MARKETING RESEARCH REPORT NO. 965

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THE POULTRY PROCESSING INDUSTRY: A Study of the Impact of Water Pollution Control Costs

U.S. DEPARTMENT OF AGRICULTURE • ECONOMIC RESEARCH SERVICE
IN COOPERATION WITH ENVIRONMENTAL PROTECTION AGENCY

ABSTRACT

This report presents estimates of costs to poultry slaughtering plants of utilizing wastewater treatment systems to meet likely future effluent limitations and discusses the economic impact of these costs. Data on industry location, water use, waste treatment, and byproduct disposition are provided. For representative plants, wastewater treatment costs ranged from 0.5 to 1.9 percent of average total costs. Plants without municipal treatment would require a total investment of $21 to $60 million to construct the current best available control technology. Wastewater treatment costs of this technology would represent 1.6 to 5.9 percent of average total costs for representative plants. High costs of constructing wastewater treatment systems to meet the effluent limitations will encourage poultry slaughtering plants to seek other alternatives to reduce water use and wasteloads.

Key Words: Poultry processing, Pollution, Waste, Wastewater treatment, Byproducts, Effluent limitations.

PREFACE

In response to concern about the costs of meeting increasingly stringent effluent limitations, the Economic Research Service, U.S. Department of Agriculture (USDA), conducted a survey of Federally inspected poultry slaughtering plants. This report presents estimates of costs to these plants of utilizing different wastewater treatment systems to satisfy these limitations. In addition to an overview of the industry, data on industry location, water use, waste treatment, and byproduct disposition are provided. The study did not evaluate inplant changes in practices that can reduce water use and wasteloads and possibly decrease wastewater treatment costs.

The Animal and Plant Health Inspection Service (APHIS), USDA, cooperated in the survey. This study was funded by the Office of Water Programs, Environmental Protection Agency (EPA).

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Washington, D.C. 20250 June 1972

SUMMARY

Large capital investments needed to construct and operate the best available control technology to meet increasingly stringent effluent limitations might force the poultry processing industry--which operates on a narrow profit margin--to seek lower cost alternatives.

The method of handling poultry byproducts--blood, offal, and feathers--generally determines the pollution potential from slaughtering operations. Current industry performance in byproduct handling and disposition is much better than 15 years ago. If practices of the earlier period were followed to the same degree today, pollution potentials of the industry would be greater.

Of the 386 poultry slaughtering plants responding to the 1971 USDA survey, 245 had final municipal waste treatment, 113 had private treatment, and 28 had no treatment. Plants with final municipal treatment accounted for about 65 percent of Federally inspected poultry slaughter; plants with private treatment, 25 percent; and those with no treatment, 6 percent.

The surveyed plants currently have an estimated investment in private wastewater treatment facilities of $7.1 to $20.3 million. Average replacement value ranges from $63,000 to $180,000 per plant with private treatment. Estimated operating and maintenance costs--including capital costs--range from 2.7 to 7.3 cents per 100 pounds of live weight slaughter. Current wastewater treatment costs range from 0.5 to 1.9 percent of total costs for representative plants.

Sixteen plants with only primary treatment and 28 with no treatment would need $1.5 to $4.5 million--an average cost per plant of $35,000 to $109,000--to upgrade wastewater treatment to the best practicable control technology (anaerobic-aerobic lagoon system). With this investment, the 141 plants with private treatment--97 currently with the equivalent of the best practicable control technology, 16 with only primary treatment, and 28 with no treatment--could likely meet effluent limitations of the best practicable control technology.

The 141 plants, including eight that currently have extended aeration, would require a total investment of $21 to $60 million to upgrade to the best available control technology (extended aeration)--an average investment per plant of $149,000 to $424,000. Operating and maintenance costs would range from 8.2 to 22.6 cents per 100 pounds live weight slaughter--representing 1.6 to 5.9 percent of total costs for representative plants.

THE POULTRY PROCESSING INDUSTRY: A STUDY OF THE IMPACT OF WATER POLLUTION CONTROL COSTS

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INTRODUCTION

The poultry processing industry faces more stringent regulations directed at reducing water pollution. The Water Quality Act of 1965 charged the States with primary responsibility for implementing and enforcing water quality standards for their interstate waters. Under this act, water quality standards were to be set as the control mechanism of water pollution. State water quality standards were subject to Federal approval and ultimately to Federal enforcement.

The Federal Water Pollution Control Act Amendments of 1971 1/ changed the control mechanism from water quality standards to effluent limitations. This legislation set a national goal of no discharge of pollutants by 1985 and established a two-phase program for achieving the objectives. 2/ By 1976, effluent limitations for industrial sources with private treatment would require the application of the best practicable control technology currently available, as defined by the Administrator of the Environmental Protection Agency (EPA). By 1981, if the elimination of the discharge of pollutants is not achieved due to cost or others factors, effluent limitations would be based on the degree of effluent control achievable through the application of the best available technology. After effluent limits are established, individual firms within an industry would have alternatives in meeting such limits and are expected to select the one that minimizes the costs of meeting effluent limits.

1/ S. 2770, passed by the U.S. Senate in November 1971.

2/ The Federal Water Pollution Control Act Amendments of 1972 (H.R. 11896), passed in March 1972, restricts the 1981 effluent limitations and goals from becoming effective until Congress enacts a specific statute after the submission of a report by the National Academy of Sciences and National Academy of Engineering on the technical, economic, social, and environmental effects of meeting or not meeting these goals. Differences in the two bills had not been resolved at the time this report was prepared.

To develop effluent limitation guidelines, EPA is conducting a comprehensive study of industrial wastewater technology through the Industrial Waste Studies Program. During the first phase of the program, private firms completed studies of 21 industrial categories under contract with EPA. Achievable effluent limits and available technology were identified in a summary report on the meat products industry, including poultry processing. 3/ A second program phase is being initiated to develop additional data to establish guidelines.

Objectives

The objectives of this study were to: (1) Identify, describe, and quantify waste disposal and treatment practices of the poultry processing industry, including sources and volumes of water used, volumes of wasteloads generated, production and disposition of by-products, and sources and types of wastewater treatment; and (2) estimate present industry wastewater treatment costs and additional costs incurred in using the current best practicable and best available control technologies and determine the potential economic impact of these costs on the industry. In this study, the best practicable control technology was assumed to be a well-operated anaerobic lagoon and shallow (aerobic) polishing lagoon system identified by EPA as an example of available technology. The best available control technology is an extended aeration system identified by EPA as providing higher quality effluents. 4/ Over time, the best practicable and best available control technologies may change as new technology is developed or existing technology is modified for both inplant operations and external wastewater treatment systems.

This study did not evaluate the effect of inplant changes on water use, wasteload reduction, treatment costs, and recovery of byproducts. A study by Crosswhite and others (7) 5/ demonstrated that inplant changes in practices can reduce water use, wasteloads, and treatment costs, and provide returns from byproduct collection, sales, and utilization.

3/ The Industrial Wastes Study Program, Summary Report on Meat Products Industry, January 7, 1972. EPA does not necessarily advocate or recommend the use of the treatment methods discussed in the summary report and encourages the use of other methods, including inplant controls, to achieve equivalent or better results. Available inplant wastewater control technology is exemplified by water reuse and recycling and elimination of unnecessary water use.

4/ Anaerobic-aerobic lagoon system provided a 95-percent reduction in the biochemical oxygen demand (BOD); extended aeration a 99-percent reduction. BOD is the amount of oxygen used in the biochemical oxidation of organic matter.

5/ The Crosswhite study was jointly funded by EPA and Gold Kist Poultry, Atlanta, Ga., under a research, development, and demonstration grant. Underscored numbers in parentheses refer to numbers listed in the References.

Methodology

Descriptive data on waste handling and treatment practices were obtained through a mail questionnaire sent in 1971 to Federal inspectors in poultry slaughtering plants. Annual plant volume data for use in classifying plants by size and type and for estimating wasteloads and byproducts were provided by APHIS. Technical data on wasteloads, water use, and treatment systems and costs were obtained primarily from EPA.

This report focuses on poultry slaughtering plants because of the magnitude of waste and water pollution problems of these plants relative to other types of poultry plants. Table 1 shows the number of slaughtering plants responding to the survey by size of plant and region. Data on further processing and cut-up plants are given in appendix tables A-1 to A-6. In addition to the 386 slaughtering plants responding, there were 345 further processing plants and 200 cut-up plants (table A-1). Survey plants accounted for 96, 90, and 90 percent, respectively, of Federally inspected slaughter, cut-up, and further processed volume based on 1970 data.

In this study, plants rather than firms were the major unit of analysis. However, there are many multiplant firms in the industry. Because of the large number of plants in the survey and the volume of industry output accounted for, the data and costs estimated should realistically represent the poultry slaughtering industry.

Table 1.--Number and size of surveyed poultry slaughtering plants, by region, 1970

Size of plant	Region						
	North Atlantic	East North Central	West North Central	South Atlantic	South Central	West	All
	Number of plants						
Small 1/...	19	24	13	6	13	19	94
Medium 2/..	13	18	35	51	70	30	217
Large 3/...	6	0	0	34	35	0	75
Total....	38	42	48	91	118	49	386

1/ Less than 10 million pounds live weight slaughter in 1970.
2/ Ten to 49.9 million pounds live weight slaughter in 1970.
3/ Fifty million pounds or more live weight slaughter in 1970.

OVERVIEW OF THE POULTRY PROCESSING INDUSTRY

Poultry plants perform the functions of slaughtering and eviscerating, further processing, and cutting up of broilers (young chickens), turkeys, mature chickens, and other classes of poultry. Usually, plants that cut up and package poultry also engage in other processing activities. Many plants specialize in the more complex functions of canning and further processing. Poultry slaughtering plants transform live poultry into icepacked or chilled ready-to-cook broilers and fresh or frozen fowl or turkeys. Further processing plants convert ready-to-cook broilers, fowl, and turkeys or boned meat into a variety of canned and processed items.

The poultry processing industry has grown in the past decade and has achieved a high level of efficiency through continual adoption of new technology. It is characterized by a high degree of vertical coordination--successive stages of production and marketing are linked together through ownership or contracting. The processing plant is an integral part of different coordination schemes. For example, the typical integrated broiler firm has its own hatchery, feed mill, and processing plant, and depends almost entirely on contract production. The firm may be local, a subsidiary of a national feed company or meat packer, or part of a large conglomerate. Turkey firms tend to follow a similar pattern; mature chickens, on the other hand, are a byproduct of commerical egg production.

Plants under Federal inspection slaughtered over 90 percent of total U.S. production of young chickens, mature chickens, and turkeys in 1970. The volume of all poultry slaughtered in Federally inspected plants increased from 8.1 to 12.9 billion pounds live weight between 1961 and 1970--a 59-percent increase. In the same period, the number of slaughtering plants dropped from 532 to 412. Federally inspected slaughter, cut-up, and further processed volumes by product class in 1970 are given in table 2. Young chickens and all turkeys accounted for 93 percent of total slaughter. Young chickens accounted for over 90 percent of total cut-up volume, while turkeys, mature chickens, and young chickens accounted for important amounts of total further processed volume. The number of Federally inspected plants handling poultry and red meat and poultry on December 31, 1970 is shown in table 3.

