# The Cost of Clean Water

U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration

## VOLUME III

INDUSTRIAL WASTE PROFILE NO. 9
DAIRIES

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FWPCA Publication No. I.W.P.-9

THE COST OF

CLEAN WATER

Volume III

Industrial Waste Profiles
No. 9 - Dairies

U. S. Department of the Interior
Federal Water Pollution Control Administration

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# PREFACE

The Industrial Waste Profiles are part of the National Requirements and Cost Estimate Study required by the Federal Water Pollution Control Act as amended. The Act requires a comprehensive analysis of the requirement and costs of treating municipal and industrial wastes and other effluents to attain prescribed water quality standards.

The Industrial Waste Profiles were established to describe the source and quantity of pollutants produced by each of the ten industries studied. The profiles were designed to provide industry and government with information on the costs and alternatives involved in dealing effectively with the industrial water pollution problem. They include descriptions of the costs and effectiveness of alternative methods of reducing liquid wastes by changing processing methods, by intensifying use of various treatment methods, and by increasing utilization of wastes in by-products or water reuse in processing. They also describe past and projected changes in processing and treatment methods.

The information provided by the profiles cannot possibly reflect the cost or wasteload situation for a given plant. However, it is hoped that the profiles, by providing a generalized framework for analyzing individual plant situations, will stimulate industry's efforts to find more efficient ways to reduce wastes than are generally practiced today.

James M. Quigley
Commissioner
Federal Water Pollution Control Administration

# INDUSTRIAL WASTE PROFILE

Prepared for F.W.P.C.A.

FWPCA Contract Number 14-12-102

June 30, 1967

**Federal Water** Pollution Control Administration
September 1967

IWP 9 - 3

## SCOPE OF MATERIAL COVERED

Industrial Waste Profile IWP-9 Dairies is a qualitative and quantitative description of wastes and wastewater generated in the Dairy Industry identified in SIC Code as 202 Dairy Products.

The Industry is examined in its important major subdivisions identified by SIC Code as follows:

2021 Creamery Butter - Establishments primarily engaged in manufacturing creamery butter.

2022 Cheese, Natural and Processed - Establishments primarily engaged in manufacturing all types of natural cheese (except cottage cheese-Industry 2026), processed cheese, cheese foods, and cheese spreads.

2023 Condensed and Evaporated Milk - Establishments primarily engaged in manufacturing condensed and evaporated milk and related products, including ice cream mix and ice milk mix made for sale as such and dry milk products.

2024 Ice Cream and Frozen Desserts - Establishments primarily engaged in manufacturing ice cream and other frozen desserts.

2026 Fluid Milk - Establishments primarily engaged in processing, packaging and distributing fluid milk and cream, cottage cheese, and related products.

The Profile is prepared for the Base Year of 1963 which permits correlation with 1963 Census of Manufacturers data for production and water use.

The waste and wastewater estimates are developed from actual plant operating experience, and are correlated with manufacturing processes and are augmented with waste reduction and removal cost estimates.

Projections of waste and wastewater for future years are developed in detail.

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## INDUSTRIAL WASTE PROFILE IWP-9 - DAIRIES

(SIC Code 202 - Dairy Products)

## INTRODUCTION

The dairy industry represents a most viable and necessary segment of our expanding economy. All members of our society use and are benefited by the diversified products being manufactured daily by this industry. Skim milk, baby formulae, multi-flavored ice creams and sherbets are examples of only a few of these basic food products. The dairy industry no longer follows the simple producer-consumer concept of former years. Dairying now encompasses a vast network of farmer cooperatives, private businesses, grocery companies and large nationwide chains, all of which contribute to the necessary process of bringing dairy products to market.

Milk production remains a basic adjunct to a healthy environment. As is true of most of our industry, technological and scientific advancements have played an immense role in streamlining the dairy industry. Although both milk production and number of cows have declined over the years, production per cow has been on the rise. Such production has increased nationwide from 6,303 lb. per year in 1957 to 7,561 lb. in 1963 and 8,513 lb. in 1966. Current industry predictions are that future total production will increase proportionately with population growth.

In 1963, 16 million cows produced approximately 127 billion lb. of milk. Approximately 125 billion lb. of this amount was utilized under five industry product classifications which will be studied in this profile. The largest portion, 52 billion lb., has been categorized under the heading of Fluid Milk. This heading also includes approximately 1½ billion lb. of milk utilized in the production of cottage cheese. The other classifications are Butter with 34 billion lb., Cheese with 14.4 billion lb., Ice Cream and Frozen Desserts with 11.9 billion lb., and Condensed and Powdered Milk with 10.8 billion lb. Each of these amounts represents the quantity of milk utilized directly under a heading. The amounts do not necessarily represent, however, the total processing under each classification, since certain "wastes" from one process may serve as the primary raw material for another process.

The classifications utilized are generally accepted throughout the dairy industry. The headings are, therefore, proper in examining wastes derived from the manufacture of a given dairy product.

The reader should assume that each product discussed is to be treated separately, exclusive of any by-products which in turn could be analyzed, e.g. that in the butter process the finished product is butter alone--the skim milk and buttermilk which are by-products of the manufacturing process are for our purposes considered as wastes. Historically, this type of waste was an actual waste to plant sewer, but now the bulk of this material is utilized for other product manufacture. In the case of the butter industry, the skim milk and buttermilk are in very large part utilized as a raw material in the condensed and evaporated milk manufacturing industries. This type of utilization is shown in the profile as "Utilization as By-product" under "Removal Methods".

The actual processing facility often consists of two or more plants. Butter plants and condenseries are often combined so that the cream and skim milk portions of the milk may be utilized in one location. Similarly, ice cream plants are often combined with fluid milk and cottage cheese plants for the most efficient utilization of milk. To the contrary, cheese plants usually manufacture cheese only, since whole milk is completely utilized.

Fluid milk plants are generally located near the area of greatest consumption since transportation costs of the finished product are greatly increased by the additional weight of bottles and cases.

This study relates waste to the amount of finished product produced rather than to the amount of raw material used, as has been done in previous studies. It is intended for the use of two broad groups: the dairy products processors and those other persons directly concerned with wastewater control. Processing matters are expressed in terms prevailing in the trade. In particular, wastes are discussed in lb. BOD (Biochemical Oxygen Demand), while quantity of wastewater is expressed in gallons.

As has been mentioned, an actual processing facility often consists of two or more plants. While this study emphasizes the isolated product/isolated waste ratio, combination plant data may be computed by adding the amounts of finished products produced and comparing this computation with the net amount of waste quantity derived from the cumulative production processes. Obtaining combination data is further aided by the fact that the individual chapters include lists of waste material which can be used in subsequent by-product processing. The reader may evaluate how these materials are utilized and eliminated from the net waste discharged.

The data compiled with regard to the actual plant operations does not include "shrinkage" (the difference between the amount of milk measured at the farm as compared with the amount received in the plant) nor does it include the normal "overfill" which usually occurs in packaging the finished product.

Therefore, the reader, in studying the individual chapters, should keep in mind these points:

1. The finished product is the basis of reference.

2. The individual profile classifies all materials other than the finished product as "waste".

3. Certain of the "wastes" of one classification are the raw materials of another.

4. The individual plants are often found in combination with other plants to fully utilize the raw material in one facility.

2021 - Creamery Butter: Establishments primarily engaged in manufacturing creamery butter.

Butter production has for many years been declining, as a result of competition from oleomargarine. Per capita consumption reached a low in 1966, but total production in the next few years is now expected to increase in proportion to population growth.

Geographically, over 70% of the butter plants in 1963 were located in the upper Mississippi Valley (about 25% in Minnesota).

The manufacturing process of butter may be outlined as follows:

1. Receipt: Raw (unpasteurized) milk and cream are received from the farm in either tank trucks or ten gallon cans.

2. Storage: The contents are subsequently pumped to refrigerated storage tanks. (A plant may have a refrigerated storage room where the milk and cream remain before being dumped into storage tanks.)

3. Separation: From the storage receptacles, the raw products are passed through a heater. The raw milk is warmed to a temperature of 90° F. and then centrifuged. The cream with a butterfat content of 30% to 40% is separated and stored separately. (The remaining skim milk is available for by-product use.)

4. Cooling: The cream is cooled in continuous coolers and pumped to storage.

5. Storage: The resultant product is held in tanks under controlled refrigeration.

6. Pasteurization: The raw cream is next pumped to a continuous flow pasteurizer, where the liquid is pasteurized and cooled. Small plant concerns may continue to use the vat type pasteurizer.

7. Pasteurized Storage: The cooled product from the pasteurizers is stored in tanks awaiting utilization further in the process stream.

8. Churning: The pasteurized cream is tempered to 45° F. and is churned. The buttermilk resulting from the churning process is drained; the butter granules are washed, drained, rewashed, drained, standardized to 80% fat with addition of water, salt, color and flavoring, and "worked" to the desired consistency. The butter portion is sent to packaging. The buttermilk portion becomes available for by-product use or is wasted.

9. Packaging: Butter is placed in various types of packaging machinery, where the commodity is extruded to the desired shape, wrapped and packaged.

