per $1,000 of Sewer Works Construction Contract, by Type of Materials, Region, and Type of Project, 1962-63--Continued

Item	All projects					United States: lines	United States: plants
	United States	North-east	North Central	South	West		
Electrical products	$ 23.30	$ 25.60	$ 20.30	$ 26.60	$ 17.90	$ 3.30	$ 47.70
Switchboards and panelboards	12.80	17.40	8.50	14.00	11.60	1.40	26.80
Wire and cable	2.30	1.70	2.70	2.30	2.10	.80	4.10
Electrical meters and instruments	2.00	2.50	2.80	1.70	1.50	.20	4.20
Transformers	1.90	.30	.90	4.00	.10	(1)	4.30
Conduit	1.60	1.50	2.10	1.60	1.30	.40	3.20
Current-carrying devices	1.20	.70	1.20	1.60	.30	.20	2.40
Lighting fixtures	1.00	1.10	1.50	.80	.80	.20	2.10
Petroleum products	14.00	14.60	13.60	12.80	16.60	16.80	10.60
Fuel and lubricating oils	8.70	8.50	10.40	9.10	5.70	9.20	8.00
Asphalt paving	4.80	5.80	2.70	3.00	10.50	7.40	1.60
Lumber and lumber products	6.70	7.30	5.50	7.90	5.00	4.40	9.40
Dimension lumber	5.40	7.10	3.70	6.10	4.50	4.20	6.90
Plumbing and heating materials and equipment	6.20	8.60	8.90	4.10	5.50	.40	13.40
Plumbing materials	1.10	2.20	1.10	.80	.70	.20	2.10
Plumbing fixtures	.50	.70	.40	.60	.10	--	1.10
Heating materials	5.20	6.50	7.80	3.40	4.70	.20	11.20
Blowers and fans	2.40	4.60	4.80	.90	1.00	.20	5.20
Boilers and radiators, warm air furnaces, unit heaters, and ventilators	1.70	1.60	1.50	1.20	3.30	(1)	3.80
Air-conditioning equipment	.60	--	1.40	.80	--	--	1.40
Chemical products	3.60	4.60	2.90	1.50	8.20	2.00	5.60
Dynamite and caps	1.80	2.70	1.40	.20	5.20	1.30	2.50
Paint	1.10	1.70	1.20	.70	1.50	.10	2.40
All other material	2.10	2.60	2.10	2.10	1.50	.90	3.50
Nursery products	1.00	1.60	1.40	.90	.60	.40	1.80
Construction equipment (rental charges and depreciation allowances)	98.60	108.10	85.00	96.70	111.70	112.50	81.80

[1] Less than $0.05.

Note: Group totals include products not shown separately.

Previous Studies

Three previous studies of labor and material requirements for sewer construction have been made in the BLS covering data relating roughly to 1934, 1940, and 1949.[4] Differences in scope, sampling, classification, and data collection in these earlier studies and the current one limit the usefulness of comparisons. However, some conclusions appear reasonable: On-site construction worker wages as a percentage of the total contract amount were as low in 1962-63 as they had been at any time over the previous 30 years; the percentage of combined overhead and profit, on the other hand, was as high or higher than it had been in the same 30-year period.

	Percent of construction contract amount			
	1962-63	1949	1940	1934
Total	100	100	100	100
Wages to on-site workers	25	32	30	26
Materials and supplies	47	44	50	51
Other costs and profits	28	24	20	23

Other costs include construction equipment depreciation, which was not shown separately in the earlier studies, and employment costs other than wages paid to on-site workers. Both of these classes of costs are believed to have increased as a percentage of total contract cost over the years.