Structure

Concentration in poultry processing generally has been low compared with other branches of food manufacturing. Census data show a slight increase in concentration between 1963 and 1967 (table 4). For 1963, the 4, 8, 20, and 50 largest companies accounted for 14, 20, 30, and 47 percent of total shipments; in

Table 2.--Federally inspected poultry slaughter, cut-up, and further processed volume, by product class, 1970

Category	Young chickens 1/	Mature chickens 2/	Turkeys 3/	Other poultry 4/	Total poultry
Slaughtered (1,000 pounds live weight)	10,073,725	810,555	1,987,715	81,860	12,953,825
Percentage of total slaughter	77.7	6.3	15.3	0.7	100.0
Cut-up (1,000 pounds ready-to-cook)	1,842,594	8,608	190,713	2,230	2,044,145
Percentage of total cut-up	90.2	0.4	9.3	0.1	100.0
Further processed (1,000 pounds ready-to-cook)	337,292	392,404	479,427	83,274	1,292,397
Percentage of total further processed	26.2	30.3	37.1	6.4	100.0

1/ Young chickens are commercially grown broilers-fryers and other young immature birds such as roasters and capons.

2/ Mature chickens are fowl from breeder and market egg flocks and stags and cocks.

3/ Includes fryer-roasters which are young immature birds, usually under 16 weeks of age; young turkeys grown to a matured market age, usually 5-7 months; and old turkeys which are fully matured birds held for egg production, usually over 15 months of age.

4/ Includes ducks, geese, guineas, squabs, pigeons, partridge, pheasants, and rabbits.

Source: Based on data from Slaughter Under Federal Inspection and Poultry Used in Further Processing, SRS-USDA, Pou 2-1(2-71).

Table 3.--Number of Federally inspected plants handling poultry and meat and poultry, December 31, 1970

Type of plant	Number
Poultry slaughtering 1/	412
Poultry slaughtering, cut-up and further processing 2/	590
Combination meat and poultry plants, primarily further processing	590
Total plants handling poultry	1,180

1/ Any plant involved in slaughtering young chickens, mature chickens, turkeys, ducks, or other poultry.
2/ Includes slaughtering plants counted above as well as specialized further processing plants and cut-up plants.

Source: Unpublished data, Animal and Plant Health Inspection Service, USDA.

Table 4.--Census concentration ratios for poultry dressing firms, 1963 and 1967

Year	Companies	Value of shipments	Pctg. of value of shipments: Firms ranking			
			1-4	1-8	1-20	1-50
	Number	Million dollars	Percent			
1963	842	2,240.9	14	20	30	47
1967	709	2,936.1	15	23	35	51

Source: Bureau of the Census, Concentration Ratios in Manufacturing, 1967, Standard Industrial Classification 2015, Part 1, August 1970.

1967, these percentages were 15, 23, 35, and 51. The number of companies decreased by 15.8 percent from 1963 to 1967, but the value of shipments increased by 31 percent.

The 4, 8, and 20 largest Federally inspected firms accounted for 18, 29, and 47 percent of total Federally inspected young chicken slaughtered in 1968 (4), compared with percentages of 18, 28, and 44 in 1964 (table 5). In 1968, the 4, 8, and 20 largest turkey firms slaughtered 30, 44, and 65 percent of total Federally inspected slaughter, an increase from the 1964 level of 22, 33, and 51 percent. For the four largest young chicken firms, the number of plants operated decreased from 36 in 1964 to 31 in 1968. The four largest turkey firms increased the number of plants operated from 29 to 30.

Table 5.--Share of Federally inspected young chicken and turkey slaughtered by the 4, 8, and 20 largest firms and the number of plants operated by these firms, 1964 and 1968

Poultry and year	Share of total Federally inspected slaughter		
	Four largest firms	Eight largest firms	20 largest firms
	Percent		
Young chickens:			
1964	18	28	44
1968	18	29	47
Turkeys:			
1964	22	33	51
1968	30	44	65
	Number of plants operated		
Young chickens:			
1964	36	51	80
1968	31	48	84
Turkeys:			
1964	29	37	56
1968	30	38	54

Source: F. L. Faber and W. W. Gallimore, Changes in Firm and Plant Size in Broiler and Turkey Processing, Poultry and Egg Situation, U.S. Dept. Agr., November 1969.

A growing share of poultry processing has been handled by the largest firms. Motivation of firms to grow by acquisition appeared to remain strong through 1970. Although the upward trend in concentration might be expected to increase through further mergers, it could be reversed if corporate management were to become dissatisfied with the relative rates of return from processing and decide to divest themselves of processing plants.

Markets

Poultry meat is marketed primarily through retail food stores; about 25 percent of broiler output is sold through institutional firms. Broilers are sold in fresh ice-packed or chilled form; ready-to-cook turkeys are sold primarily in frozen form; and most mature chickens are further processed. Further processed poultry products accounted for about 13 percent of total poultry slaughter (ready-to-cook weight) in 1970. For turkeys, 31 percent of total slaughter (ready-to-cook) was used in further processed products in 1970. 6/ Broilers, which are sold and consumed on a year-round basis, are in direct competition with red meats, particularly pork. Because of the seasonal consumption pattern for turkeys, turkey meat has less sustained direct competition from red meats.

Excluding live poultry, the prices of inputs purchased by poultry processing firms have been rising steadily. The index of prices paid for intermediate goods and services for food marketing firms rose steadily from 116 (1957-59 = 100) in 1967 to 134 in September 1970 (14). In addition, labor costs, which amount to about one-half of total costs incurred by firms processing and distributing farm products, have been increasing rapidly for several years. The trend of rising input costs is expected to continue. Prices of live poultry did not exhibit an upward trend from 1960 to 1970. Wholesale prices, that is, prices received by firms for dressed ready-to-cook poultry, have trended downward since 1960. For selected chicken processing firms, net income after taxes averaged 0.65 percent of sales, 3.6 percent of assets, and 7.7 percent of net worth from 1959 to 1964 (6). For selected turkey processing firms, the figures for the period were 1.3, 8.2, and 17.8 percent, respectively. In general, poultry meat firms face rising production and processing costs and considerable downward pressure on final product prices.

6/ Unpublished data from the Meat and Poultry Inspection Division, APHIS, USDA.

Location of Production

Broilers and turkeys are produced in highly concentrated geographic areas and, with few exceptions, slaughtering plants are located in production areas. The location of these plants has shifted over time from market to production areas. Because of the limited state of technology in production, transportation, processing, and distribution, plants once were required to locate near major markets. With development of new technology and changes in industry structure toward coordinated systems, slaughtering plants no longer have to be located close to markets. On the other hand, because of the market-oriented nature of the processed poultry business, many further processing plants are in heavily populated areas.

For broilers, the 10 top producing States--primarily in the South Atlantic and South Central regions--accounted for 84 percent of total U.S. production in 1970 (table 6). These two regions produced 87 percent of commercial broiler supply in 1970 (table 7). All regions except these two experienced declines in shares of U.S. broiler production from 1960 to 1970. For turkeys, the top 10 States--including Minnesota, California, North Carolina, Missouri, and Arkansas--produced 75 percent of U.S. turkey output in 1970. Production of turkeys is not as concentrated regionally as broiler production, with the two largest regions--West North Central and West--accounting for 52 percent of turkey output in 1970. Production of mature chickens is less regionally concentrated than that of broilers or turkeys, with the top 10 States accounting for 56 percent of U.S. production in 1970. The two largest regions--South Atlantic and South Central--accounted for 48 percent of the total.

INDUSTRY LOCATION, WATER USE, AND WASTE TREATMENT

This section presents information obtained from the survey of Federally inspected poultry slaughtering plants. Where pertinent, data are broken down by plant size and region. Estimates of water use and wasteloads were made for four groups of plants--those with private treatment, municipal treatment, private-municipal treatment, and no treatment. The estimating procedure based water use and wasteloads on actual volumes of poultry slaughtered in plants in 1970. Standard raw wasteloads from the Industrial Waste Study of the Meat Products Industry (2) provided the basic water, BOD, 7/ and suspended solid parameters 8/ per 1,000 pounds

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7/ Estimates of BOD wasteloads were based on BOD_5 parameters. See footnote 4 for a definition of BOD.

8/ Suspended solids are wastes that will not sink or settle in plant effluent and which must be removed by secondary or tertiary treatment.

Table 6.--Leading 10 States in production of broilers, mature chickens, and turkeys, 1970

Broilers		Mature chickens		Turkeys	
State	Production (live weight)	State	Production (live weight)	State	Production (live weight)
	Pounds		Pounds		Pounds
Georgia	1,577,149	California	102,824	California	302,834
Arkansas	1,539,126	Georgia	100,546	Minnesota	302,677
Alabama	1,313,981	Arkansas	84,582	North Carolina	175,959
North Carolina	1,137,295	North Carolina	72,026	Texas	169,150
Mississippi	892,660	Pennsylvania	63,558	Missouri	158,979
Maryland	722,452	Alabama	61,265	Arkansas	143,081
Texas	662,591	Mississippi	51,006	Iowa	122,015
Delaware	521,535	Texas	46,037	Indiana	93,374
California	338,922	Florida	44,144	Utah	85,294
Maine	321,510	Indiana	42,441	Virginia	77,451
Total	9,027,221	Total	668,429	Total	1,630,814

Source: Based on data from Statistical Reporting Service, USDA.

Table 7.--Production of broilers, mature chickens, and turkeys, by region, 1970

Region 1/	Broilers	Mature chickens	Turkeys
	1,000 pounds live weight		
North Atlantic	594,356	167,156	59,828
	2/(5.5)	(14.0)	(2.7)
East North Central	155,086	145,191	273,188
	(1.4)	(12.1)	(12.5)
West North Central	161,984	160,664	638.712
	(1.5)	(13.5)	(29.3)
South Atlantic	4,528,245	278,502	372,638
	(41.9)	(23.4)	(17.1)
South Central	4,855,432	295,965	341,901
	(44.9)	(24.7)	(15.7)
West	506,740	147,457	498,186
	(4.8)	(12.3)	(22.7)
United States (48)	10,801,843	1,194,935	2,184,453
	(100.0)	(100.0)	(100.0)

1/ States in regions: North Atlantic--Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, New York, Connecticut, New Jersey, and Pennsylvania; East North Central--Ohio, Indiana, Illinois, Michigan, and Wisconson; West North Central--Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas; South Atlantic--Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida; South Central--Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, and Texas; West--Montana, Wyoming, California, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, Colorado, and Idaho.

2/ Number in parentheses is regional share of U.S. total.

Source: Based on data from Statistical Reporting Service, USDA.

of product used for converting plant volumes to plant and industry water use and wasteloads (table A-7). Standard raw wasteloads are based on the effluent from a well-run slaughtering plant before primary or secondary treatment.

The 386 slaughtering plants surveyed accounted for 96 percent of Federally inspected slaughter in 1970, 76 percent of cut-up volume, and 42 percent of further processed volume (table 8). One hundred thirteen plants with private waste treatment accounted for 25 percent of 1970 slaughter, 23 percent of further processed volume, and 9 percent of cut-up volume. A total of 245 plants with final municipal treatment had 65, 49, and 32 percent of these categories, respectively (table 8). Twenty-eight plants with no waste treatment had 6 percent of slaughter, 4 percent of cut-up volume, and 0.5 percent of further processed poultry. Thus, most Federally inspected poultry are slaughtered in plants that have some type of private, municipal, or combination waste treatment system. However, not all private or municipal treatment systems provide secondary treatment.