10. Cold Storage: Butter is placed in cold storage until needed for customer delivery

11. Shipping: Packaged butter is usually placed in refrigerated vehicles for delivery to customers.

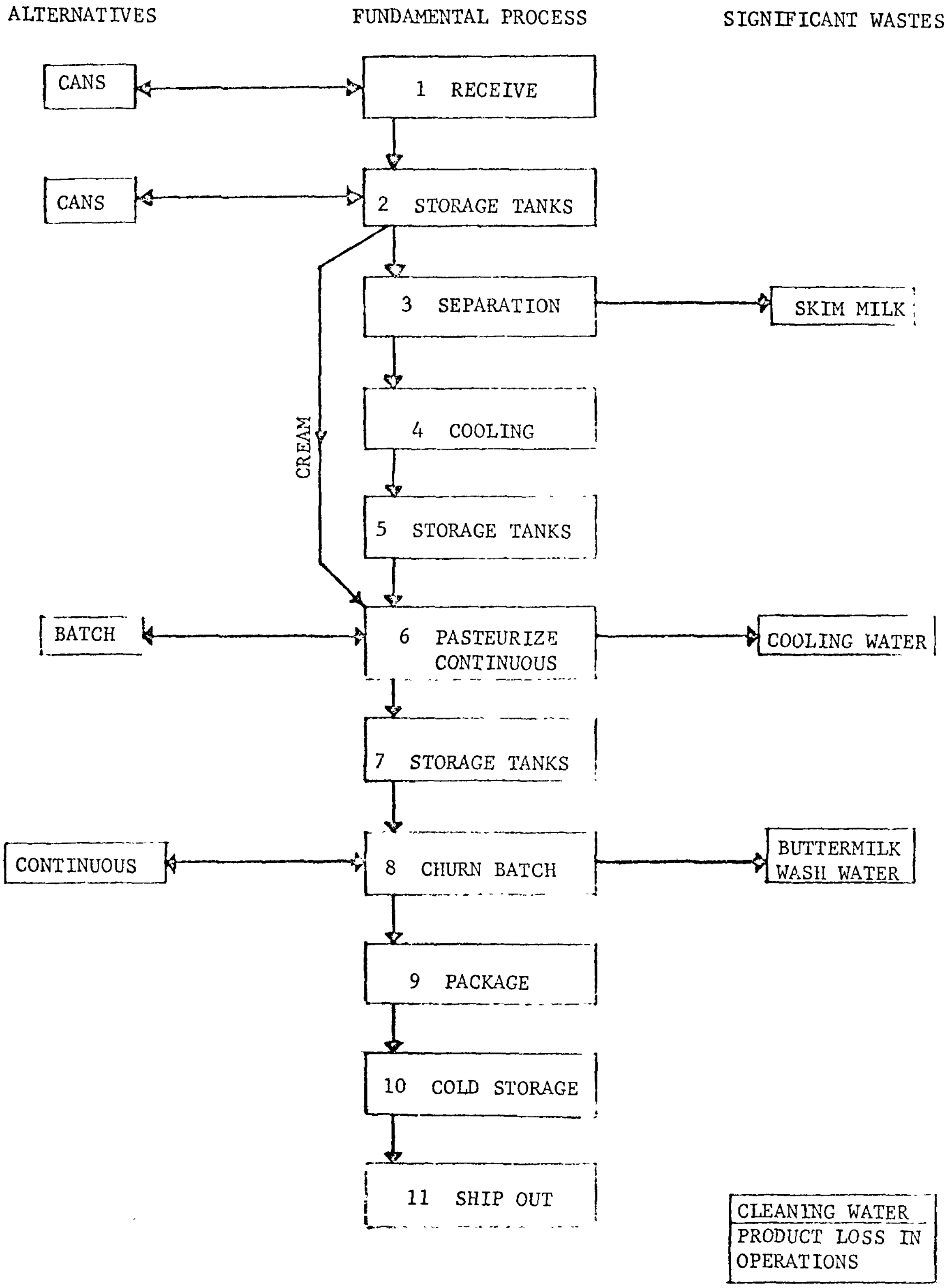
A flow diagram is included on Page IWP 9-11.

## Waste and Wastewater

The significant wastes derived from the fundamental butter process are skim milk from the separation process and buttermilk from the churning operation. These waste products may be converted to valuable by-products through evaporating the moisture and drying the residue to a powder form for human consumption or animal feed. Normally, these wastes are forwarded to condenseries; however, in the smaller plants a significant amount of skim milk and buttermilk is a "net" waste. If the skim milk and buttermilk are treated as wastes, they become a difficult waste problem because of the high protein content. The skim milk has a BOD of 7.3% and buttermilk, 6.4%.

Less significant sources of wastes are (1) the spillage which occurs in normal processing and packaging operations and (2) the wastes incurred with cleaning equipment at the end of a day's operation. Some clear water waste occurs in those plants using water for once-through cooling in their refrigeration systems. This technique is often used in rural plants with their own wells or in areas of abundant water supply.

No water that comes in contact with butter during the manufacturing process may be reused because of the danger of contamination.


ALTERNATIVES
FUNDAMENTAL PROCESS
SIGNIFICANT WASTES
CANS
1 RECEIVE
CANS
2 STORAGE TANKS
3 SEPARATION
SKIM MILK
CREAM
4 COOLING
5 STORAGE TANKS
BATCH
6 PASTEURIZE CONTINUOUS
COOLING WATER
7 STORAGE TANKS
CONTINUOUS
8 CHURN BATCH
BUTTERMILK WASH WATER
9 PACKAGE
10 COLD STORAGE
11 SHIP OUT
CLEANING WATER
PRODUCT LOSS IN OPERATIONS

## RECENT DEVELOPMENTS

The fundamental butter process changed little from 1950 to 1966, and little change is forecast for 1967 to 1977. Nevertheless, several developments of interest have occurred.

The most significant change has been in the number reduction of butter plants. Due to economical pressures, many small plants have closed or have merged. This trend, which is expected to continue, is depicted on Page IWP 9-13.

Since 1950, bulk tank trucks have largely replaced the 10-gallon cans used in Step 1, "Receipt", of the fundamental process. The trend has occurred because the use of trucks has virtually eliminated physical labor, improved sanitation maintenance and reduced the likelihood of contamination.

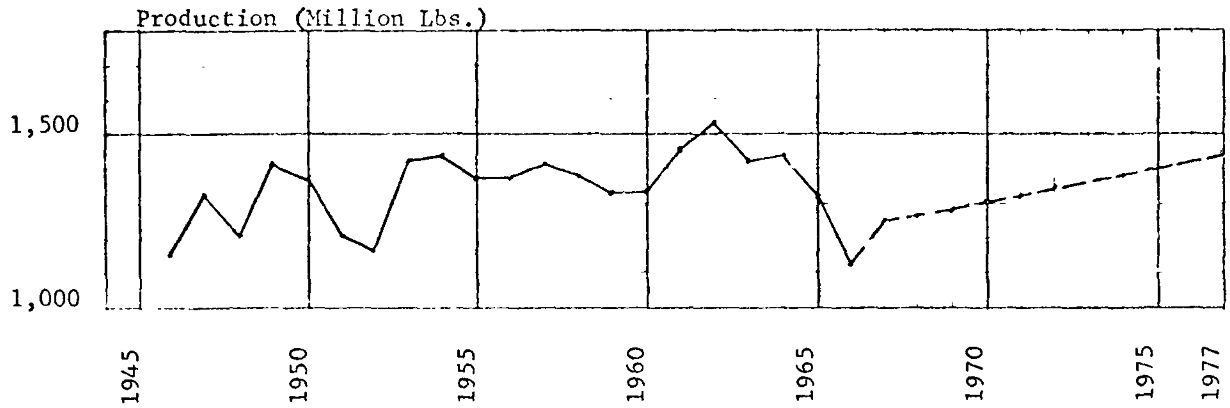
Self-cleaning (CIP) separators used in Step 3 of the fundamental process are now available. Such machinery reduces the amount of manual washing required, as well as the reduction of physical labor.

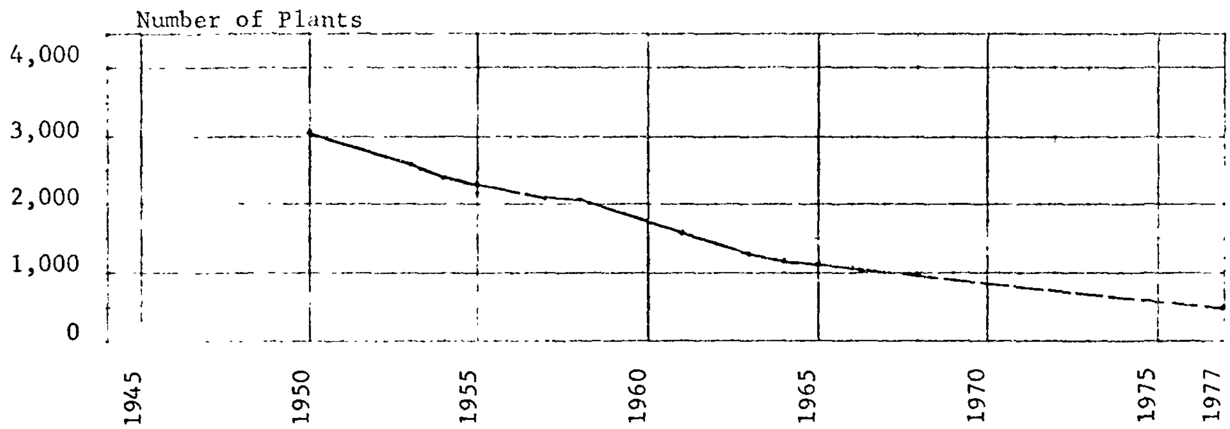
Because of tremendous volume, large plants utilize continuous flow equipment, as opposed to batch type machinery. This development has tended to reduce the percentage of plant loss in operations and, consequently, has helped to minimize wastes. Greatly improved heating and refrigeration systems have reduced water needs considerably.

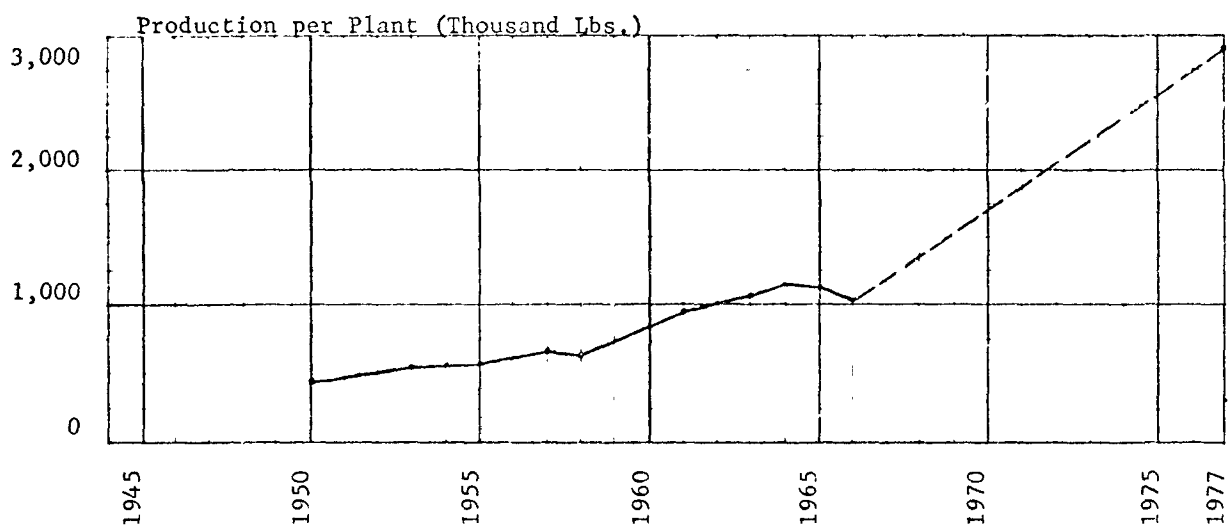
The trend in packaging is to smaller units which better serve the needs and desires of the consumer. Automatic packaging continues to replace manual methods. Not only is the amount of waste reduced, but new machinery fills more accurately.