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[4] "Relative Cost of Material and Labor in Construction of Water and Sewerage Systems," Monthly Labor Review, January 1935 (based on data collected at around 1934), pp. 145-146; "Expenditures for Labor and Material and Man-Hours of Labor Created per $1 million of Contracts Awarded for Sewers and Sewerage Systems," BLS mimeographed release, November 1944 (based on data collected at around 1940); "Expenditures per Million Dollars for Construction of New Water Supply and Sewage Disposal Systems," BLS mimeographed release, May 1951 (based on data for 1948-50).

The overall percentage of materials cost in total cost appears to have decreased only slightly over the years, but there have been significant shifts in the relative importance of some materials. The use of lumber products has decreased, probably reflecting the greater use of steel shoring and prefabricated forms. The total amount of "concrete products" has increased, and the amount of cement and aggregates has decreased, as ready-mixed concrete has replaced site-mixed. Concrete products also appear to have gained at the expense of brick, where precast concrete manholes and manhole sections have replaced brick manholes.

For the earliest two studies and the latest, overall man-hours data are available, suggesting the possibility of measuring changes in output per man-hour over the 30-year period. The available data, however, do not relate production man-hours to units of physical output, such as linear feet of pipe laid, but only to dollars of contract amount. These dollars may represent different physical quantities at different times owing to construction price changes. To measure the change in man-hour requirements for equivalent amounts of construction, it is necessary to adjust the dollars for price changes so that they represent approximately equal physical quantities. Making such an adjustment in the case of sewer construction results in an indicated increase of 40 to 50 percent in output per man-hour over the 30-year period.

A part of this increase resulted from the transfer of certain operations from on-site to off-site locations, as for example, the prefabrication of forms for concrete work, the precasting of some concrete products, the premixing of concrete, and even the manufacture of jointing elements on some piping. However, a part of the increase is due to improved methods, particularly in excavation.

Scope and Method of Survey

Sample

This study is based on data covering 138 prime contracts for the construction of sewer facilities. Of these, 85 were constructed under the Water Pollution Control Program of the Public Health Service, and 53 under that part of the Accelerated Public Works Program which was administered by the Community Facilities Administration. The work under the former program was done chiefly in 1962 and 1963; work under the latter program was accomplished chiefly in 1963. The samples each represented about 1 in 8 of the total number of projects undertaken by these agencies during the respective periods. Sample projects were located in 44 States and the District of Columbia.

To obtain a representative sample, projects were selected by type of project, broad geographical region, amount of contract, and whether within or outside a metropolitan area. The distribution of the sample projects by these categories is shown in table A-1. In tabulating the data, however, weighting was applied to adjust for nonrespondents, and for some differences in project characteristics disclosed in the course of the survey. Unless otherwise stated, all measures presented in the report are based on weighted data.

Man-hour Estimates

Estimates of total man-hour requirements for sewer construction are derived by combining estimates of on-site and off-site man-hours.

On-site man-hours. With minor exceptions, construction under both the Federal Water Pollution Control Program and the Accelerated Public Works Program is subject to prevailing wage laws. To check compliance with these laws, regulations require that each contractor on such construction file a copy of his weekly project payroll with the sponsoring agency. These payrolls are thus a primary source of data on construction man-hours worked and wages paid on a project. In the current study, the payroll files for the sample projects were made available for data transcription through the cooperation of the Public Health Service's Division of Water Supply and Pollution Control and the Community Facilities Administration's Public Facilities Division.

Although these payrolls were the basic source of on-site labor data, some classes of on-site workers are exempt from the legal reporting requirements. These exemptions include supervisory, technical, and clerical personnel, and self-employed subcontractors (working proprietors). Moreover, the processing of the payrolls raised frequent questions regarding data completeness and meaning. These missing data were obtained and questions concerning data meaning resolved by telephone or correspondence, or, most commonly, through visits by BLS field representatives, in the course of the materials data collection.