Slaughtering Plant Processes

The major standard manufacturing processes in a modern poultry slaughtering plant with flow-away systems for handling feathers and offal--head, feet, and viscera--are receiving, killing, defeathering, eviscerating, chilling, packing, and further processing (fig. 1). These plant processes, including subprocesses of scalding, washing, offal and blood handling, and cleanup, are the major sources of water pollutants in the poultry processing industry (2). Pollutants in the industry consist of blood, offal, grease, cleanup chemicals, nutrients, manure, feed, and feathers.

In the receiving area, manure, feathers, and dirt are major pollutants that accumulate. If live poultry is held for a relatively short time (as is common practice), these pollutants are of minor importance compared with those resulting from other processes. Waste materials collected by dry cleaning are dumped as refuse or loaded onto the offal truck, along with feathers, offal, and blood, and sent to rendering. Relatively small amounts of water are used in this area, following dry cleanup, to remove residual material.

Feathers, dirt, manure, and blood are pollutants that may enter into the sewer from the killing area. Blood is the most significant pollutant, contributing about 40 percent of BOD loading. Congealed blood and other pollutants too difficult to remove by draining may be flushed to sewers during cleanup. In some plants, birds are electrically shocked adjacent to the killing operation. Manual severance of the juglar vein is the most common killing technique, although some plants use an

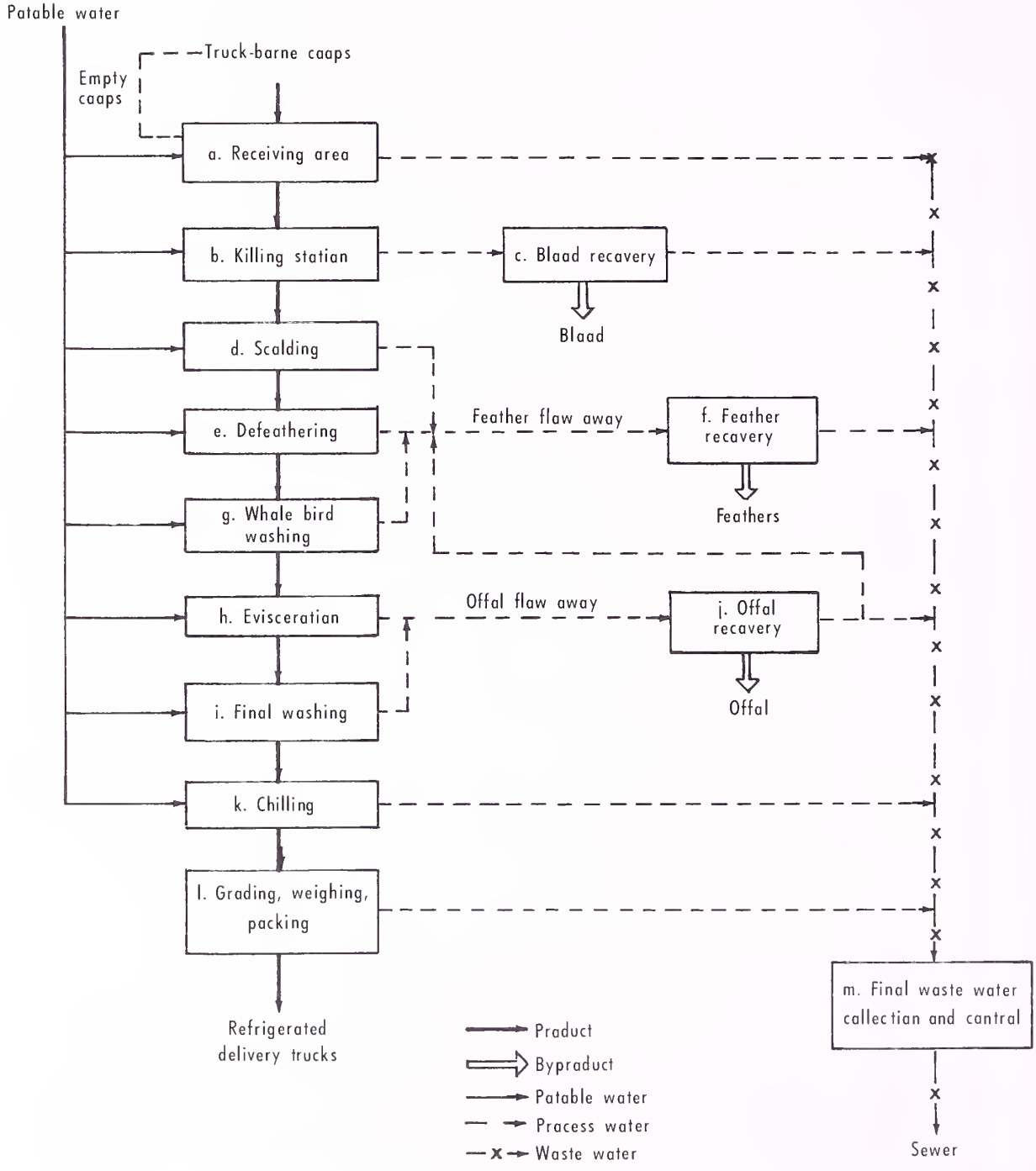
Table 8.--Volume of slaughter, cut-up, and further processed output accounted for by surveyed poultry slaughter plants, by source of waste treatment, 1970

Source of waste treatment	Plants	Slaughter					Cut-up	Further processing
		Broilers	Mature chickens	Turkeys	Other poultry	Total poultry		
	Number	1,000 lb. live weight					1,000 lb. RTC 1/	
Private	113	2,598,439	139,756	382,964	68,175	3,189,334	468,126	121,025
Municipal	193	4,810,244	404,503	1,219,414	4,282	6,438,443	744,385	324,985
Private and municipal	52	1,507,246	154,649	319,218	2,162	1,983,275	260,637	94,198
No treatment	28	753,573	36,326	17,440	3,508	810,847	81,617	6,515
Total	386	9,669,502	735,234	1,939,036	78.127	12,421,899	1,554,765	546,725
		Percent						
Percentage of 1970 U.S. Federally-inspected slaughter		96.0	90.6	97.5	95.1	96.0	76.0	42.3

1/ RTC = ready-to-cook weight.

Source: Survey data and unpublished data from APHIS, USDA.

FIGURE 1.--FLOW CHART OF POULTRY PROCESSING PLANT



automatic mechanical system. The killing area is usually a well-contained area with high walls on both sides to restrict drainable blood to this area. Many plants attempt to recover as much as possible of the free draining blood, but only about 70 percent is recovered in the killing area under best conditions. Therefore, considerable blood can drain onto floors in other areas of the plant as the birds move through the various operations. Some plants have installed blood collection troughs under conveyor lines to prevent blood from draining onto floors and later being flushed into sewers. In the killing area, blood is usually allowed to congeal on the floor and is removed as a semisolid. Blood collected in this area is usually mixed with feathers and offal on the offal truck. A less common practice, but one which appears to be increasingly used, is to load the blood into receiving tanks attached to the offal truck. This prevents drainage from the truck into a sewer and keeps the byproducts separate for rendering.

After killing, the birds are scalded in either a scald tank or a spray scald and feathers are removed mechanically--usually by continuous-type machines equipped with rubber fingers attached to rotating drums. After defeathering, remaining pin feathers are removed, usually by hand. Warm water is sprayed onto birds as a lubricant and to flush away feathers. Wastewater from the defeathering operations results from continuous overflow from the scald tank and the final dump of the scald tank at the end of the operating day. Wastewater from defeathering operations also results from continuous water spray from the defeathering machines and from washdown of floors and equipment during cleanup. Overflow wastewater from the scald tank, which is 1 quart per bird, contains feathers, blood, dirt, and manure--making this waste stream high in pollutional strength. Water in the scald tank is dumped daily, but the volume is small and does not contribute much to total wasteload. Feathers flumed away contain manure, dirt, and blood. These materials may be dissolved or suspended in the wastewater. Feathers can be removed easily from wastewater by screening.

The evisceration room is segregated from killing, scalding, and defeathering areas of the plant to prevent cross contamination from any previous operation. When the birds enter the eviscerating area, their feet are removed, usually with an automatic cutter. On the evisceration line, the oil gland is removed and the peritoneal cavity is opened. The viscera are then pulled out and exposed, and the carcass and entrails are inspected by regulatory personnel. The giblets are recovered, trimmed, and washed, and the inedible viscera is discharged. The lungs are removed by vacuum, raking, or by hand. The head is removed and, finally, the neck is removed and washed. Cleaning of the gizzard involves splitting, washing out the contents, peeling the inner liner, and a final wash. The giblets are sent to giblet chillers. The inedible viscera and head are carried away by water in the

offal flow-away system, and the birds are thoroughly washed, both inside and outside, and conveyed to chillers. Potential pollutants from the evisceration process include feet, heads, viscera, crop, windpipes, lungs, grit, sand and gravel, flesh, fat, grease, and blood. Usually, these are received by the offal flow-away system which carries them to the screening room. The screening removes the bulk of the suspended material; however, some soluble organic matter, blood, grit, sand, fat, grease, and flesh particles are not removed. It is not uncommon for evisceration to account for 40-50 percent of the BOD load in plant effluent. Major sources of water from evisceration are flow-away water and water from the many hand washers located on the eviscerating trough and from the washers in the automatic gizzard splitters. Reducing the water flow as much as possible from these major sources in evisceration would lower the hydraulic load of the plant significantly. Because of a high positive correlation between water use and wasteload, this would likely reduce BOD loadings (7).

The birds must be chilled before packed for shipment. Removal of the body heat is an important operation because rapid cooling ensures flavor and lengthens market life. Almost all modern poultry processing plants use large chilling tanks containing ice water. Several forms of these tanks are in use: One is a large enclosed drum which rotates about a central axis; another is a perforated cylinder mounted within a chilling vat; and a third is a large open chilling vat containing a mechanical rocker to provide agitation. In all these, the birds cascade forward with the flow of water. Most poultry plants use several chilling vats in series. The flow is countercurrent through the series, so the first chilling vat is warmer than the next and so on down the line. In this arrangement, ice and water are added to the last chiller. The effluent from the first chiller may go to the offal flow-away system. Normally, the carcass is chilled in 30-40 minutes. A similar but separate and smaller chilling system is used for cooling giblets. After the birds are chilled, they are rehung on a different conveyor line so the excess moisture can drain off. The birds are then conveyed to an automatic weighing and separating area and are graded and packed or undergo further processing. Pollutants resulting from the chilling of birds include fats, grease, blood, and meat tissue. Chilling operations normally account for less than 8 percent of the total BOD load in the plant effluent. Chilling therefore is not considered a major source of BOD, although it may contribute a major share of the grease load.