Permanent stainless steel piping systems were introduced in the early 1950's. Such systems are cleaned in place, as opposed to the daily take-apart systems formerly accepted. This type equipment reduces the quantity of soap required and, therefore, reduces waste. The fact that the systems are permanently installed has reduced plant product losses; also, sanitation and product shelf life has been increased--a factor which has tended to reduce waste.

Significant changes have occurred in material handling within plants by the introduction of sophisticated converyors and stacking, grouping and palletization equipment. Even though machines have tended to increase individual plant wastes through the enlarged usage of water-soap lubricants, product loss and waste has been reduced because of the less likelihood of package damage.




2021 - Creamery Butter IWP 9-13

The trends may best be shown in tabular form, which follows. The reader should note that these industry changes have occurred over a span of years.

The process which will become prevalent is identified as P, and that which is becoming less used as S.

TABLE IWP 9 - 14

Estimated Percentage of Plants Employing Process

| | | | 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|---|---|---|
| (b) | P | Receive in Tank Trucks | -0- | 40 | 50 | 60 | 70 |
| | S | Receive in Cans | 100 | 60 | 50 | 40 | 30 |
| (c) | P | Separate Manually | 100 | 100 | 98 | 96 | 93 |
| | S | Separate CIP | -0- | -0- | 2 | 4 | 7 |
| (d) | P | Pasteurize Continuously | -0- | 20 | 25 | 30 | 35 |
| | S | Pasteurize Batch | 100 | 80 | 75 | 70 | 65 |
| (e) | P | Churn Batch | 100 | 100 | 100 | 98 | 95 |
| | S | Churn Continuously | * | * | * | 2 | 5 |
| (f) | P | Package Automatically | 15 | 40 | 50 | 60 | 70 |
| | S | Package Manually | 85 | 60 | 50 | 40 | 30 |
| (g) | P | CIP Piping | -0- | 20 | 30 | 40 | 60 |
| | S | Take-apart Piping | 100 | 80 | 70 | 60 | 40 |
| (h) | P | Automatic Material Handling | 20 | 50 | 60 | 70 | 75 |
| | S | Manual Material Handling | 80 | 50 | 40 | 30 | 25 |

The estimates represent the observations and opinions of people in the industry including processors, material and equipment suppliers and manufacturers and industry associations and consultants.

*Less than 1%

## Comparative Waste Control Problems

The subprocesses (Table IWP 9-14) do not require different treatment from the fundamental processes; however, the choice of subprocess is largely determined by the total volume produced. Large plants often utilize continuous flow processes because of greater productivity per piece of equipment. These processes generate less waste per pound of finished product.

Skim milk, buttermilk, product spillage, cleaning water and soaps--all constitute the significant wastes for any type process utilized.

In order to best estimate total industrial waste and wastewater, it is desirable to identify the existing levels of technology. The following table illustrates three technological levels. The fundamental process steps from Page IWP 9-9 are used as reference for the table which follows.

TABLE IWP 9 - 15

Comparative Technology

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
|---|---|---|---|
| 1. | Receive in cans | Receive in tank trucks | Receive in tank trucks |
| 2. | Store in cans | Store in tanks | Store in tanks |
| 3. | Heat, then separate centrifugally | Heat, then separate centrifugally | Heat, then separate centrifugally |
| 4. | Cool in batches | Cool continuously | Cool continuously |
| 5. | Store raw product in cans | Cold storage in tanks | Store raw products in tanks |
| 6. | Pasteurize and cool in batches | Pasteurize and cool in batches | Pasteurize and cool in batches |
| 7. | Storage in batch pasteurizers | Pasteurized storage in tanks | Pasteurized storage in tanks |
| 8. | Churn in batches | Churn in batches | Churn continuously |
| 9. | Package manually | Package semi-automatically | Package automatically |
| 10. | Store in cold storage | Inventory in cold storage | Inventory in cold storage |
| 11. | Ship out | Ship out | Ship out |
| 12. | Take-apart piping | Partial CIP piping | CIP piping |
| 13. | Manual material handling | Partial automatic material handling | Automatic material handling |

## Size vs. Technology

In 1963 there were 1,321 butter plants producing 1,419,688,000 lb. of butter. The industry considers a plant producing under one-half million pounds per year as "small", one-half to three million pounds as "medium" and over three million pounds as "large".

Waste and wastewater are a function of size as well as technology. TABLE IWP 9-16 represents the industry's opinion of the relationship of size and technology.

TABLE IWP 9 - 16

Plant Statistics

1963

| | | |
|---|---|---|
| Small | 714 | 54% produce less than 1/2 million pounds per year |
| Medium | 477 | 36% produce 1/2 to 3 million pounds per year |
| Large | 130 | 10% produce more than 3 million pounds per year |
| Total: | 1,321 | plants produced 1,419,688,000 lb. in 1963 |

| Percentage Technology Levels | Percentage of Various Sizes | | |
|---|---|---|---|
| | Small Less than ½ | Medium ½ to 3 | Large More than 3 |
| 40% Older Technology | 94% | 4% | 2% |
| 55% Typical Technology | 30 | 62 | 8 |
| 5% Advanced Technology | 2 | 4 | 94 |

The above relationship provides a basis for computation of overall plant wastes produced when related to unit waste production of various size plants utilizing three technology levels.

## Gross Waste Quantities Before Treatment or Other Disposal

In plants of advanced technology, waste generated is less than in those plants less advanced. Waste and wastewater per pound of finished product are as follows:

TABLE IWP 9 - 17-A

Waste and Wastewater per Pound of Finished Product

| | Skim & Buttermilk Pounds BOD | Product Pounds BOD | Chemicals Pounds BOD | Wastewater Gallons |
|---|---|---|---|---|
| Older Technology | 1.586 | .0168 | .0017 | 13.5 |
| Typical Technology | 1.586 | .0067 | .0007 | 6.5 |
| Advanced Technology | 1.586 | .0034 | .0003 | 4.1 |

This data represents industry operating experience. Skim milk and buttermilk wastes are similar for all levels of technology because the basic processes are similar; however, the other wastes are affected by plant size and technology. Skim milk and buttermilk are largely utilized in by-product manufacture.

## Seasonal Waste Production Pattern

Waste quantities tend to be directly proportional to production quantities; however, wastewater is generated in larger quantities in the warm months, reflecting increased refrigeration requirements. The following table illustrates this relationship.

TABLE IWP 9 - 17-B

Percentage of Yearly Total of Skim, Product, Soap & Chemical and Wastewater

| | S-P-S & C | Wastewater | | S-P-S & C | Wastewater |
|---|---|---|---|---|---|
| January | 9.5 | 7.5 | July | 7.8 | 9.8 |
| February | 9.7 | 8.7 | August | 6.4 | 8.4 |
| March | 10.6 | 9.6 | September | 4.8 | 6.8 |
| April | 10.7 | 10.7 | October | 5.7 | 5.7 |
| May | 11.0 | 12.0 | November | 5.9 | 4.9 |
| June | 10.1 | 11.1 | December | 6.8 | 4.8 |

This seasonal variation is not expected to change.

The relationship of plant size and technology shown in Table IWP 9-16 permits a comparison of the number of plants in each technology level. The unit wastes from Table IWP 9-17-A, when applied to the number of plants, result in Table IWP 9-18.

TABLE IWP 9 - 18

Gross Waste Quantities for Average Size Plants

A. Older Technology: These plants process 1,060 lb. of finished product per day.

Significant Wastes - Lb. per Day

| # Plants | Skim & Buttermilk Pounds BOD* | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gal. per Day |
|---|---|---|---|---|
| 528 | 1,681 | 17.8 | 1.8 | 14,400 |

B. Typical Technology: These plants process 3,900 lb. of finished product per day.

Significant Wastes - Lb. per Day

| # Plants | Skim & Buttermilk Pounds BOD* | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gal. per Day |
|---|---|---|---|---|
| 727 | 6,185 | 26.29 | 2.6 | 25,700 |

C. Advanced Technology: These plants process 17,300 lb. of finished product per day.

Significant Wastes - Lb. per Day

| # Plants | Skim & Buttermilk Pounds BOD* | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gal. per Day |
|---|---|---|---|---|
| 66 | 27,438 | 58.32 | 5.8 | 72,700 |

*The largest portion of skim milk and buttermilk is utilized in by-product manufacture and does not go to sewer.

## TABLE IWP 9 - 19-A

### Gross Waste Quantities Before Treatment or Disposal

The individual plant data (Table IWP 9-18) when multiplied by the number of plants results in gross waste quantities before treatment, disposal or utilization in by-product manufacture.

| | Significant Wastes Per Year* | | | |
|---|---|---|---|---|
| | Skim Milk & Buttermilk Pounds BOD (Millions) | Product Pounds BOD (Millions) | Soap & Chemicals Pounds BOD (Millions) | Wastewater Gallons (Millions) |
| Older Technology | 508 | 2.94 | .3 | 2,366 |
| Typical Technology | 2,584 | 5.96 | .6 | 5,847 |
| Advanced Technology | 1,039 | 1.20 | .1 | 1,496 |
| Total | 4,131 | 10.10 | 1.0 | 9,709 |
| Individual Plant Range | | ± 50% | ± 50% | ± 20% |

## TABLE IWP 9 - 19-B

### Projected Waste and Wastewater

The relationship among change in total production, plant size and technology change is shown in the following table:

1963 and Projected Gross Wastes and Wastewater in Millions*

| | 1963 | 1968 | 1969 | 1970 | 1971 | 1972 | 1977 |
|---|---|---|---|---|---|---|---|
| Lb. Product Manufactured | 1,420 | 1,274 | 1,290 | 1,306 | 1,327 | 1,348 | 1,455 |
| Lb. BOD Skim Milk and Buttermilk | 4,131 | 3,706 | 3,753 | 3,799 | 3,860 | 3,921 | 4,233 |
| Lb. BOD Product | 10.10 | 8.97 | 9.0 | 9.01 | 9.06 | 9.11 | 9.31 |
| Lb. BOD Soap & Chemicals | 1.0 | .9 | .9 | .9 | .9 | .9 | .9 |
| Subtotal | 4,142.10 | 3,715.87 | 3,762.9 | 3,808.91 | 3,869.96 | 3,931.01 | 4,243.21 |
| Gal. Wastewater | 9,736 | 8,473 | 8,313 | 8,148 | 8,006 | 7,856 | 6,982 |

Projections of product manufactured are based upon industry and government estimates.

*Table IWP 9-35 shows net wastes which excludes skim milk and buttermilk used in by-product manufacture.

## Waste Reduction Practices

The waste reduction practices utilized in the industry do not vary greatly. Skim milk and buttermilk are in large part used in by-product manufacture. If not used, these materials become a portion of the total plant waste. (A common sewer piping system can be used for the entire plant.) The wastes other than miscellaneous chemicals are of a "biodegradable" nature.