Table A-1.. Number of Sample Contracts in Selected Categories

	Total	Under $ 50,000		$ 50,000 and under $ 100,000		$ 100,000 and under $ 300,000		$ 300,000 and under $ 500,000		$ 500,000 and under $ 1,000,000		$ 1,000,000 and over	
		Metropolitan area	Nonmetropolitan area	Metropolitan area	Nonmetropolitan area	Metropolitan area	Nonmetropolitan area	Metropolitan area	Nonmetropolitan area	Metropolitan area	Nonmetropolitan area	Metropolitan area	Nonmetropolitan area
Total	138	11	12	10	15	18	27	8	15	7	4	9	2
Lines, total....	86	9	4	8	10	9	19	7	8	5	2	5	0
Northeast ...	19	4	1	0	2	5	1	2	3	0	1	0	0
North Central	23	4	1	4	1	2	5	1	3	1	0	1	0
South	28	1	1	2	5	1	10	3	2	1	0	2	0
West	16	0	1	2	2	1	3	1	0	3	1	2	0
Plants, total...	52	2	8	2	5	9	8	1	7	2	2	4	2
Northeast ...	9	0	0	1	1	3	0	0	1	1	1	1	0
North Central	16	1	4	0	2	2	2	0	2	0	0	2	1
South	17	1	4	1	0	0	5	1	3	0	1	1	0
West	10	0	0	0	2	4	1	0	1	1	0	0	1

Off-site man-hours. Off-site man-hour requirements in construction represent chiefly the hours required to produce and distribute the materials, supplies, and equipment used. Estimation of these hours therefore began with a listing of the value of all such items. For the present study, this listing was obtained in one of two ways. For jobs under $500,000, a mail questionnaire initially was used. [5] For larger jobs, and for nonrespondents on the smaller jobs, data were obtained in visits by BLS field representatives. For a relatively small number of subcontractors who were out of business or otherwise inaccessible, uncooperative, or whose contracts were exceedingly small, estimates of both labor and materials were prepared on the basis of reports for similar jobs. In all, the study of the 138 sample projects required contact of (or estimates for) 645 prime and subcontractors.

The materials listings thus obtained were classified into categories (consistent with the 4-digit Standard Industrial Classification) as found in the Census of Manufactures product groups. For each of these groups, the average amounts required for $1,000 of sewer facilities construction were calculated. Each of these averages was reduced by a ratio representing the difference between manufacturer's and contractor's valuation. The amounts thus reduced were consistent with Census data published for these various components.

Primary man-hours for manufacturing sewerage materials (i.e., the hours required in the final manufacturing stage) were developed by multiplying these average amounts by a ratio of manufacturing man-hours to $1,000 of production. These ratios were computed from the output and employment data in the 1962 Survey of Manufactures.

Primary man-hours for trade and transportation were derived in a similar manner. Here, however, employment ratios were applied to the difference between producer's and purchaser's valuation, which was taken as the total of all distribution costs between the sites of final manufacture and construction.

To compute secondary man-hours to produce the materials (i.e., hours required in all stages of production other than final manufacture and transportation), the 1958 interindustry study by the Office of Business Economics of the U.S. Department of Commerce was used. This study

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[5] The questionnaire requested detailed information on type, quantity, and cost of materials and supplies; equipment depreciation and rental costs; and subcontractors (names, addresses, nature of work and subcontract amounts), the subcontractors, in turn, also being sent a copy of the questionnaire.

indicates the amount of secondary product or service required of each of its 78 industry sectors to produce the primary product. Summing these amounts and applying the appropriate employment ratios produced the number of secondary man-hours required in each of the sectors.

Two other minor components were required to complete the compilation of total off-site hours as defined for this series of studies. One of these is the hours required to produce the contractors' purchases of overhead materials and services. The quantities of these items were estimated and included in the man-hour conversions just described. The other is the hours worked by the off-site employees of the construction industry. The estimate for these hours is based on the difference between the proportion of all nonconstruction workers in the contract construction industry as reported in the BLS employment trend series, and the proportion of on-site nonconstruction man-hours as developed in this study.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1966 O - 219-825