Plant Location

Slaughtering plants are located in all six geographic regions (table 1), but tend to concentrate in major production areas. In 1970, the South Atlantic and South Central regions accounted for 87 percent of total U.S. young chicken production,

48 percent of mature chicken production, and 33 percent of turkey production (table 7). Of the 386 plants surveyed, 209 were in these two regions (table 1). These regions had 69 of 75 large plants--those with 50 million pounds or more live weight slaughter annually. The remaining six plants were in the North Atlantic region. The concentration of large plants in these regions reflects the predominance of broiler production. In 1969, there were 63 large Federally inspected broiler plants, compared with only five turkey plants with output over 40 million pounds live weight. 9/ Relatively more small plants were in the other four regions, particularly in the North Atlantic and East North Central regions, where small plants accounted for 19 of 38 and 24 of 42 plants (table 1).

These data show poultry slaughtering plant wasteloads in all regions, with the greatest amounts produced in the South Atlantic and South Central regions. Data on plant location relative to municipal limits and size of population center provide more specific information on plant location.

Location Relative to Municipal Limits

Access to municipal water and sewer services for slaughtering plants depends on location. Location outside of municipal limits does not always preclude a plant from having municipal services; location within municipal limits does not mean every plant uses these services. However, this locational criterion is an approximate measure of the availability of these services.

A majority of all plants--273 of 386--are located within municipal limits (table 9). The West North Central, South Central, West, and South Atlantic regions had larger proportions of plants within municipal limits. The West North Central and South Central regions had 46 of 48 and 99 of 118 plants inside municipal limits. In contrast, the North Atlantic and East North Central regions had 20 of 38 and 21 of 42 plants similarly located.

In total, there were only minor variations in plant size and location relative to municipal limits. However, in the North Atlantic and East North Central regions where small plants represented 50 percent or more of all plants, larger proportions of both small and medium plants were outside municipal limits.

9/ Unpublished data from Meat and Poultry Inspection Division, APHIS, USDA.

Table 9.--Location of surveyed poultry slaughtering plants relative to municipal limits, by size of plant and region, 1970

Plant size and location	Region						
	North Atlantic	East North Central	West North Central	South Atlantic	South Central	West	All
	Number of plants						
Small:							
Within....	10	12	12	2	11	14	61
Outside...	9	11	1	4	2	5	32
Total...	19	1/24	13	6	13	19	1/94
Medium:							
Within....	5	9	34	29	59	20	156
Outside...	8	8	1	20	11	6	54
Total...	13	1/18	35	1/51	70	1/30	1/217
Large:							
Within....	5	--	--	22	29	--	56
Outside...	1	--	--	11	5	--	17
Total...	6	--	--	1/34	1/35	--	1/75
All.....	38	42	48	91	118	49	386

1/ Differences in total and components exist because some plants did not indicate location.

Location by Size of Population Center

To locate in rural production areas, plants must have available either municipal water and sewer services or privately constructed services. Many municipalities have offered low-cost water and sewer services to industrial users to attract new industries. The shift of slaughtering plants to production areas and the efforts of towns to attract industry have resulted in more plants being located in or near small population centers. The tendency for plants with municipal treatment to be located in relatively small population centers results in increased industrial wasteloads for municipal treatment systems. A broiler plant slaughtering 50 million pounds per year requires a treatment system that can handle the domestic sewage load of 10,500 people 10/. For adequate sewage treatment, a population center

10/ This assumes a BOD value of 1,776 pounds per day (8.3 pounds per 1,000 pounds broilers) and a population equivalent of 0.17 pound BOD per person per day.

of 10,000 with a poultry plant of this size would require a treatment system with twice the capacity needed solely for domestic sewage. In some cases, there is more than one slaughtering plant using a city's municipal treatment system, and other industrial users may also exist. For some population centers, industrial and domestic wasteloads may exceed the capacity of sewage treatment systems. 11/

A majority of all plants surveyed were in or near population centers of less than 10,000 (table 10); of the 386 plants, 240, or 62 percent, were in that category. 12/ About 76 percent of all plants were in or near population centers of less than 20,000. The North Atlantic and East North Central regions had a higher proportion of all plants in or near population centers of less than 5,000 than the other regions, particularly the South Central and West regions (table 11). These two regions had a higher proportion of plants in the 20,000-or-more population center size classifications. In total, there were no major variations between plant size and plant location by size of population center. However, on a regional basis, relatively more small and medium plants in the North Atlantic and East North Central regions were in or near population centers of less than 5,000.

Fifty-two percent of plants using municipal treatment were in or near population centers of less than 10,000 (table 12). Relative to all plants surveyed, plants with municipal treatment were less concentrated in or near population centers of less than 10,000. Sixty-nine percent of plants with municipal treatment were in or near population centers of less than 20,000. The North Atlantic, East North Central, and West North Central regions had a higher proportion of plants with municipal treatment in or near population centers of less than 10,000 than other regions. The South Atlantic, South Central, and West regions had 25 of 47, 47 of 94, and 25 of 35 plants in or near population centers of over 10,000 (table 13). For all plants with municipal treatment, 118 of 245 were in this category. A higher proportion of small plants with municipal treatment was in or near population centers of 40,000 and over, compared with medium and large plants.

Water Sources and Use

Poultry slaughtering plants obtain water from municipal and nonmunicipal water systems and from private wells. Of the 386 plants, 240 obtained water from municipal systems, 104 from private wells, and 42 from both sources or from nonmunicipal sources (table 14). The North Atlantic and East North Central

11/ This study did not evaluate the performance of municipal systems treating poultry plant wastes.

12/ All plants surveyed are included in the table, whether within or outside municipal limits.

Table 10.--Number and distribution of surveyed poultry slaughtering plants, by size of plant and size of population center, 1970

Size of population center	Size of plant											
	Small			Medium			Large			All		
	Number	Percent	Cumulative percent	Number	Percent	Cumulative percent	Number	Percent	Cumulative percent	Number	Percent	Cumulative percent
0-999	22	23.4	23.4	28	12.9	12.9	10	13.3	13.3	60	15.5	15.5
1,000-2,499	14	14.9	38.3	47	21.7	34.6	17	22.8	36.1	78	20.4	35.9
2,500-4,999	11	11.7	50.0	25	11.5	46.1	10	13.3	49.4	46	11.8	47.7
5,000-9,999	15	16.0	66.0	31	14.3	60.4	10	13.3	62.7	56	14.5	62.2
10,000-19,999	7	7.4	73.4	35	16.1	76.5	12	16.0	78.7	54	14.0	76.2
20,000-29,999	5	5.3	78.7	9	4.1	80.6	6	8.0	86.7	20	5.2	81.4
30,000-39,999	2	2.2	80.9	6	2.8	83.4	0	0.0	86.7	8	2.1	83.5
40,000 and over	18	19.1	100.0	36	16.6	100.0	10	13.3	100.0	64	16.5	100.0
Total	94	100.0	100.0	217	100.0	100.0	75	100.0	100.0	386	100.0	100.0

Source: Population based on information in the National Atlas of the U.S.A., 1970.

Table 11.--Location of all surveyed poultry slaughtering plants, by size of population center and by region and size of plant, 1970

Region and plant size	Size of population center								
	0-999	1,000-2,499	2,500-4,999	5,000-9,999	10,000-19,999	20,000-29,999	30,000-39,999	40,000 & over	All
	Number of plants								
North Atlantic:									
Small	9	7	--	1	1	--	--	1	19
Medium	4	5	1	--	2	--	--	1	13
Large	1	--	1	2	--	1	--	1	6
Total	14	12	2	3	3	1	--	3	38
East North Central:									
Small	7	4	5	2	2	2	1	1	24
Medium	5	5	4	2	1	--	--	1	18
Large	--	--	--	--	--	--	--	--	--
Total	12	9	9	4	3	2	1	2	42
West North Central:									
Small	2	--	3	4	1	--	--	3	13
Medium	1	11	3	9	5	3	2	1	35
Large	--	--	--	--	--	--	--	--	--
Total	3	11	6	13	6	3	2	4	48
South Atlantic:									
Small	2	1	1	--	--	2	--	--	6
Medium	11	11	5	7	9	1	--	7	51
Large	6	10	2	3	7	1	--	5	34
Total	19	22	8	10	16	4	--	12	91
South Central:									
Small	1	--	--	3	3	--	--	6	13
Medium	4	13	11	8	13	3	4	14	70
Large	3	7	7	5	5	4	--	4	35
Total	8	20	18	16	21	7	4	24	118
West:									
Small	1	2	2	5	--	1	1	7	19
Medium	3	2	1	5	5	2	--	12	30
Large	--	--	--	--	--	--	--	--	--
Total	4	4	3	10	5	3	1	19	49
Total	60	78	46	56	54	20	8	64	386

Table 12.--Number and distribution of surveyed poultry slaughtering plants using municipal treatment, by size of plant and size of population center, 1970

Size of population center	Size of plant											
	Small			Medium			Large			All		
	Number	Percent	Cumulative percent	Number	Percent	Cumulative percent	Number	Percent	Cumulative percent	Number	Percent	Cumulative percent
0-999	3	6.7	6.7	8	5.3	5.3	2	4.2	4.2	13	5.3	5.3
1,000-2,499	6	13.3	20.0	25	16.4	21.7	9	18.8	23.0	40	16.3	21.6
2,500-4,999	4	8.9	28.9	18	11.8	33.5	9	18.8	41.8	31	12.7	34.3
5,000-9,999	8	17.8	46.7	28	18.5	52.0	7	14.6	56.4	43	17.6	51.9
10,000-19,999	3	6.7	53.4	28	18.5	70.5	11	22.8	79.2	42	17.1	69.0
20,000-29,999	4	8.9	62.3	9	5.9	76.4	5	10.4	89.6	18	7.3	76.3
30,000-39,999	2	4.4	66.7	6	3.9	80.3	0	0.0	89.6	8	3.3	79.6
40,000 and over	15	33.3	100.0	30	19.7	100.0	5	10.4	100.0	50	20.4	100.0
Total	45	100.0	100.0	152	100.0	100.0	48	100.0	100.0	245	100.0	100.0

Source: Population based on information in the National Atlas of the U.S.A., 1970.