Certain processing practices produce varying amounts of wastes. Table IWP 9-20 illustrates such relationships.

### TABLE IWP 9 - 20

### Processing Practices

The fundamental process used with the "older" technology as the reference base, described on Pages IWP 9-15 (A).

| Alternate Process | % Waste Reduction Efficiency | | |
|---|---|---|---|
| | Product | Soap & Chemical | Wastewater |
| (a) Plant - Large vs. Small | 80 | 50 | 54 |
| (b) Receive - Tanks vs. Cans | 50 | 60 | 85 |
| (c) Separator - CIP vs. Manual | -0- | 50 | 50 |
| (d) Pasteurize - Continuous vs. Batch | 20 | 60 | 60 |
| (e) Churn - Continuous vs. Batch | 20 | 20 | 20 |
| (f) Packaging - Automatic vs. Manual | 10 | 15 | 15 |
| (g) Piping - CIP vs. Take-apart | 30 | 50 | 40 |
| (h) Material Handling - Automatic vs. Manual | 15 | * | * |

*Increases wastewater proportionately to lubricant used.

A large plant may be created by the consolidation of several smaller facilities. The subprocesses (b-h) may be applied to any plant on an individual basis and are not dependent on each other; however, the common practice is to utilize continuous flow and automatic equipment together.

Continuous flow and automatic equipment tend to have capacity ratings which justify the use thereof only in the average to larger size plants. Continuous churns are rare even in the largest of plants because of initial cost and because very high production capacities do not permit flexibility of operation.

## Treatment Practices

The practice most used in the disposal of skim milk and buttermilk wastes is by-product manufacture.

Another popular practice utilizes the Management Technique, i.e., the closest possible supervision of day-to-day operations to eliminate processing loss--loss due to waste resulting from the initial shrinkage of the raw material as well as the overfill of the finished package.

In general, most waste that goes to plant sewers is subsequently flowed to municipal sewers; to a lesser extent, waste may be discharged directly into lakes or streams.

The disposal through use of sewage plants represents the least used treatment practice.

The following table illustrates the effectiveness of the individual treatment practice.

### TABLE IWP 9 - 21

### Treatment Practices

| Removal Method | Normal Removal Efficiency % of Total Wasteload Removed | | | |
|---|---|---|---|---|
| | Skim Milk & Buttermilk | Product | Soap & Chemicals | Wastewater |
| (a) Ridge and Furrow | 95-100 | 95-100 | 95-100 | 4* |
| (b) Spray Irrigation | 95-100 | 95-100 | 95-100 | 5* |
| (c) Aerated Lagoon | 90-95 | 90-95 | 90-95 | 1* |
| (d) Trickling Filter | 90-95 | 90-95 | 90-95 | 0 |
| (e) Activated Sludge | 90-95 | 90-95 | 90-95 | 0 |
| (f) Municipal Sewer | 100 | 100 | 100 | 0 |
| (g) To Waterways | 100 | 100 | 100 | 0 |
| (h) Utilization as Byproduct | 85 | 99.5 | NA | 99.5 |
| (i) Management Technique | 50-75 | 50-75 | 50-75 | 10-75 |

NA = Not Applicable

*Estimated percent of total evaporated to the atmosphere, the remainder going to waterways.

Assuming optimum conditions, the removal methods (supra) could be employed in any given plant; however, the utilization of the ridge and furrow, spray irrigation, and aerated lagoon type processes require significant amounts of land. Furthermore, soil and climate limit both the physical size of a treatment plant as well as the choice of the treatment process.

The trickling filter and activated sludge processes are relatively compact; however, these types require greater capital investment and have higher operating costs than the other methods.

The trend is to connect plants to municipal systems wherever possible in order to simplify day-to-day operations and to minimize capital investment.

The utilization of skim milk and buttermilk in by-product manufacture will tend to increase because of increasing relative value and need for these products.

The management technique is now being widely accepted and involves close supervision of day-to-day operations, the utilization of preventative maintenance techniques, and the use of inventory control procedures.

It is estimated that the following percentages of industrial waste have been or will be discharged to a municipal sewer:

| 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|
| 1 | 5 | 10 | 32 | 53 |

The high BOD requirements of butter plant wastes necessitate that the capacity of a particular municipal plant be reviewed prior to the connection of a new butter plant wasteload to the system.

Pretreatment is not usually required because of the characteristics of the waste; however, pretreatment may be required if the municipal plant is of inadequate size.

The various practices have been utilized in varying degrees. Plant location, capital costs, operating costs and problems--all influence the type adoption.

TABLE IWP 9 - 23

Rate of Adoption of Waste Treatment Practices Since 1950

The rate of treatment practice adoption is shown in percentages.

| | Removal Method | % of Plants Employing Listed Methods | | | | |
|---|---|---|---|---|---|---|
| | | 1950 | 1963 | 1967 | 1972 | 1977 |
| (a) | Ridge and Furrow | U* | 8 | 10 | 15 | 15 |
| (b) | Spray Irrigation | U | 5 | 5 | 5 | 5 |
| (c) | Aerated Lagoon | U | 5 | 10 | 15 | 25 |
| (d) | Trickling Filter | U | U | U | U | U |
| (e) | Activated Sludge | U | U | U | U | U |
| (f) | Municipal Sewer | U | 5 | 10 | 32 | 53 |
| (g) | To Waterways | 98 | 73 | 58 | 30 | -0- |
| (h) | Utilization as Byproduct | 50 | 90 | 95 | 99 | 100 |
| (i) | Management Technique | 40 | 50 | 60 | 65 | 70 |

*U = Under 1%

## Waste Reduction or Removal Cost Information

The butter industry has a rather modest capital investment in sewerage treatment facilities.

The estimated capital investment in waste removal facilities in 1963 was $380,000 and the estimated annual operating expense was $76,000.

In 1966 the capital investment was estimated to have increased to $900,000 and the annual operating expense to have increased to $180,000.

## Comparative Investment & Operating Expenses

Plant sizes have been classified as small, medium and large and technology levels have been described as old, typical and advanced.

A comparison of investment costs and operating costs for providing waste and wastewater removal facilities between plants of different sizes and technologies for the various subprocesses and removal methods will provide valuable data for determining which subprocess or method offers the most attractive opportunities for use in the future to implement the Clean Water Restoration Act.

The next several pages include comparison tables. The tables are based on investment and operating costs as experienced by industry. Land has been estimated at $300 per acre for ridge and furrow, spray irrigation and aerated lagoon installations.

Capital investment for utilization of skim milk and buttermilk as by-products does not require condensing or drying equipment as sufficient capacity exists in the condensing industry to perform this function. It is only necessary to provide storage and transportation facilities to move the skim milk and buttermilk to the condensing plant.

The management technique requires no additional capital investment. Nominal expense is incurred for educational purposes.

Economic life in relation to processing equipment represents current thinking of industry needs for return on investment and recognizes obsolescence.

Economic life in relation to removal methods represents observed useful life.

TABLE IWP 9 - 25

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of small size. Daily "net" waste quantities from plant to sewer are 53.2 pounds BOD (±50%) and 12,000 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 1060 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks vs. Cans | 5,000 | -1,000 | 13 |
| (c) Separator - CIP vs. Manual | NA | NA | NA |
| (d) Pasteurize - Continuous vs. Batch | 15,000 | +2,000 | 13 |
| (e) Churn - Continuous vs. Batch | NA | NA | NA |
| (f) Packaging - Automatic vs. Manual | 15,000 | +4,700 | 4 |
| (g) Piping - CIP vs. Take-apart | 12,000 | +1,800 | 13 |
| (h) Material Handling - Automatic vs. Manual | 6,000 | ±0 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 3,900 | $ +800 | 20 |
| (b) Spray Irrigation | 11,000 | +2,200 | 20 |
| (c) Aerated Lagoon | 3,200 | +600 | 20 |
| (d) Trickling Filter | 52,500 | +10,500 | 15 |
| (e) Activated Sludge | 35,000 | +7,000 | 15 |
| (f) Municipal Sewer | 200 | +300 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 4,500 | -96,100 | 30 |
| (i) Management Technique | -0- | -7,500 | * |

NA = Not Applicable * Permanent

See Reference Notes on Page IWP 9 - 8 and IWP 9-24.

TABLE IWP 9 - 26

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of small size. Daily "net" waste quantities from plant to sewer are 40.3 pounds BOD (±50%) and 4,700 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 1060 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) Receive - Tanks Typical vs. Advanced | -0- | -0- | 13 |
| (c) Separator - CIP vs. Manual | NA | NA | NA |
| (d) Pasteurize - Continuous vs. Batch | 15,000 | +2,000 | 13 |
| (e) Churn - Continuous vs. Batch | NA | NA | NA |
| (f) Packaging - Automatic Typical vs. Advanced | 5,000 | -3,000 | 4 |
| (g) Piping - CIP Typical vs. Advanced | 6,000 | +900 | 13 |
| (h) Material Handling - Typical vs. Advanced | 3,000 | ±0 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 1,600 | $ 300 | 20 |
| (b) Spray Irrigation | 4,400 | 900 | 20 |
| (c) Aerated Lagoon | 2,700 | 500 | 20 |
| (d) Trickling Filter | 20,700 | 4,200 | 15 |
| (e) Activated Sludge | 13,800 | 2,800 | 15 |
| (f) Municipal Sewer | 200 | 200 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 4,500 | -96,100 | 30 |
| (i) Management Technique | -0- | - 2,800 | * |

NA = Not Applicable * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-24.

TABLE IWP 9 - 27

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of small size. Daily "net" waste quantities from plant to sewer are 36.6 pounds BOD (±50%) and 2,100 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 1,060 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks | AH | NA | 13 |
| (c) Separator - CIP | NA | NA | NA |
| (d) Pasteurize - Continuous | AH | AH | 13 |
| (e) Churn - Continuous | NA | NA | NA |
| (f) Packaging - Automatic | AH | NA | 4 |
| (g) Piping - CIP | AH | NA | 13 |
| (h) Material Handling | AH | NA | NA |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 780 | $ 160 | 20 |
| (b) Spray Irrigation | 1,950 | 390 | 20 |
| (c) Aerated Lagoon | 2,340 | 470 | 20 |
| (d) Trickling Filter | 33,800 | 6,750 | 15 |
| (e) Activated Sludge | 13,000 | 2,600 | 15 |
| (f) Municipal Sewer | 200 | 185 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 4,500 | -96,100 | 30 |
| (i) Management Technique | -0- | -1,200 | * |

NA = Not Applicable
AH = Already installed by definition

* Permanent

See Reference Notes on Page IWP 9 - 8 and IWP 9 - 24.

TABLE IWP 9 - 28

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of medium size. Daily "net" waste quantities from plant to sewer are 196 pounds BOD (±50%) and 44,070 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 3,900 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks vs. Cans | 5,000 | -3,500 | 13 |
| (c) Separator - CIP vs. Manual | 25,000 | +1,000 | 13 |
| (d) Pasteurize - Continuous vs. Batch | 18,000 | -1,200 | 13 |
| (e) Churn - Continuous vs. Batch | NA | NA | NA |
| (f) Packaging - Automatic vs. Manual | 15,000 | -5,300 | 4 |
| (g) Piping - CIP vs. Take-apart | 25,000 | -3,800 | 13 |
| (h) Material Handling - Automatic vs. Manual | 15,000 | ±0 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $14,400 | $ 2,900 | 20 |
| (b) Spray Irrigation | 40,600 | 8,100 | 20 |
| (c) Aerated Lagoon | 11,800 | 2,400 | 20 |
| (d) Trickling Filter | 73,500 | 14,700 | 15 |
| (e) Activated Sludge | 49,000 | 9,800 | 15 |
| (f) Municipal Sewer | 200 | 1,000 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 11,400 | -381,500 | 30 |
| (i) Management Technique | -0- | -30,000 | * |

NA = Not Applicable * Permanent

See Reference Notes on Page IWP 9-8 and 9-24.

## TABLE IWP 9 - 29

## Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of medium size. Daily "net" waste quantities from plant to sewer are 153 pounds BOD (±50%) and 17,200 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 3,900 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) Receive - Tanks vs. Cans Typical vs. Advanced | -0- | -0- | 13 |
| (c) Separator - CIP vs. Manual | 25,000 | +1,000 | 13 |
| (d) Pasteurize - Continuous vs. Batch | 18,000 | -1,200 | 13 |
| (e) Churn - Continuous vs. Batch | NA | NA | NA |
| (f) Packaging - Automatic Typical vs. Advanced | 5,000 | -2,200 | 4 |
| (g) Piping - CIP Typical vs. Advanced | 12,000 | -1,900 | 13 |
| (h) Material Handling - Typical vs. Advanced | 7,500 | ±0 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 5,600 | $ 1,100 | 20 |
| (b) Spray Irrigation | 16,000 | 3,200 | 20 |
| (c) Aerated Lagoon | 9,300 | 1,900 | 20 |
| (d) Trickling Filter | 35,000 | 7,000 | 15 |
| (e) Activated Sludge | 23,400 | 4,700 | 15 |
| (f) Municipal Sewer | 200 | 800 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 11,400 | -381,500 | 30 |
| (i) Management Technique | -0- | -11,700 | * |

NA = Not Applicable     * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-24.



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TABLE IWP 9 - 30

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of medium size. Daily "net" waste quantities from plant to sewer are 139 pounds BOD (±50%) and 7,800 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 3,900 lbs/day | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) | Receive - Tanks | AH | NA | 13 |
| (c) | Separator - CIP | | | 13 |
| (d) | Pasteurize - Continuous | AH | NA | 13 |
| (e) | Churn - Continuous | NA | NA | NA |
| (f) | Packaging - Automatic | AH | NA | 4 |
| (g) | Piping - CIP | AH | NA | 13 |
| (h) | Material Handling - Automatic | AH | NA | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $ 2,600 | $ 500 | 20 |
| (b) | Spray Irrigation | 7,300 | 1,400 | 20 |
| (c) | Aerated Lagoon | 8,300 | 1,700 | 20 |
| (d) | Trickling Filter | 38,000 | 7,600 | 15 |
| (e) | Activated Sludge | 18,200 | 3,600 | 15 |
| (f) | Municipal Sewer | 200 | 700 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Utilization as Byproduct | 11,400 | -381,500 | 30 |
| (i) | Management Technique | -0- | 5,600 | * |

NA = Not Applicable
AH = Already installed by definition

* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-24.

TABLE IWP 9 - 31

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of large size. Daily "net" waste quantities from plant to sewer are 869 pounds BOD (±50%) and 195,490 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| | Product = 17,300 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) | Receive - Tanks vs. Cans | 32,000 | -14,400 | 13 |
| (c) | Separator - CIP vs. Manual | 50,000 | + 2,000 | 13 |
| (d) | Pasteurize - Continuous vs. Batch | 35,000 | -7,200 | 13 |
| (e) | Churn - Continuous vs. Batch | 125,000 | -23,000 | 13 |
| (f) | Packaging - Automatic vs. Manual | 45,000 | -21,200 | 4 |
| (g) | Piping - CIP vs. Take-apart | 35,000 | -13,100 | 13 |
| (h) | Material Handling - Automatic vs. Manual | 35,000 | -25,800 | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $ 63,500 | $ 11,400 | 20 |
| (b) | Spray Irrigation | 180,000 | 32,400 | 20 |
| (c) | Aerated Lagoon | 52,000 | 9,400 | 20 |
| (d) | Trickling Filter | 230,000 | 41,500 | 15 |
| (e) | Activated Sludge | 152,000 | 27,400 | 15 |
| (f) | Municipal Sewer | 200 | 4,350 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Utilization as Byproduct | 52,000 | 1,730,000 | 30 |
| (i) | Management Technique | -0- | -134,500 | * |

NA = Not Applicable      * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-24.

## TABLE IWP 9 - 32

### Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of large size. Daily "net" waste quantities from plant to sewer are 677 pounds BOD (±50%) and 76,200 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 17,300 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) Receive - Tanks vs. Cans Typical vs. Advanced | -0- | -0- | 13 |
| (c) Separator - CIP vs. Manual | 50,000 | +2,000 | 13 |
| (d) Pasteurize - Continuous Typical vs. Advanced | 5,000 | -800 | 13 |
| (e) Churn - Continuous vs. Batch | 125,000 | -16,000 | 13 |
| (f) Packaging - Automatic Typical vs. Advanced | 15,000 | -7,100 | 4 |
| (g) Piping - CIP Typical vs. Advanced | 18,000 | -6,600 | 13 |
| (h) Material Handling - Typical vs. Advanced | 18,000 | -12,500 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 24,800 | $ 4,500 | 20 |
| (b) Spray Irrigation | 70,000 | 12,600 | 20 |
| (c) Aerated Lagoon | 42,000 | 7,500 | 20 |
| (d) Trickling Filter | 108,000 | 19,500 | 15 |
| (e) Activated Sludge | 71,500 | 13,000 | 15 |
| (f) Municipal Sewer | 200 | 3,400 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 52,000 | -1,730,000 | 30 |
| (i) Management Technique | -0- | -53,500 | * |

NA = Not Applicable      * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-24.

TABLE IWP 9 - 33

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of large size. Daily "net" waste quantities from plant to sewer are 615 pounds BOD (±50%) and 34,600 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 17,300 lbs/day | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) | Receive - Tanks | AH | NA | 13 |
| (c) | Separator - CIP | AH | NA | 13 |
| (d) | Pasteurize - Continuous | AH | NA | 13 |
| (e) | Churn - Continuous | AH | NA | 13 |
| (f) | Packaging - Automatic | AH | NA | 4 |
| (g) | Piping - CPI | AH | NA | 13 |
| (h) | Material Handling - Automatic | AH | NA | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $11,300 | $ 2,000 | 20 |
| (b) | Spray Irrigation | 32,000 | 5,800 | 20 |
| (c) | Aerated Lagoon | 37,000 | 6,700 | 20 |
| (d) | Trickoing Filter | 70,000 | 12,600 | 15 |
| (e) | Activated Sludge | 47,000 | 8,500 | 15 |
| (f) | Municipal Sewer | 200 | 3,100 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Utilization as Byproduct | 52,000 | -1,730,000 | 30 |
| (i) | Management Technique | -0- | -26,500 | * |

NA = Not Applicable
AH = Already installed by definition

* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-24.

The tables indicate that several subprocesses and removal methods are particularly attractive in terms of small capital investment and low annual operating expense.

The utilization of skim milk and buttermilk for byproduct manufacture eliminates these materials as wastes and in most operations represents very significant economic gains. The plant with condensing and drying equipment always utilizes these materials, the plant without this equipment generally sells these materials. In the small plants the volume of skim milk and buttermilk is such that there is greater difficulty in finding a market than in the larger plants, and consequently these materials are often dumped to sewers. The trends toward larger plants and increasing need for these materials will result in a reduction of wastes.

The application of Management Technique requires no capital investment and very little operating expense. This method results in significant economy in plant operations, and is a highly desirable practice.

Disposal of remaining waste to municipal sewers requires only nominal investment and operating cost to the plant and is attractive to the plant operation. However, if a municipality establishes a sewage rate based directly on plant waste loads, then comparative economics determine whether or not a plant should adopt further waste removal methods.

Summary of Projected Wasteloads

| Year | Waste | Gross Waste Generated | Removal * | Net Waste Discharged |
|---|---|---|---|---|
| | | Million | % | Million |
| 1963 | Skim Milk & Buttermilk (Lbs. BOD) | 4,131 | 85 | 619.6 |
| | Product (Lbs. BOD) | 10.10 | 15 | 8.6 |
| | Soap & Chemical (Lbs. BOD) | 1.0 | 15 | .9 |
| | | ST 4,142.10 | ST | 629.1 |
| | Water (Gallons) | 9,736 | 5 | 9,249 |

*Percentage of waste reduced or removed by process changes, waste treatment and byproducts utilization

Summary of Projected Wasteloads

| Year | Waste | | Gross Waste Generated Million | Removal * % | | Net Waste Discharged Million |
|---|---|---|---|---|---|---|
| 1968 | Skim & Buttermilk (Lbs. BOD) | | 3,706 | 91 | | 333.5 |
| | Product (Lbs. BOD) | | 8.97 | 30 | | 6.28 |
| | Soap & Chemical (Lbs. BOD) | | .9 | 30 | | .6 |
| | | ST | 3,715.87 | | ST | 340.38 |
| | Water (Gallons) | | 8,473 | 5 | | 8,050 |
| 1969 | Skim & Buttermilk (Lbs. BOD) | | 3,753 | 92 | | 300.2 |
| | Products (Lbs. BOD) | | 9.00 | 40 | | 5.4 |
| | Soap & Chemical (Lbs. BOD) | | .9 | 40 | | .5 |
| | | ST | 3,762.90 | | ST | 306.1 |
| | Water (Gallons) | | 8,313 | 5 | | 7,897 |
| 1970 | Skim & Buttermilk (Lbs. BOD) | | 3,799 | 93 | | 265.9 |
| | Product (Lbs. BOD) | | 9.01 | 50 | | 4.5 |
| | Soap & Chemical (Lbs. BOD) | | .9 | 50 | | .5 |
| | | ST | 3,808.91 | | ST | 270.9 |
| | Water (Gallons) | | 8,148 | 5 | | 7,741 |
| 1971 | Skim & Buttermilk (Lbs. BOD) | | 3,860 | 94 | | 231.6 |
| | Products (Lbs. BOD) | | 9.06 | 60 | | 3.6 |
| | Soap & Chemical (Lbs. BOD) | | .9 | 60 | | .4 |
| | | ST | 3,869.96 | | ST | 235.6 |
| | Water (Gallons) | | 8,006 | 5 | | 7,606 |
| 1972 | Skim & Buttermilk (Lbs. BOD) | | 3,921 | 95 | | 196.1 |
| | Product (Lbs. BOD) | | 9.11 | 70 | | 2.7 |
| | Soap & Chemical (Lbs. BOD) | | .9 | 70 | | .3 |
| | | ST | 3,931.01 | | ST | 199.1 |
| | Water (Gallons) | | 7,856 | 5 | | 7,463 |
| 1977 | Skim & Buttermilk (Lbs. BOD) | | 4,233 | 99.5 | | 21.2 |
| | Product (Lbs. BOD) | | 9.31 | 99.5 | | .46 |
| | Soap & Chemicals (Lbs. BOD) | | .9 | 99.5 | | .05 |
| | | ST | 4,243.21 | | ST | 21.71 |
| | Water (Gallons) | | 6,982 | 5 | | 6,633 |

*Percentage of waste reduced or removed by process changes, waste treatment and by-products utilization

2022 - Cheese, Natural and Processed: Establishments primarily engaged in manufacturing all types of natural cheese (except cottage cheese--Industry 2026), processed cheese, cheese foods and cheese spreads.