Table 13.--Location of surveyed poultry slaughtering plants using municipal treatment, by size of population center and by region and size of plant, 1970

Region and plant size	Size of population center								
	0-999	1,000-2,499	2,500-4,999	5,000-9,999	10,000-19,999	20,000-29,999	30,000-39,999	40,000 & over	All
	Number of plants								
North Atlantic:									
Small	1	2	--	--	--	--	--	--	3
Medium	1	--	--	--	1	--	--	1	3
Large	--	--	1	--	--	1	--	--	2
Total	2	2	1	--	1	1	--	1	8
East North Central:									
Small	1	2	1	1	--	1	1	--	7
Medium	2	3	2	2	1	--	--	--	10
Large	--	--	--	--	--	--	--	--	--
Total	3	5	3	3	1	1	1	--	17
West North Central:									
Small	1	--	3	3	1	--	--	3	11
Medium	1	9	3	9	5	3	2	1	33
Large	--	--	--	--	--	--	--	--	--
Total	2	9	6	12	6	3	2	4	44
South Atlantic:									
Small	--	--	--	--	--	2	--	--	2
Medium	1	3	2	6	6	1	--	5	24
Large	1	5	2	2	7	--	--	4	21
Total	2	8	4	8	13	3	--	9	47
South Central:									
Small	--	--	--	2	2	--	--	6	10
Medium	3	8	10	8	10	3	4	13	59
Large	1	4	6	5	4	4	--	1	25
Total	4	12	16	15	16	7	4	20	94
West:									
Small	--	2	--	2	--	1	1	6	12
Medium	--	2	1	3	5	2	--	10	23
Large	--	--	--	--	--	--	--	--	--
Total	--	4	1	5	5	3	1	16	35
Total	13	40	31	43	42	18	8	50	245

Table 14.--Water source for surveyed poultry slaughtering plants, by size of plant and region, 1970

Plant size and water source	Region						
	North Atlantic	East North Central	West North Central	South Atlantic	South Central	West	All
	Number of plants						
Small:							
Municipal...	3	8	9	1	10	13	44
Private.....	16	14	3	5	1	3	42
Other 1/....	--	2	1	--	2	3	8
Total.....	19	24	13	6	13	19	94
Medium:							
Municipal...	3	8	28	29	59	23	150
Private.....	9	9	2	16	8	2	46
Other 1/....	1	1	5	6	3	5	21
Total.....	13	18	35	51	70	30	217
Large:							
Municipal...	4	--	--	19	23	--	46
Private.....	2	--	--	8	6	--	16
Other 1/....	--	--	--	7	6	--	13
Total.....	6	--	--	34	35	--	75
All.....	38	42	48	91	118	49	386

1/ Includes plants with both private and municipal sources and plants purchasing water from other sources.

regions had proportionately more plants using private water sources than other regions (table 14). In these two regions, a majority relied on private water sources. For all regions, small plants used private sources to a greater extent than medium and large plants. Small plants accounted for a greater proportion of total plants in the North Atlantic and East North Central regions. The use of private water sources in these regions may be explained, in part, by the tendency for more plants to be located outside municipal limits and to be in or near population centers of less than 5,000, compared with plants in other regions. The size of population center may limit the availability of municipal water.

Volume of Water Used

Based on 1970 plant operations, the total volume of water used by surveyed plants was estimated to be 27.3 billion gallons (table 15). Of that amount, 17.8 billion gallons came from municipal sources, 5.7 billion from private sources, and 3.8 billion from other sources. Plants with final municipal treatment used 18.4 billion gallons; those with private treatment, 7.1 billion; and those with no treatment, 1.8 billion.

The South Atlantic and South Central regions accounted for 21.1 of the 27.3 billion gallons used by surveyed plants (table 15). The higher average volume per plant for these regions reflected the greater concentration of large plants in the South Atlantic and South Central regions. For all plants, average annual water use per plant was 70.8 million gallons, compared with 112.8 and 92.8 million gallons for plants in the South Atlantic and South Central regions (table 15).

Disposition of Byproducts

Poultry slaughtering plants produce significant volumes of byproducts--the major ones are blood, feathers, and offal (the head, feet, and viscera). All plants surveyed produced 861 million pounds of blood, 2,070 million of offal, and 864 million of feathers (table 16).

The handling of byproducts determines to a major extent the amount of byproducts that escape into plant effluent and increase the difficulty and costs of wastewater treatment. In addition to the incentive of lower treatment costs, major byproducts in themselves have economic value. The primary use of blood, offal, and feathers is in byproduct meals which are used as protein supplements in animal feeds. Inplant equipment such as screens and traps reduce the amount of byproducts that enter into final plant effluent. Water is used in most plants to remove byproducts from processing areas to central collection points (table A-6). The use of water for transporting byproducts increases the probability of higher BOD levels of plant effluent (2, 7).

The survey showed that slaughtering plants use various means of disposing their byproducts (table 17). Estimates of volumes of each major byproduct by method of disposition are provided in table 18. Nearly all offal and feathers were estimated to be salvaged and kept out of the final wastewaters of plants. However, 14 percent of total blood was estimated to be unsalvaged. Grease was another byproduct which was not salvaged by a large number of plants. These data suggest that BOD loadings for plants not salvaging blood and grease are higher than necessary and that economic losses are incurred through byproduct escape.

Table 15.--Estimated annual total and average plant water use and wasteloads for surveyed poultry slaughtering plants, by region, based on 1970 plant operations 1/

Region	Source of waste treatment											
	Private			Municipal			None			All sources		
	Water	BOD	Suspended solids	Water	BOD	Suspended solids	Water	BOD	Suspended solids	Water	BOD	Suspended solids
	1,000 gal.	1,000 lb.	1,000 lb.	1,000 gal.	1,000 lb.	1,000 lb.	1,000 gal.	1,000 lb.	1,000 lb.	1,000 gal.	1,000 lb.	1,000 lb.
North Atlantic:												
Total	922,215	3,306	2,444	517,702	1,827	1,365	410,116	1,478	1,114	1,850,033	6,611	4,923
Avg. per plant	36,889	132	98	64,712	228	171	82,023	296	223	48,685	174	130
East North Central:												
Total	346,806	1,415	885	553,322	2,204	1,489	54,044	296	148	954,172	3,915	2,522
Avg. per plant	15,509	67	42	32,548	130	88	13,511	59	37	22,178	93	60
West North Central:												
Total	32,569	117	73	1,639,870	6,576	4,246	25,792	120	75	1,698,231	6,813	4,394
Avg. per plant	16,284	58	37	37,269	149	97	12,896	60	38	35,379	142	92
South Atlantic:												
Total	4,135,747	15,020	11,351	5,824,517	21,424	16,038	300,264	1,105	827	10,260,528	37,549	28,216
Avg. per plant	103,393	376	284	123,925	456	341	75,066	275	207	112,750	413	310
South Central:												
Total	1,307,520	4,775	3,645	8,621,151	31,738	23,908	1,023,870	3,757	2,880	10,952,541	40,270	30,433
Avg. per plant	93,394	341	260	91,714	338	254	102,387	376	288	92,818	341	258
West:												
Total	355,182	1,499	983	1,253,230	5,165	3,464	2,285	9	7	1,610,697	6,663	4,454
Avg. per plant	32,289	136	89	35,806	148	99	761	3	2.5	32,871	136	91
All Regions:												
Total	7,100,039	26,132	19,381	18,409,792	68,934	50,510	1,816,371	6,765	5,051	27,326,202	101,821	74,942
Avg. per plant	62,835	231	172	75,142	281	206	64,870	242	180	70,793	264	194

1/ Parameters used in estimating water use and wasteloads are provided in table A-7.

Table 16.--Production of poultry byproducts, by number of surveyed poultry slaughtering plants and source of waste treatment, 1970 1/

Source of waste treatment	Plants	Byproduct		
		Blood	Offal	Feathers
	Number	1,000 pounds		
Private	113	221,172	535,893	218,480
Municipal	193	446,600	1,063,584	450,380
Private and municipal	52	137,260	330,261	138,678
No treatment	28	56,360	140,722	56,514
Total	386	861,392	2,070,460	864,052

1/ Parameters used in estimating byproduct production are provided in table A-7.

For all byproducts salvaged, the major practice was sale to renderers and others. Seventy-one percent of offal, 72 percent of feathers, and 55 percent of blood was sold to renderers and others. Twenty-seven percent of offal, 26 percent of feathers, and 22 percent of blood was rendered by plants. 13/ Some by-products were given to renderers and others. One percent of offal, 1.3 percent of feathers, and 1.8 percent of blood was dumped, burned, or disposed of in some way.

A comparison of the 1970 data with those of a 1955 USDA study--Utilization and Disposal of Poultry Byproducts and Wastes (MRR No. 143)--indicates that the poultry industry has made marked improvement in its byproduct handling and disposition. If practices of the earlier period were followed today, the pollution potentials of the industry would be greater. In the 1955 study, 343 poultry plants were surveyed. For these plants, only 44 percent of blood was salvaged, of which 25 percent was dumped. Therefore, only about 33 percent of blood was utilized in some manner. Nearly all offal and feathers were salvaged--that

13/ In some cases, byproducts were not rendered on site but at some central location by the parent firm. Data were insufficient to detail these practices.

Table 17.--Distribution of practices for disposition of poultry byproducts, by type of byproduct and number of plants, 1970

Disposition practice (percent)	Byproduct			
	Blood	Offal	Feathers	Grease
	Number of plants			
Not salvaged 1/:				
0-9.9	34	9	16	14
10-19.9	15	3	2	8
20-49.9	25	1	1	4
50-74.9	10	0	0	9
75-100	60	4	5	77
Sold to renderers, others:				
0-9.9	2	0	0	1
10-19.9	0	1	0	0
20-49.9	3	1	1	1
50-74.9	13	2	2	8
75-100	179	258	259	155
Given to renderers, others:				
0-9.9	0	1	0	0
10-19.9	0	0	0	0
20-49.9	0	0	0	1
50-74.9	1	1	0	1
75-100	38	24	18	24
Rendered by this plant:				
0-9.9	0	0	1	0
10-19.9	1	0	0	0
20-49.9	3	0	0	0
50-74.9	1	2	1	4
75-100	54	64	64	49
Dumped, burned, etc.:				
0-9.9	1	3	3	1
10-19.9	3	0	1	3
20-49.9	0	1	1	1
50-74.9	0	0	1	2
75-100	23	12	28	20

1/ The byproduct is not collected but enters the plant's wastewater stream.

Table 18.--Volume and percentage of poultry byproducts disposed from surveyed poultry slaughtering plants, 1/ by disposition practice, 1970

Disposition practice	Byproduct		
	Blood	Offal	Feathers
	1,000 pounds		
Not salvaged 2/	120,562	12,047	3,773
	3/(14.2)	(0.6)	(0.4)
Sold to renderers, others	462,272	1,452,353	611,527
	(54.6)	(70.8)	(71.6)
Given to renderers, others	59,044	19,637	6,938
	(7.0)	(1.0)	(0.8)
Rendered by this plant	189,588	544,353	221,658
	(22.4)	(26.6)	(25.9)
Dumped, burned, etc.	15,032	20,708	11,194
	(1.8)	(1.0)	(1.3)
Total	846,498	2,049,098	855,090
	(100.0)	(100.0)	(100.0)

1/ Total volumes shown here are less than those in table 16 because all plants did not indicate disposition of byproducts.
2/ Byproduct is not collected but enters into plant's wastewater stream.
3/ Number in parentheses is percentage of total volume.

is, kept from final plant effluent--but 20 percent of offal and 34 percent of feathers were dumped after collection. The predominant practice was to give byproducts to renderers and farmers who were the major outlets. No on-site rendering or rendering by parent firms was reported.

Waste Treatment and Wasteloads

Of the 386 plants surveyed in 1970, 245 had final municipal waste treatment; plants with private treatment numbered 113; and 28 had no treatment (table 19). The West North Central, South Central, West, and South Atlantic regions had relatively more plants with municipal treatment than the North Atlantic and East North Central regions. The West North Central and South Central regions had 44 of 48 and 94 of 118 plants with municipal

Table 19.--Waste treatment source for surveyed poultry slaughtering plants, by size of plant and region, 1970

Plant size and source of waste treatment	Region						
	North Atlantic	East North Central	East North Central	South Atlantic	South Central	West	All
	Number of plants						
Small:							
Private	14	14	1	3	1	4	37
Municipal	2	5	9	1	8	11	36
Private-municipal	1	2	2	1	2	1	9
None	2	3	1	1	2	3	12
Total	19	24	13	6	13	19	94
Medium:							
Private	9	7	1	25	8	7	57
Municipal	2	6	29	23	45	16	121
Private-municipal	1	4	4	1	14	7	31
None	1	1	1	2	3	--	8
Total	13	18	35	51	70	30	217
Large:							
Private	2	--	--	12	5	--	19
Municipal	2	--	--	16	18	--	36
Private-municipal	--	--	--	5	7	--	12
None	2	--	--	1	5	--	8
Total	6	--	--	34	35	--	75
All	38	42	48	91	118	49	386

treatment, compared with 8 of 38 and 17 of 42 plants for the North Atlantic and East North Central regions. Regional variations in private and municipal waste treatment tend to parallel variations in plant location relative to municipal limits. Plants tend to be relatively more concentrated within municipal limits where they make greater use of municipal water and waste treatment services.