The cheese industry has grown over the years at a slightly faster rate than population growth. This trend is expected to continue.

In 1963 over 53% (690) of all cheese plants were located in Wisconsin. New York possessed the next largest number of plants with 85, followed by Illinois with 60, Iowa with 46, Ohio with 34 and Michigan with 33.

The manufacturing process of cheese is as follows:

1. Receipt: Raw milk and skim milk are received in tank trucks and are emptied by pumping to storage.

2. Storage: The raw (unpasteurized) milk is stored in refrigerated tanks until ready for further use.

3. Separation: For low fat cheese, the raw products are pumped through a heating device and sent to a centrifugal separator which removes all or part of the cream from the product. This cream becomes available for by-product manufacture.

4. Pasteurization: The raw milk is usually pasteurized in a continuous flow pasteurizer, although in smaller operations batch pasteurizers continue to be used.

5. Batch Set-Cooking: The pasteurized product is normally cooled in the pasteurizer to the desired temperature and pumped into cheese vats. The milk is then innoculated with a culture. At the end of a controlled period of time, the curd which results from bacterial action is drained and becomes available for either by-product manufacture or is treated as waste.

6. Batch Drain-Cut-Salt-Mill Vat: The curd from the cooking vat is washed with potable water which completes the rinsing away of whey and serves as a cooling medium. This water goes to waste. At this time salt may be added, and the curd may be cut or milled.

7. Press-Hoops: The curd is pressed (compressed) and placed into hoops, which are can-shaped molds.

8. Incubation and Storage: The cheese hoops are placed in controlled environment storage rooms to permit "aging", the incubation period necessary to complete the formation of cheese. This period may be a very short time or it may be a matter of months, the time depending upon the variety of cheese being manufactured. When the cheese is removed from the incubation

storage a portion may go directly to packaging while the other portion may be used for processed cheese.

9. Ingredient Preparation: In the preparation of processed cheese, the hoop cheese is ground and placed in vats where stabilizers, flavoring, and other needed ingredients are added.

10. Blending: The ingredients are then blended.

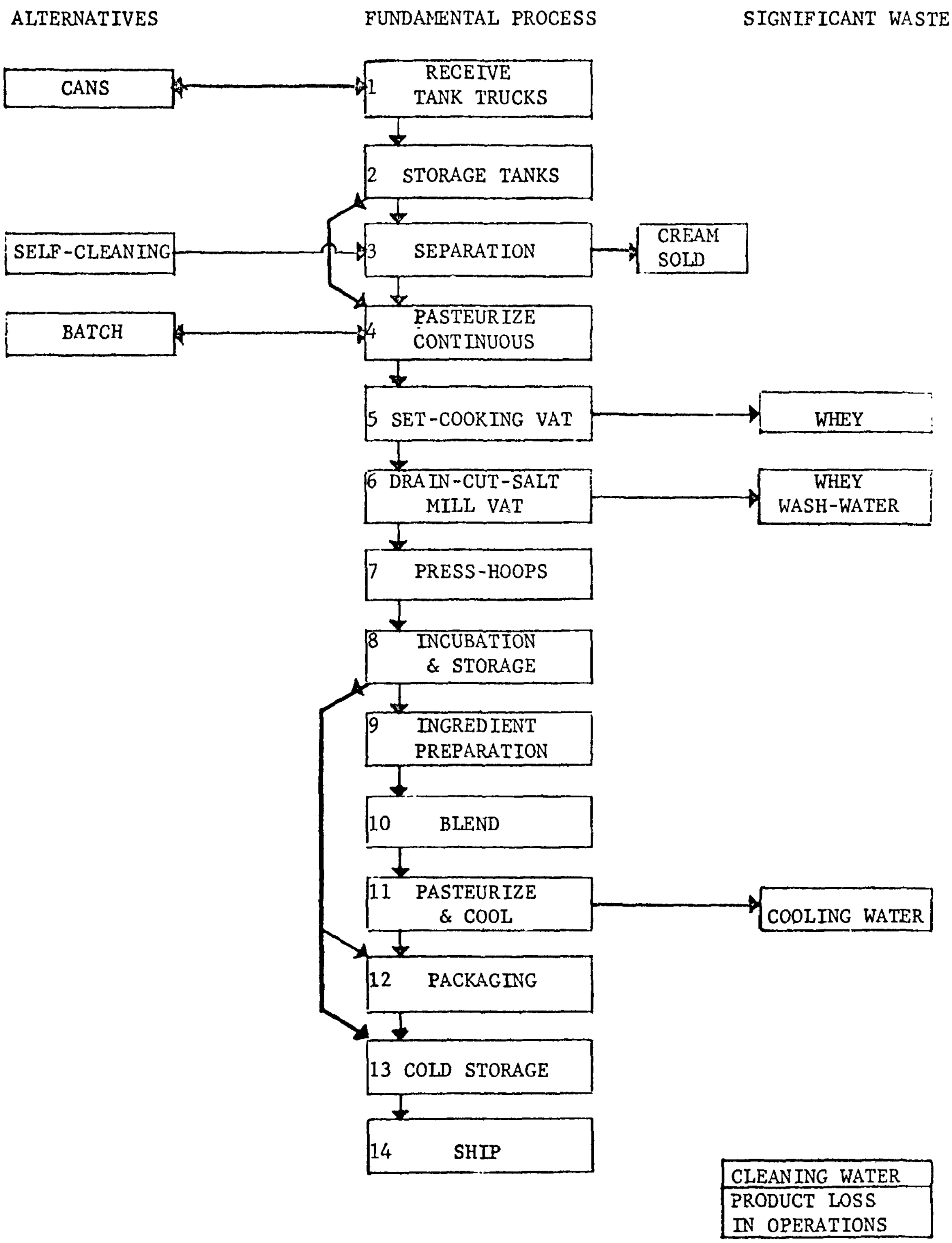
11. Vat Pasteurization and Cooling: The blended ingredients are pasteurized, partially cooled, and sent to packaging.

12. Packaging: The hoop and processed cheese are conveyed to filling and packaging machines which shape and place the cheese in characteristic packages and wrappers.

13. Cold Storage: From packaging, the cheese is stored and inventoried in a cold storage area until needed.

14. Shipping: The cheese is removed from cold storage and placed on refrigerated vehicles for delivery to the consumer.

A flow diagram is included on Page IWP 9-38.


ALTERNATIVES
FUNDAMENTAL PROCESS
SIGNIFICANT WASTE
CANS
1 RECEIVE TANK TRUCKS
2 STORAGE TANKS
SELF-CLEANING
3 SEPARATION
CREAM SOLD
BATCH
4 PASTEURIZE CONTINUOUS
5 SET-COOKING VAT
WHEY
6 DRAIN-CUT-SALT MILL VAT
WHEY WASH-WATER
7 PRESS-HOOPS
8 INCUBATION & STORAGE
9 INGREDIENT PREPARATION
10 BLEND
11 PASTEURIZE & COOL
COOLING WATER
12 PACKAGING
13 COLD STORAGE
14 SHIP
CLEANING WATER
PRODUCT LOSS IN OPERATIONS

## Waste and Wastewater

The significant waste from the fundamental cheese process is whey. This waste product may be converted to valuable byproducts through evaporating the moisture and drying the residue to a powder form for human consumption or animal feed.

If whey is sent to the plant disposal system, the material becomes a most difficult waste problem because of the high protein and acidic content. Approximately 54% of the solids in the raw material remains in the whey resulting in a BOD of 3.2%.

To date, whey processing remains a problem to the industry. Recent research has shown that mechanical screens are ineffective in separating whey waste; on a small scale, expensive centrifuging has been utilized effectively. Whey contains .9% to 1% albumin which, if heated and treated with acid, will result in removal of 60% to 70%. This processing, however, reduces the BOD load by only 20% to 25% and has proven to be too expensive for normal processing use. The most practical utilization of whey has been through the facilities of drying plants; however, these operate either at the breakeven point or with only a slight profit.

Less significant sources of wastes are (1) the spillage which occurs in normal processing and packaging operations and (2) the wastes incurred with cleaning equipment at the end of a day's operation. Some clear water waste occurs in those plants using water for once-through cooling in their refrigeration systems. This technique is often used in rural plants with their own wells or in areas of abundant water supply.

No water that comes in contact with cheese during the manufacturing process may be reused because of the danger of contamination.

## RECENT DEVELOPMENTS

The fundamental cheese process has changed little from 1950 to 1966, and little change is forecast for 1967 to 1977. Nevertheless, several developments of interest have occurred.

The most significant change has been in the number reduction of cheese plants. Due to economical pressures, many small plants have closed or have merged. This trend, which is expected to continue, is depicted on Page IWP 9-41.

Since 1950, bulk tank trucks have largely replaced the 10-gallon cans used in Step 1, "Receipt", of the fundamental process. The trend has occurred because the use of trucks has virtually eliminated physical labor, improved sanitation maintenance and reduced the likelihood of contamination.