More medium and large plants (152 of 217 and 48 of 75) utilized municipal waste treatment than did small plants (45 of 94). Similarly, 37 of 94 small plants used private treatment, while 57 of 217 and 19 of 75 medium and large plants had private treatment (table 19). A higher proportion of small and large plants than medium plants had no treatment.

Types of Municipal and Private Treatment

Of the 245 municipal systems treating poultry plant wastes, 108 were activated sludge or trickling filters, 66 were lagoons, and 31 were primary only (table 20). The use of only primary treatment by several municipalities indicates that many poultry slaughtering plants do not receive adequate sewage treatment.

Plants with private waste treatment utilized mainly lagoons. Of the 113 plants with private treatment, 72 used some kind of lagoon system (table 21). Forty-one of the 72 plants had anaerobic-aerobic lagoon systems, and 31 had other lagoon systems. As noted earlier, the anaerobic-aerobic lagoon system was defined in this study as the best practicable control technology.

Sixteen plants had only primary treatment and 15 used irrigation to dispose of and utilize plant effluent. Eight plants used extended aeration and only two used activated sludge. Extended aeration was defined in this study as the best available control technology.

Thirteen of the 16 plants with only primary treatment were small plants, 11 of which were located in the North Atlantic and East North Central regions (table 21). Three medium plants had only primary treatment, and none of the large plants had only primary treatment. The relatively large number of small plants with only primary treatment (13 of 37) reflects, in part, the greater costs of secondary treatment systems.

Wasteloads Generated

Wasteloads, as measured by BOD and suspended solids, were estimated for all plants on the basis of volume of slaughter in 1970. As stated previously, specific parameters used are shown in table A-7. Total annual BOD and suspended solids production

Table 20.--Type of municipal treatment facilities treating wastewater from surveyed poultry slaughtering plants, by size of plant and region, 1970

Plant size and type of municipal treatment system	Region						
	North Atlantic	East North Central	West North Central	South Atlantic	South Central	West	All
	Number of plants						
Small:							
Primary	--	--	1	--	--	3	4
Anaerobic-aerobic lagoon	--	4	1	--	--	--	5
Other lagoon systems	1	--	2	--	--	1	4
Trickling filter	--	--	4	1	2	3	10
Activated sludge	1	2	1	--	5	4	13
Extended aeration	1	--	--	1	2	--	4
Other	--	1	2	--	1	1	5
Total	3	7	11	2	10	12	45
Medium:							
Primary	3	1	4	2	8	6	24
Anaerobic-aerobic lagoon	--	6	7	2	9	3	27
Other lagoon systems	--	3	2	2	11	--	18
Trickling filter	--	--	10	3	14	3	30
Activated sludge	--	--	6	9	10	5	30
Irrigation	--	--	--	--	--	2	2
Extended aeration	--	--	--	4	4	--	8
Other	--	--	4	2	3	4	13
Total	3	10	33	24	59	23	152
Large:							
Primary	--	--	--	1	2	--	3
Anaerobic-aerobic lagoon	--	--	--	2	3	--	5
Other lagoon systems	1	--	--	2	4	--	7
Trickling filter	1	--	--	3	6	--	10
Activated sludge	--	--	--	8	7	--	15
Extended aeration	--	--	--	4	3	--	7
Other	--	--	--	1	--	--	1
Total	2	--	--	21	25	--	48
All	8	17	44	47	94	35	245

Table 21.--Type of private treatment facilities for surveyed poultry slaughtering plants, by size of plant and region, 1970

Plant size and type of private treatment system	Region						
	North Atlantic	East North Central	West North Central	South Atlantic	South Central	West	All
	Number of plants						
Small:							
Primary	5	6	--	--	1	1	13
Anaerobic-aerobic lagoon	6	3	--	1	--	--	10
Other lagoon systems	1	4	1	1	--	1	8
Irrigation	2	1	--	--	--	2	5
Extended aeration	--	--	--	1	--	--	1
Total	14	14	1	3	1	4	37
Medium:							
Primary	--	--	1	--	--	2	3
Anaerobic-aerobic lagoon	3	4	--	13	5	1	26
Other lagoon systems	3	2	--	6	2	2	15
Activated sludge	1	--	--	1	--	--	2
Irrigation	2	1	--	3	--	2	8
Extended aeration	--	--	--	2	1	--	3
Total	9	7	1	25	8	7	57
Large:							
Anaerobic-aerobic lagoon	--	--	--	1	4	--	5
Other lagoon systems	1	--	--	6	1	--	8
Irrigation	1	--	--	1	--	--	2
Extended aeration	--	--	--	4	--	--	4
Total	2	--	--	12	5	--	19
All	25	21	2	40	14	11	113

for the survey plants was 101.8 and 74.9 million pounds (table 15). Average annual volumes per plant were about 264,000 pounds of BOD and 194,000 pounds of suspended solids. Reflecting the greater concentration of plants and their larger size, the South Atlantic and South Central regions accounted for 37.5 and 40.3 million pounds of BOD, with averages per plant of about 413,000 and 341,000 pounds, respectively. The East North Central region had the smallest production of BOD and suspended solids as well as the lowest plant averages. The North Atlantic, West North Central, and West regions had comparable production levels and plant averages (table 15).

In total, 7.1 billion gallons of wastewater, 26.1 million pounds of BOD, and 19.4 million pounds of suspended solids were discharged to private treatment, compared with 18.4 billion gallons of water, 68.9 million pounds of BOD, and 50.5 million pounds of suspended solids discharged to municipal treatment. Discharged without treatment were 1.8 billion gallons of wastewater, 6.8 million pounds of BOD, and 5.0 million pounds of suspended solids.

Wasteload Reduction by Existing Private and Municipal Treatment

Reductions in total BOD and suspended solids wasteloads by private and municipal treatment were estimated. Secondary treatment by private or municipal facilities was assumed to reduce both BOD and suspended solids by 90 percent; primary treatment was assumed to reduce these wasteloads by 40 percent. Logically, wasteloads receiving no treatment remained in the total net wasteloads after treatment. Table 22 gives total national and regional gross wasteloads, wasteloads going to private and municipal treatment, and total net wasteloads after private and municipal treatment, including those receiving no treatment.

Regional variations in the degree of total wasteload reduction by municipal and private treatment reflect the mix of plant size, utilization of only primary treatment by either municipal or private sources, and proportion of plants having no treatment. On a national basis, the reduction in total gross wasteloads from poultry slaughtering plants averaged about 81 percent.

Potential Wasteload Reduction by Treatment

To assess the effect on wasteload reductions if plants had the best practicable control technology (anaerobic-aerobic lagoon system) or its equivalent, those plants with existing primary treatment only and plants with no treatment were assumed to have the best practicable technology. Therefore, 113 and 28 plants, 141 in total, had the best practicable treatment or existing

Table 22.--Estimated annual gross wasteloads prior to treatment and net wasteloads after treatment, by treatment facilities for the surveyed poultry slaughtering plants and by region, 1970

Region	Gross wasteloads						Net wasteloads after treatment					
	Total		To municipal treatment		To private treatment		Total		Municipal		Private	
	BOD	Suspended solids	BOD	Suspended solids	BOD	Suspended solids	BOD	Suspended solids	BOD	Suspended solids	BOD	Suspended solids
	1,000 pounds											
North Atlantic	6,611	4,923	1,827	1,365	3,306	2,444	2,209	1,655	390	290	342	252
East North Central	3,915	2,522	2,204	1,489	1,415	885	594	360	242	114	156	98
West North Central	6,813	4,394	6,576	4,246	117	73	1,116	701	929	584	67	42
South Atlantic	37,549	28,216	21,424	16,038	15,020	11,351	5,352	4,016	2,746	2,054	1,502	1,135
South Central	40,270	30,443	31,738	23,908	4,775	3,645	8,888	6,727	4,653	3,503	478	345
West	6,663	4,454	5,155	3,464	1,499	983	1,502	1,024	1,107	758	386	259
Total	101,821	74,942	68,924	50,510	26,132	19,381	19,661	14,483	10,067	7,303	2,931	2.131

secondary treatment processes providing an assumed 95-percent reduction in BOD and a 90-percent reduction in suspended solids. Municipal treatment processes were assumed to be the same as currently exist so that several poultry plants still received only primary treatment. The effect on total gross wasteloads of this potential change is given in table 23. The amount of BOD in the gross wasteload from all plants dropped from 101.8 million pounds to 11.7 (table 23). The reduction was 88.5 percent, compared with 81 percent when existing treatment was used.

The same procedure was used to determine the effect on gross wasteloads if the 141 plants had the best available control technology (extended aeration), which would reduce BOD and suspended solids by 99 percent. In this case, total gross wasteload was reduced from 101.8 million pounds of BOD to 10.4 million pounds (table 23)--an overall reduction of about 90 percent. There was a greater percentage reduction in BOD in some regions because of more extensive use of private treatment facilities and less utilization of municipal treatment which had secondary treatment efficiency of 90 percent or less. If both municipal and private treatments constituted the best available treatment, the overall reduction in gross wasteloads would be 99 percent spread uniformly among all regions. In this case, gross BOD wasteload would be reduced drastically from 101.8 million pounds to about 1.0 million.

WASTEWATER TREATMENT COSTS

Estimating Procedure

Private and municipal wastewater treatment costs were estimated for the poultry slaughtering industry. Wastewater treatment is designed specifically for reduction of BOD, suspended solids, and other pollutants in the final plant effluent. It excludes processes directly undertaken for recovery and utilization of byproducts. Methods of private wastewater treatment included anerobic-aerobic lagoons, irrigation, and extended aeration.

Because of the lack of adequate data, the cost of municipal waste treatment was based on an average sewage charge per thousand gallons and total volume treated by municipal sources. The use of an average sewer charge did not reflect regional variations or use of surcharges on BOD and other pollutants.