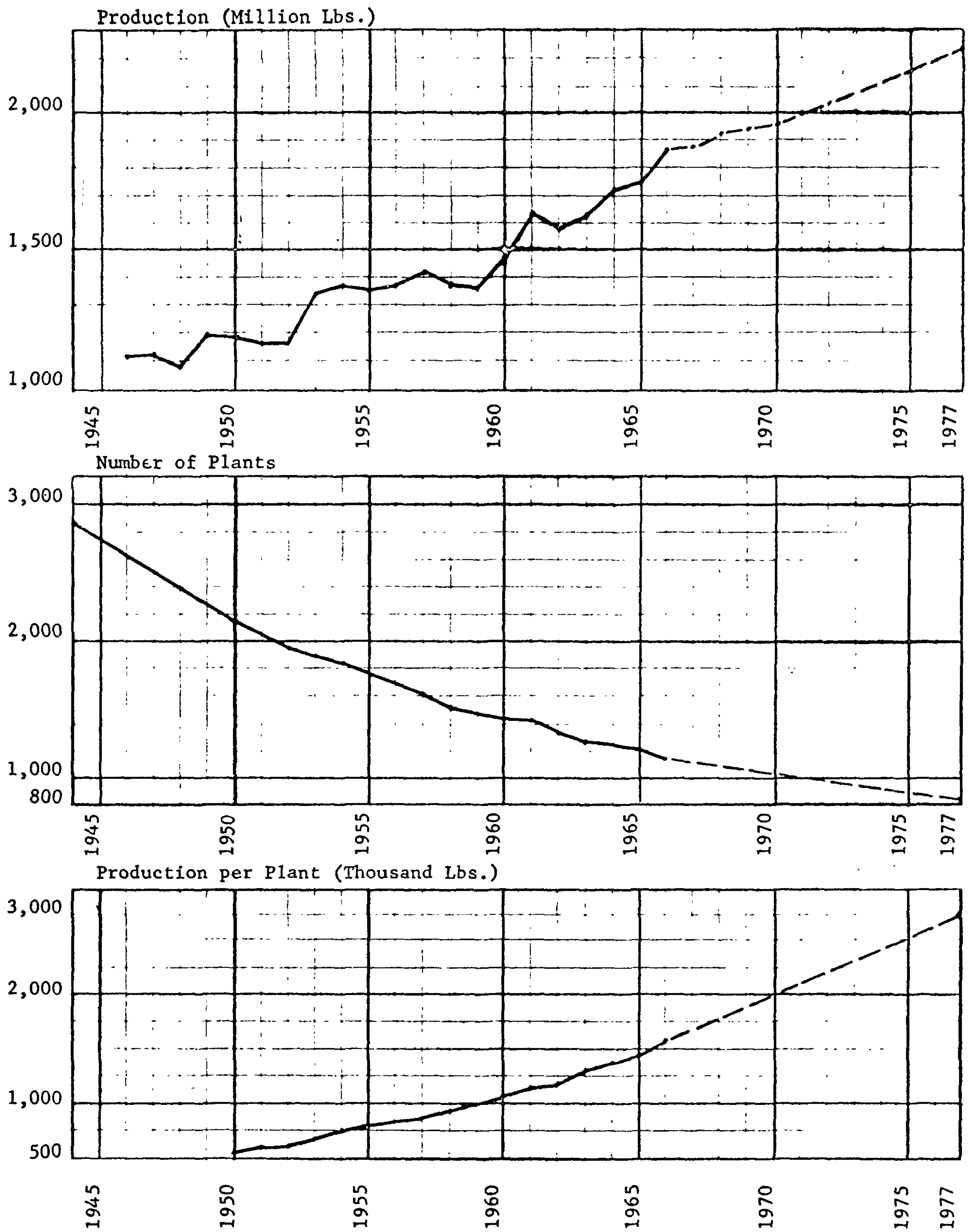
Self-cleaning (CIP) separators used in Step 3 of the fundamental process are now available. Such machinery reduces the amount of manual washing required, as well as the reduction of physical labor.

Because of tremendous volume, large plants utilize continuous flow equipment, as opposed to batch type machinery. This development has tended to reduce the percentage of plant loss in operations and, consequently, has helped to minimize wastes (other than whey). Greatly improved heating and refrigeration systems have reduced water needs considerably.

The trend in packaging is to smaller units which better serve the needs and desires of the consumer. Automatic packaging continues to replace manual methods. Not only is the amount of waste reduced, but new machinery fills more accurately.

Permanent stainless steel piping systems were introduced in the early 1950's. Such systems are cleaned in place, as opposed to the daily take-apart systems formerly accepted. This type equipment reduces the quantity of soap required and, therefore, reduces waste. The fact that the systems are permanently installed has reduced plant product losses; also, sanitation and product shelf life has been increased--a factor which has tended to reduce waste.

Significant changes have occurred in material handling within plants by the introduction of sophisticated conveyors and stacking, grouping and palletization equipment. Even though machines have tended to increase individual plant wastes through the enlarged usage of water-soap lubricants, product loss and waste has been reduced because of the less likelihood of package damage.


Production (Million Lbs.)
2,000
1,500
1,000
1945
1950
1955
1960
1965
1970
1975
1977
Number of Plants
3,000
2,000
1,000
800
1945
1950
1955
1960
1965
1970
1975
1977
Production per Plant (Thousand Lbs.)
3,000
2,000
1,000
500
1945
1950
1955
1960
1965
1970
1975
1977

The trends may best be shown in tabular form, which follows. The reader should note that the alternative subprocesses and other industry changes have occurred over a span of years.

The process which will become prevalent is identified as P, and that which is becoming less used as S.

TABLE IWP 9 - 42

Estimated Percentage of Plants Employing Process

| | | | 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|---|---|---|
| (b) | P | Receive in Tank Trucks | -0- | 40 | 50 | 60 | 70 |
| | S | Receive in Cans | 100 | 60 | 50 | 40 | 30 |
| (c) | P | Separator (Manual) | 100 | 100 | 98 | 96 | 94 |
| | S | Separator CIP | -0- | -0- | 2 | 4 | 6 |
| (d) | P | Pasteurize Continuously | -0- | -0- | 2 | 4 | 7 |
| | S | Pasteurize Batch | 100 | 100 | 98 | 96 | 93 |
| (e) | P | Batch Set | 100 | 100 | 99 | 98 | 95 |
| | S | Continuous Set | -0- | -0- | 1 | 2 | 5 |
| (f) | P | Package Automatically | 10 | 35 | 50 | 65 | 75 |
| | S | Package Manually | 90 | 65 | 50 | 35 | 25 |
| (g) | P | CIP Piping | -0- | 20 | 30 | 40 | 60 |
| | S | Take-apart Piping | 100 | 80 | 70 | 60 | 40 |
| (h) | P | Automatic Material Handling | 20 | 50 | 60 | 70 | 75 |
| | S | Manual Material Handling | 80 | 50 | 40 | 30 | 25 |

The estimates represent the observations and opinions of people in the industry, including processors, material and equipment suppliers and manufacturers and industry associations and consultants.

## Comparative Waste Control Problems

The subprocesses (Table IWP 9-14) do not require different treatment from the fundamental processes; however, the choice of subprocess is largely determined by the total volume produced. Large plants often utilize continuous flow processes because of greater productivity per piece of equipment. These processes generate less waste per pound of finished product.

The whey from the cheese manufacturing process, wash water, product spillage and waste during normal processing, and cleaning water and soaps represent the significant wastes for all processes and subprocesses.

Whey constitutes by far the largest volume of waste and is high in protein content as well as acidity.

In order to best estimate total industry waste and wastewater, it is desirable to identify levels of technology within the industry. The following table illustrates three technological levels. The fundamental process steps from Page IWP 9-36 are used as reference for this table.

TABLE IWP 9 - 43

Comparative Technology

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
|---|---|---|---|
| 1. | Receive in cans | Receive in tank trucks | Receive in tank trucks |
| 2. | Store in cans | Store in tanks | Store in tanks |
| 3. | Separation, if required, centrifugally | Separate as required; heat and separate centrifugally | Separate as required; heat and separate centrifugally |
| 4. | Pasteurize in batches | Pasteurize continuously | Pasteurize continuously |
| 5. | Set-cooking vat manually agitated | Set-cooking vat equipped with mechanical agitation and pushers | Set-cooking vat equipped with mechanical agitators and pushers |
| 6. | Drain, cut, salt and mill in the set-cooking vat | Drain, cut, salt, mill vat, curd pumped to this vat from the set-cooking vat | Drain, cut, salt, mill vat, curd pumped to this vat from the set-cooking vat |
| 7. | Press in hoops manually | Press in hoops, curd conveyed and pressed automatically | Press in hoops, curd conveyed and pressed automatically |

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
|---|---|---|---|
| 8. | Incubate in controlled environment | Incubation in storage under controlled environment | Incubation in storage under controlled environment |
| 9. | Ingredient preparation for processed cheese, manual | Ingredient prepara- equipment usually mechanical | Ingredient preparation equipment usually mechanical |
| 10. | Blend ingredients manually | Blend ingredients mechanically | Blend ingredients mechanically |
| 11. | Pasteurize and cool in batches | Vats, batch pasteurization and cooling | Vats, batch pasteurization and cooling |
| 12. | Package manually | Package in large part automatically | Package automatically |
| 13. | Inventory in cold storage | Inventory in cold storage | Inventory in cold storage |
| 14. | Ship out | Ship out | Ship out |
| 15. | Take-apart piping and | CIP piping (partial) and | CIP piping and |
| 16. | Manual materials handling | Partial automatic materials handling | Automatic materials handling |

## Size vs. Technology

In 1963 there were 1,282 cheese plants producing 1,631,817,000 pounds of cheese. The industry considers a plant producing under one-half million pounds per year as "small", one-half to two million pounds as "medium" and over two million pounds as "large".

Waste and wastewater are a function of size as well as technology. TABLE IWP 9-45 represents industry opinion of the relationship of size and technology.

### TABLE IWP 9 - 45

### Plant Statistics

### 1963

| | | |
|---|---|---|
| Small | 483 | 37% produce less than ½ million pounds per year |
| Medium | 620 | 49% produce from ½ to 2 million pounds per year |
| Large | 179 | 14% produce more than 2 million pounds per year |
| Total: | 1,282 | plants produced 1,631,817,000 pounds in 1963 |

| Percentage Technology Levels | Percentage of Various Sizes: Small Less than ½ | Medium ½ to 2 | Large More than 2 |
|---|---|---|---|
| 30% Older Technology | 90% | 10% | 0% |
| 60% Typical Technology | 3 | 85 | 12 |
| 10% Advanced Technology | 0 | 26 | 102 |

The relationship provides a basis for computation of overall plant wastes produced when related to unit waste production of various size plants of the three technology levels.