Replacement value and operating and maintenance costs of existing private wastewater treatment facilities were estimated for 113 plants with private treatment. In addition, required investment and operating and maintenance costs of adding the best practicable control technology--anaerobic-aerobic lagoons--were estimated for the 16 plants with private treatment having

Table 23.--Estimated annual gross wasteloads prior to treatment and net wasteloads after treatment if all plants with private treatment and those with no treatment had the best practicable control technology (or its equivalent) and the best available control technology 1/

Region	Gross wasteloads						Net wasteloads after best practicable treatment						Net wasteloads after best available treatment					
	Total		To municipal treatment		To private treatment		Total		Municipal		Private		Total		Municipal		Private	
	BOD	Suspended solids	BOD	Suspended solids	BOD	Suspended solids	BOD	Suspended solids	BOD	Suspended solids	BOD	Suspended solids	BOD	Suspended solids	BOD	Suspended solids	BOD	Suspended solids
	1,000 pounds																	
North Atlantic	6,611	4,923	1,827	1,365	4,784	3,558	629	646	390	290	239	356	438	326	390	290	48	36
East North Central	3,915	2,522	2,204	1,489	1,711	1,033	328	217	242	114	86	103	259	124	242	114	17	10
West North Central	6,813	4,394	6,576	4,246	237	148	941	599	929	584	12	15	931	586	929	584	2	2
South Atlantic	37,549	28,216	21,424	16,038	16,125	12,178	3,552	3,272	2,746	2,054	806	1,218	2,907	2,176	2,746	2,054	161	122
South Central	40,270	30,433	31,738	23,908	8,532	6,525	5,080	4,156	4,653	3,503	427	653	4,738	3,569	4,653	3,503	85	65
West	6,663	4,454	5,155	3,464	1,508	990	1,182	857	1,107	758	75	99	1,122	768	1,107	750	15	10
Total	101,821	74,942	68,924	50,510	32,897	24,432	11,712	9,747	10,067	7,303	1,645	2,444	10,395	7,549	10,067	7,303	328	245

1/ Best practicable control technology is anaerobic-aerobic lagoons; best available control technology is extended aeration.

only primary treatment and the 28 plants with no treatment. Thus, a total replacement value and/or investment required to bring 141 plants up to the equivalent of secondary treatment was derived. This assumed that the 97 plants with existing private secondary treatment could meet the effluent limits of the best practicable control technology. Finally, for the 141 plants, excluding those with extended aeration treatment, investment and operating and maintenance costs of using the best available control technology were estimated. In this procedure, it was assumed that each plant without the best available control technology had to construct and operate extended aeration facilities, and that no existing treatment facilities or portions thereof were used to reduce the required investment.

Replacement value or required investment for lagoon systems, activated sludge, and extended aeration facilities were estimated from cost equations in Construction Costs of Municipal Waste Water Treatment Plants, 1967-1969 (5). Regional cost equations were used for lagoon systems. The size of individual wastewater treatment facilities was determined from daily BOD loads, which were divided by 0.17 to estimate facility size in terms of population equivalents. For irrigation systems, replacement cost was based on data in Irrigation as a Low Cost Method of Sewage Disposal (12). Costs from this source were adjusted to be representative of the current period. For primary treatment, replacement costs were taken from The Cost of Clean Water, Industrial Waste Profile No. 8, 1968 (1). Size and cost of irrigation and primary facilities were based on wastewater flow rather than population equivalents.

For all types of treatment facilities, construction costs were multiplied by a factor of 1.2 to reflect land and other nonrecurring costs. Replacement value or investment was equal to construction costs times a factor of 1.2. Annual operating and maintenance costs, which included capital costs, were based on the complexity of treatment systems and their capital investment. These annual costs ranged from 7 to 20 percent of total replacement value or required investment. Data on the relationships between operating and maintenance costs and capital investment were obtained from several sources (1, 12). Since most of the cost equations used were derived from regression analyses, low, expected, and upper values of investment and operating and maintenance costs were estimated, which provided a range of cost estimates instead of a single estimate. By this method, lower and upper bounds were placed on estimates.

Present Wastewater Treatment Costs

The annual expenditure by the 245 surveyed poultry processing firms for municipal waste treatment was estimated to be $4.6 million (table 24). This estimate was based on 18.4 billion gallons of wastewater treated by municipalities at a charge of

25 cents per 1,000 gallons (7). Based on the average volume of water per plant treated by municipalities--75.1 million gallons (table 15), the average annual expenditure was $18,800 per plant. Total live weight slaughter of the 245 plants was 8.4 billion pounds. A cost of 5.5 cents per 100 pounds live weight slaughter was thereby derived.

Estimates of replacement value and operating and maintenance costs for the 113 plants with private wastewater treatment are given in table 25. Replacement value ranged from $7.1 to $20.3 million with an expected value of $12.0 million. Average replacement value per plant ranged from $63,000 to $180,000, with an expected value of $107,000. The expected annual industry operating and maintenance costs were estimated to be $1.4 million. Replacement values and operating and maintenance costs were converted to a cost per 100 pounds live weight slaughter. On this basis, low, expected, and upper estimates of replacement value were 22.0 cents, 38.0 cents, and 64.0 cents per 100 pounds, while the similar levels of operating and maintenance cost estimates were 2.7 cents, 4.5 cents, and 7.3 cents per 100 pounds.

Economies of scale studies have identified unit costs for alternative sizes of broiler and turkey plants (9, 10). To provide a comparison of wastewater treatment costs with total plant costs, adjustments in these data were made to derive current estimates of broiler and turkey processing costs. Costs were estimated for a broiler plant slaughtering 50 million pounds live weight annually and for a turkey plant slaughtering 30 million pounds live weight. These plant sizes were selected as representative of poultry slaughtering plants. Average total cost for the broiler plant was $3.82 per hundred pounds live weight; the cost for the turkey plant was $5.27 per hundred pounds live weight. The turkey plant incurred higher costs because of the seasonal use of turkeys. Many turkey slaughtering plants operate only 4 or 5 months a year, compared with year-round operations of broiler plants. Therefore, the underutilization of turkey plant capacity increases unit costs.

Based on these average total plant costs, the operating and maintenance costs of existing private wastewater treatment facilities ranged from 0.7 to 1.9 percent of average total broiler plant cost, and from 0.5 to 1.4 percent of turkey plant cost.

The total estimated annual cost--including expenditures for municipal treatment and the expected value of operating and maintenance costs of private treatment--to the surveyed slaughtering plants of wastewater treatment was $6 million. For the 358 plants with private or municipal treatment, the weighted average cost of municipal and private treatment was 5.2 cents per hundred pounds live weight slaughter.

Table 24.--Estimated cost of municipal waste treatment for surveyed poultry slaughtering plants, 1970

Item	Cost
	1,000 dollars
Total	4,600
Average per plant 1/	18.8
	Cents
Average per 100 pounds live weight slaughter	5.5

1/ 245 plants with a total live weight slaughter of 8.4 billion pounds.

Table 25.--Estimates of replacement value and annual operating and maintenance costs of waste treatment facilities for surveyed poultry slaughtering plants, 1970

Item	Level of cost estimate		
	Low	Expected	Upper
	1,000 dollars		
Replacement value:			
Total	7,108	12,036	20,341
Average per plant	62.9	106.5	180.0
Annual operating and maintenance costs:			
Total	862	1,424	2,350
Average per plant 1/	7.6	12.6	20.8
Average per 100 pounds live weight slaughter 1/:	Cents		
Replacement value	22.0	38.0	64.0
Operating and maintenance costs	2.7	4.5	7.3

1/ 113 plants with private treatment and total live weight slaughter of 3.2 billion pounds.

Costs of Upgrading to Best Practicable Technology

The replacement value or required investment and operating and maintenance costs of bringing the treatment systems of the 113 plants with private treatment up to the equivalent of the best practicable control technology and of adding the best practicable control technology to 28 plants with no treatment are given in table 26. These costs include those of existing treatment for 97 plants plus the costs of upgrading the 44 plants with primary or no treatment to the best practicable technology.

Total replacement value or investment ranged from $8.6 to $25.1 million, with an expected value of $14.7 million. Average per plant cost ranged from $61,200 to $178,300. Estimates of annual operating and maintenance costs ranged from $1.0 to $2.7 million, with an average expected value of $11,400 per plant. On a cost per 100 pounds live weight slaughter basis, low, expected, and upper estimates of replacement value and investment were 21.6 cents, 36.8 cents, and 62.8 cents. Similar levels of operating and maintenance costs were 2.4 cents, 4.0 cents, and 6.7 cents per 100 pounds.

The total additional industry investment required to adapt the best practicable control technology in the 16 plants with primary treatment and in the 28 plants with no treatment ranged from $1.5 to $4.8 million, with an expected value of $2.7 million. Average investment ranged from $35,000 to $109,000 per plant.

Cost of Upgrading to Best Available Control Technology

An estimate also was made of the investment needed for 133 of 141 plants without extended aeration treatment to acquire the best available control technology (table 26). These data reflect the costs incurred by the plants, based on the assumption that new facilities were added in entirety without the use of existing facilities to offset required investments. Replacement costs for the eight plants with extended aeration also are included.

Estimates of total investment ranged from $21 to $60 million, with an expected value of $36 million; average investment per plant was $149,000 to $424,000. Estimates of annual operating and maintenance costs ranged from $3.3 to $9.0 million, with average annual costs ranging from $23,000 to $64,000 per plant. On a cost per 100 pounds live weight slaughter basis, low, expected, and upper estimates of investment were 52.4 cents, 90.0 cents, and 149.3 cents. Similar levels of operating and maintenance costs were 8.2 cents, 13.6 cents, and 22.6 cents per 100 pounds.

Table 26.--Estimates of replacement value or investment and annual operating and maintenance costs if all surveyed poultry slaughtering plants with private treatment and those with no treatment had best practicable control technology (or its equivalent) or best available control technology

Item	Best practicable technology or equivalent			Best available technology		
	Level of cost estimate			Level of cost estimate		
	Low	Expected	Upper	Low	Expected	Upper
	1,000 dollars					
Investment or replacement value:						
Total	8,626	14,731	25,136	20,973	35,978	59,723
Average per plant 1/	61.2	104.5	178.3	148.7	255.2	423.6
Annual operating and maintenance costs:						
Total	968	1,613	2,685.8	3,275	5,437	9,024
Average per plant	6.9	11.4	19.0	23.2	38.6	64.0
	Cents					
Average per 100 pounds live weight slaughter:						
Investment or replacement value	21.6	36.8	62.8	52.4	90.0	149.3
Operating and maintenance costs	2.4	4.0	6.7	8.2	13.6	22.6

1/ 141 plants with private treatment and total live weight slaughter of 4.0 billion pounds.

Based on average total broiler and turkey slaughtering plant costs, estimates of operating and maintenance costs of the best available control technology ranged from 1.6 to 4.3 percent of average total turkey plant costs and from 2.1 to 5.9 percent of average total broiler plant costs.

POTENTIAL ECONOMIC IMPACT

For the 44 plants with no treatment or only primary treatment, the estimated investment required to upgrade to the best practicable control technology ranges from $1.5 to $4.8 million. This group of plants accounted for about 7 percent of Federally inspected slaughter in 1970. Of the 44 plants, 25 were small with less than 10 million pounds annual live weight slaughter. Therefore, a relatively greater number of small plants would require investment in treatment systems. Eleven plants were medium size and eight were large.

The 44 plants were distributed among regions as follows: 10 in the North Atlantic, 10 in the East North Central, 11 in the South Central, six in the West, four in the South Atlantic, and three in the West North Central. The larger share of investment would fall in the former three regions. Based on average expected plant investment, total investment in the North Atlantic, East North Central, and South Central regions was $613,000, $613,000, and $674,000, respectively.

The 141 plants would need $21 to $60 million to upgrade to the best available technology. This group was responsible for about 31 percent of Federally inspected slaughter in 1970. Of the 141 plants, 49 were small, 65 medium, and 27 large. Most of these plants were located in the North Atlantic, East North Central, and South Atlantic regions, which had 30, 25, and 44 plants, respectively. In these three regions, a greater proportion of plants relied on private treatment than in other regions. Consequently, a larger share of required investment would fall in these regions. Based on average expected plant investment, total required investments in the North Atlantic, East North Central, and South Atlantic regions were $7.7, $6.4, and $11.2 million, respectively.

The relatively narrow profit margins in poultry meat production and processing restrict capital accumulation potentials of poultry firms--especially small single plant-specialized firms. Although multiplant firms--specialized poultry firms, feed manufacturers, meat packers, cooperatives, or conglomerates--might be expected to acquire capital with less difficulty than other firms in the industry, decisions to invest capital in wastewater treatment systems would involve such factors as plant location, age of plant, profit margins, importance of the specific plant to the multiplant firm, and access to municipal treatment.

The cessation of operations of poultry plants for any reason can have serious implications for the local economy. In addition to plant unemployment, poultry producers supplying live poultry through contracts or the market would have to find other outlets or cease operations. Since producers would be dependent on the availability of other plants, they could have unused buildings and equipment. Input suppliers, primarily hatcheries and feed manufacturers, would also experience losses in sales. The potential consequences of plant closings because of failure to comply with water pollution control regulations have to be evaluated on a case-by-case basis. In general, however, the firm, employees, producers and input suppliers, and the community would suffer economic losses.

If the industry upgraded to the best practicable control technology, the additional costs incurred would not likely be reflected in higher average poultry meat prices because of the relatively small share of Federally inspected output accounted for by the 44 plants with no treatment or primary treatment only. However, these plants would probably have to seek external sources of capital to subsidize their upgrading since a majority of them are small. Failure of the plants to comply with regulations and potential cessation of operations would have no longrun impact on industry output because of the excess capacity in processing and the expansionary nature of the poultry meat industry. Cessation of operations would cause certain groups to incur economic losses--at least for an interim period. In general, however, the potential impact on the industry of upgrading to the best practicable control technology appears to be relatively small.

The potential economic impact of the industry upgrading to the best available control technology is much greater. The required investment of the best available technology was over twice as large as that of the best practicable technology. At the expected estimate level, industry investment was $36 million for the former and $14.7 million for the latter. If the 141 plants upgraded to the best available control technology, average annual operating and maintenance costs would range from 1.6 to 5.9 percent of average total plant costs for representative broiler and turkey plants. Relative to the 0.5 to 1.8 percent range of the best practicable technology level, these percentages represent a sizable increase. As noted previously, because of narrow industry profit margins, any increase in cost would be economically significant 14/ and would likely be passed on to consumers. Effects on poultry meat prices are difficult to project, but some increase in prices could be expected.

14/ At the expected estimate level, the cost of the best available technology would be 0.64 percent of sales for broiler firms and 0.46 percent of sales for turkey firms, compared with 0.21 and 0.14 percent of sales for existing treatment. In 1964, net income after taxes for selected chicken processors was 0.66 percent of sales and 1.08 percent of sales for selected turkey processors (6).

Many firms of all sizes would have difficulty obtaining the necessary large sums of capital; some would have to turn to external low-cost sources of capital. Hence, a decision to invest in wastewater treatment would be carefully evaluated. Because of the 31-percent share of Federally inspected output accounted for by this group, potential ramifications of these plants not meeting effluent limits of the best available control technology and subsequently ceasing operations would be serious in terms of economic losses to specific groups, including higher product prices passed on to consumers.

The large capital investment required by the industry to construct and operate the best available control technology--defined here as extended aeration--to meet specific effluent standards might encourage firms to seek lower cost alternatives. In contrast to constructing a specific type of treatment system--regardless of the type--to meet increasingly stringent effluent limitations, the industry might make changes in plant practices.

Plants using municipal treatment may be charged higher prices for water and sewer services as municipalities attempt to make industrial users pay their share of municipal treatment costs. Higher costs and surcharges on pollutants will provide economic incentive to the industry to reduce water use and wasteloads. Consequently, all plants with either private or municipal wastewater treatment will be seeking the lowest cost alternative for compliance with effluent standards.

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APPENDIX TABLES

Table A-1.--Number and type of plant responding to the survey, by region, 1970 1/

Type of plant	Region						
	North Atlantic	East North Central	West North Central	South Atlantic	South Central	West	All
	Number						
Slaughtering	38	42	48	91	118	49	386
Further processing	118	53	26	72	33	43	345
Cut-up	63	32	16	35	15	39	200
Total	219	127	90	198	166	131	931

1/ A plant that slaughtered any volume of poultry was defined as a slaughtering plant even if it cut up or further processed poultry. A plant was defined as a cut-up or further processing plant depending on which activity produced the greater annual volume in pounds.

Table A-2.--Location of poultry plants relative to municipal limits, by type of plant and region, 1970

Type of plant and municipal limits	Region						
	North Atlantic	East North Central	West North Central	South Atlantic	South Central	West	All
	Number						
Slaughtering:							
Within limits	20	21	46	53	99	34	273
Outside limits	18	19	2	35	18	11	103
Total	38	40	48	88	117	45	376
Further processing:							
Within limits	102	50	26	53	31	37	299
Outside limits	11	0	2	16	2	6	37
Total	113	50	28	69	33	43	336
Cut-up:							
Within limits	59	25	13	26	14	37	174
Outside limits	3	6	2	9	1	2	23
Total	62	31	15	35	15	39	197
Grand total	213	121	91	192	165	127	909

Table A-3.--Source of water for poultry plants, by type of plant and region, 1970

Type of plant and water source	Region						
	North Atlantic	East North Central	West North Central	South Atlantic	South Central	West	All
	Number						
Slaughtering:							
Private well	27	23	5	29	15	5	104
Municipal	10	16	37	49	92	36	240
Other 1/	1	3	6	13	11	8	42
Total	38	42	48	91	118	49	386
Further processing:							
Private well	19	7	1	15	3	5	50
Municipal	94	42	23	52	28	37	276
Other	1	4	2	4	0	1	12
Total	114	53	26	71	31	43	338
Cut-up:							
Private well	5	3	2	8	1	2	21
Municipal	57	28	14	27	14	36	176
Other	1	1	0	0	0	1	3
Total	63	32	16	35	15	39	200
Grand total	215	127	90	197	164	131	924

1/ Includes plants having both private and municipal sources and plants purchasing water from other sources.

Table A-4.--Source of waste treatment for poultry plants, by type of plant and region, 1970

Type of plant and waste treatment source	Region						
	North Central	East North Central	West North Central	South Atlantic	South Central	West	All
	Number						
Slaughtering:							
Private	25	21	2	40	14	11	113
Municipal	6	11	38	40	71	27	193
Private-municipal	2	6	6	7	23	8	52
None	5	4	2	4	10	3	28
Total	38	42	48	91	118	49	386
Further Processing:							
Private	20	4	1	11	1	1	38
Municipal	80	40	21	42	25	28	236
Private-municipal	1	7	4	6	3	7	28
None	13	2	0	10	3	6	34
Total	114	53	26	69	32	42	336
Cut-up:							
Private	3	2	2	6	2	3	18
Municipal	49	25	13	24	9	33	153
Private-municipal	2	1	0	0	0	0	3
None	6	2	1	2	4	2	17
Total	60	30	16	32	15	38	191
Grand total	212	125	90	192	165	129	913

Table A-5.--Type of treatment system for poultry plants with private treatment, by type of plant and region, 1970

Type of plant and treatment	Region						
	North Atlantic	East North Central	West North Central	South Atlantic	South Central	West	All
	Number						
Slaughtering:							
Primary 1/	5	6	1	0	1	3	16
Anaerobic-aerobic lagoons	9	7	0	15	9	1	41
Other lagoon systems	4	6	1	13	3	3	30
Activated sludge	1	0	0	1	0	0	2
Irrigation	5	2	0	4	0	4	15
Extended aeration	0	0	0	7	1	0	8
Other	1	0	0	0	0	0	1
Total	25	21	2	40	14	11	113
Further processing:							
Primary	14	1	1	6	1	1	24
Other lagoon systems	2	0	0	2	0	0	4
Activated sludge	1	0	0	1	0	0	2
Irrigation	1	2	0	2	0	0	5
Extended aeration	2	1	0	0	0	0	3
Total	20	4	1	11	1	1	38
Cut-up:							
Primary	2	1	1	3	0	2	9
Anaerobic-aerobic lagoons	0	0	0	0	1	1	2
Other lagoon systems	1	1	1	1	0	0	4
Trickling filter	0	0	0	1	0	0	1
Irrigation	0	0	0	1	0	0	1
Total	3	2	2	6	1	3	17
Grand total	48	27	5	57	16	15	168

1/ Defined as the use of sedimentation tanks in which solids and floating materials are allowed to settle before effluent is discharged.

Table A-6.--Poultry plants with and without flow away systems for handling wastes, by type of plant and region, 1970

Type of plant and system	Region						
	North Atlantic	East North Central	West North Central	South Atlantic	South Central	West	All
	Number						
Slaughtering:							
With flow away	33	35	37	80	110	39	334
Without flow away	5	7	10	9	7	9	47
Further processing:							
With flow away	18	12	4	20	2	10	66
Without flow away	91	40	19	42	25	27	244
Cut-up:							
With flow away	13	1	4	3	2	9	32
Without flow away	37	28	10	23	13	21	132
Total	197	123	84	177	159	115	855

Table A-7.--Coefficients used in estimating byproducts, water use, and wasteloads of poultry slaughtering plants

Variable	Unit	Value per 1,000 pounds 1/
Byproducts:		
Blood		
Young chickens	Pounds	70
Mature chickens	do.	70
Turkeys	do.	70
Other poultry	do.	70
Offal		
Young chickens	do.	175
Mature chickens	do.	170
Turkeys	do.	125
Other poultry	do.	140
Feathers		
Young chickens	do.	70
Mature chickens	do.	70
Turkeys	do.	70
Water use:		
Young chickens	Gallons	2,198
Mature chickens	do.	2,173
Turkeys	do.	1,700
Other poultry	do.	2,100
Cut-up	do.	500
Further processing	do.	500
Wasteloads:		
BOD--		
Young chickens	Pounds	8.2
Mature chickens	do.	8.7
Turkeys	do.	8.0
Other poultry	do.	8.0
Suspended solids--		
Young chickens	do.	6.3
Mature chickens	do.	5.4
Turkeys	do.	5.0
Other poultry	do.	5.0
Time span of operation 2/:		
Young chicken, mature chicken, and other poultry plants	Days	234
Turkey plants	do.	130

1/ Live weight except for cut-up and further processed coefficients which are ready-to-cook weight.

2/ These coefficients are based on a maximum of 260 operating days per year. We assumed that the chicken and other poultry plants operated at 90 percent capacity--0.90 x 260 = 234. Turkey plants were assumed to operate at 50 percent of capacity--0.50 x 260 = 130.

Source: Environmental Protection Agency, Industrial Waste Study of the Meat Products Industry, 1971; U.S. Department of Agriculture, Processing Poultry Byproducts in Poultry Slaughtering Plants, Marketing Research Report No. 181, 1957; and industry contacts.