287-032 O - 68 - 4

## Gross Waste Quantities Before Treatment or Other Disposal

In plants of advanced technology, waste generated is less than in those less advanced. Unit waste and wastewater quantities per pound of finished product are as follows:

TABLE IWP 9 - 46-A

Waste and Wastewater Quantities per Pound of Finished Product

| | Cream Pounds BOD | Whey Pounds BOD | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gallons |
|---|---|---|---|---|---|
| Older Technology | .044 | .259 | .030 | .003 | 23.1 |
| Typical Technology | .037 | .258 | .012 | .001 | 18.1 |
| Advanced Technology | .036 | .253 | .0045 | .0005 | 12.9 |

This data represents industry operating experience. Whey waste is similar for all levels of technology because the basic process is similar for all levels; however, the other wastes are affected to a greater extent by changes in technology.

## Seasonal Waste Production Pattern

Waste quantities tend to be directly proportional to production quantities; however, wastewater is used in greater quantities in the warm months, reflecting increased refrigeration requirements. The following table illustrates the relationship.

TABLE IWP 9 - 46-B

Percentage of Yearly Total

| | Production | Wastewater | | Production | Wastewater |
|---|---|---|---|---|---|
| January | 7.6 | 6.2 | July | 9.3 | 10.6 |
| February | 7.3 | 7.9 | August | 8.1 | 9.2 |
| March | 8.9 | 8.3 | September | 7.3 | 8.0 |
| April | 9.3 | 9.1 | October | 7.1 | 6.9 |
| May | 10.3 | 10.6 | November | 6.9 | 6.5 |
| June | 10.5 | 11.0 | December | 7.4 | 6.7 |

This seasonal variation is not expected to change.

The relationship of size and technology shown in Table IWP 9-45 permits estimating the number of plants of each technology level. The unit wastes from Table IWP 9-46-A, when applied to the number of plants, results in Table IWP 9-47.

## TABLE IWP 9 - 47

### Gross Waste Quantities for Average Size Plants

A. Older Technology: These plants process 1,060 lb. of finished product per day.

Significant Wastes - Lb. per Day

| # Plants | Cream Pounds BOD | Whey Pounds BOD | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gals. per Day |
|---|---|---|---|---|---|
| 513 | 45.9 | 269.7 | 31.2 | 3.1 | 2,890 |

B. Typical Technology: These plants process 5,000 lb. of finished product per day.

Significant Wastes - Lb. per Day

| # Plants | Cream Pounds BOD | Whey Pounds BOD | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gals. per Day |
|---|---|---|---|---|---|
| 641 | 183.5 | 1280.0 | 60.0 | 6.0 | 10,850 |

C. Advanced Technology: These plants process 13,000 lb. of finished product per day.

Significant Wastes - Lb. per Day

| # Plants | Cream Pounds BOD | Whey Pounds BOD | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gals. per Day |
|---|---|---|---|---|---|
| 128 | 466.8 | 3286.0 | 58.8 | 5.9 | 20,120 |

TABLE IWP 9 - 48A

Gross Waste Quantities Before Treatment or Disposal

The individual plant data (Table IWP 9-47) when multiplied out by the number of plants results in gross waste quantities before treatment, disposal or utilization in byproduct manufacture.

Significant Wastes Per Year

| | Cream Pounds BOD (Millions) | Whey Pounds BOD (Millions) | Product Pounds BOD (Millions) | Soap & Chemicals Pounds BOD (Millions) | Wastewater Gallons (Millions) |
|---|---|---|---|---|---|
| Older Technology | 8.8 | 51.3 | 6.0 | .6 | 549 |
| Typical Technology | 36.7 | 256.0 | 12.0 | 1.2 | 2170 |
| Advanced Technology | 18.7 | 131.3 | 2.4 | .3 | 803 |
| Total | 64.2 | 428.6 | 20.4 | 2.1 | 3522 |
| Individual Plant Range: | ±10% | ±10% | ±50% | ±50% | ±20% |

TABLE IWP 9 - 48B

Projected Waste and Wastewater

The relationship among change in total production, plant size and technology change is shown in the following table:

1963 and Projected Gross Wastes and Wastewater in Millions

| | 1963 | 1968 | 1969 | 1970 | 1971 | 1972 | 1977 |
|---|---|---|---|---|---|---|---|
| Lb. Product Manufactured | 1,632 | 1,921 | 1,945 | 1,966 | 2,001 | 2,032 | 2,244 |
| Lb. BOD Cream | 64.2 | 75.6 | 76.5 | 77.3 | 78.7 | 79.9 | 88.3 |
| Lb. BOD Whey | 428.6 | 504.5 | 510.8 | 516.3 | 525.5 | 533.6 | 589.3 |
| Lb. BOD Product | 20.4 | 23.8 | 23.8 | 23.9 | 2.4 | 24.1 | 25.3 |
| Lb. BOD Soap & Chemicals | 2.0 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.5 |
| Subtotal | 515.2 | 606.3 | 613.5 | 619.9 | 609.0 | 640.0 | 705.4 |
| Gal. Wastewater | 3,522 | 4,022 | 3,945 | 3,861 | 3,800 | 3,727 | 3,390 |

Projections of Product Manufactured are based upon industry and government estimates.

## Waste Reduction Practices

The waste reduction practices utilized in the industry do not vary greatly. Wastes from the various processes and subprocesses are all similar in nature and thus a common sewer piping system is used for the entire plant. The wastes other than miscellaneous chemicals are of a "biodegradable" nature.

Certain of the processing practices produce varying amounts of wastes. Table IWP 9-49 illustrates these relationships.

### TABLE IWP 9 - 49

### Processing Practices

Fundamental Process Used as the Reference Base is "Older" Technology Described on Pages IWP 9 - 43

| Alternate Process | % Waste Reduction Efficiency | | |
|---|---|---|---|
| | Product | Soap & Chemical | Wastewater |
| (a) Plant - Large vs. Small | 85 | 45 | 45 |
| (b) Receive - Tanks vs. Cans | 50 | 85 | 85 |
| (c) Separator - CIP vs. Manual | 0 | 50 | 0 |
| (d) Pasteurize - Continuous vs. Batch | 20 | 60 | 60 |
| (e) Set - Continuous vs. Batch | 5 | 30 | 10 |
| (f) Packaging - Automatic vs. Manual | 10 | 30 | 15 |
| (g) Piping - CIP vs. Take-apart | 30 | 40 | 40 |
| (h) Material Handling - Automatic vs. Manual | 10 | * | * |

*Increases wastewater proportionately to lubricant used.

A large plant may be created by the consolidation of several smaller facilities. The other subprocesses (b-g) may be applied to any plant on an individual basis and are not dependent on each other; however, the common practice is to utilize continuous flow and automatic equipment together.

Continuous flow and automatic equipment tends to have capacity ratings that justify the use thereof only in the average to larger size plants.

## Treatment Practices

The utilization of whey in byproduct manufacture is the treatment method being given the greatest amount of attention; however, a relatively small amount is being so used.

Another popular practice utilizes the Management Technique, i.e., the closest possible supervision of day-to-day operations to eliminate processing loss--loss due to waste resulting from the initial shrinkage of the raw material as well as the overfill of the finished package.

In general, most waste that goes to plant sewers is subsequently flowed to municipal sewers; to a lesser extent, waste may be discharged directly into lakes or streams.

The disposal through use of sewage plants represents the least used treatment practice.

The following table illustrates the effectiveness of the various treatment practices.

### TABLE IWP 9 - 50

### Treatment Practices

Removal efficiency of various treatment methods in use in 1963 for a plant of "Typical" technology

| Removal Method | Normal Removal Efficiency % of Total Wasteload Removed | | |
|---|---|---|---|
| | Product | Soap & Chemicals | Wastewater |
| (a) Ridge and Furrow | 95-100 | 95-100 | 4* |
| (b) Spray Irrigation | 95-100 | 95-100 | 5* |
| (c) Aerated Lagoon | 90-95 | 90-95 | 1* |
| (d) Trickling Filter | 90-95 | 90-95 | 0 |
| (e) Activated Sludge | 90-95 | 90-95 | 0 |
| (f) Municipal Sewer | 100 | 100 | 0 |
| (g) To Waterways | 100 | 100 | 0 |
| (h) Utilization as Byproduct | 99.5 | NA | 99.5 |
| (i) Management Technique | 50-75 | 50-75 | 10-75 |

*Estimated percent of total evaporated to the atmosphere. The remainder goes to waterways.

Assuming optimum conditions, the removal methods (supra) could be employed in any given plant; however, the utilization of the ridge and furrow, spray irrigation, and aerated lagoon type processes require significant amounts of land. Furthermore, soil and climate limit both the physical size of a treatment plant as well as the choice of the treatment process.

The trickling filter and activated sludge processes are relatively compact; however, these types require greater capital investment and have higher operating costs than the other methods.

The trend is to connect plants to municipal systems wherever possible in order to simplify day-to-day operations and to minimize capital investment.

The utilization of whey and cream in byproduct manufacture will tend to increase because of increasing relative value and need for these products.

The management technique is now being widely accepted and involves close supervision of day-to-day operations, the utilization of preventative maintenance techniques, and the use of inventory control procedures.

It is estimated that the following percentages of industrial waste have been or will be discharged to a municipal sewer:

| 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|
| 1 | 5 | 10 | 32 | 53 |

The high BOD requirements of cheese plant wastes necessitate that the capacity of a particular municipal plant be reviewed prior to the connection of a new cheese plant wasteload to the system.

Pretreatment is not usually required because of the characteristics of the waste; however, pretreatment may be required if the municipal plant is of inadequate size.

The various practices have been utilized in varying degrees. Plant location, capital costs, operating costs and problems--all influence the type adoption.

TABLE IWP 9 - 52

Rate of Adoption of Waste Treatment Practices Since 1950

The rate of adoption of treatment practice is shown in percentages.

| | Removal Method | % of Plants Employing Listed Methods 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|---|---|
| (a) | Ridge and Furrow | U* | 8 | 10 | 15 | 15 |
| (b) | Spray Irrigation | U | 5 | 5 | 5 | 5 |
| (c) | Aerated Lagoon | U | 5 | 10 | 15 | 25 |
| (d) | Trickling Filter | U | U | U | U | U |
| (e) | Activated Sludge | U | U | U | U | U |
| (f) | Municipal Sewer | U | 5 | 10 | 32 | 53 |
| (g) | To Waterways | 98 | 73 | 58 | 30 | 0 |
| (h) | Utilization as Byproduct | 50 | 90 | 95 | 99 | 100 |
| (i) | Management Technique | 40 | 50 | 60 | 65 | 70 |

*U = Under 1%

## Waste Reduction or Removal Cost Information

The cheese industry has a modest capital investment in sewerage treatment facilities, and annual operating and maintenance expenditures.

The estimated capital investment in waste removal facilities in 1963 was $600,000 and the estimated annual operating expense was $120,000.

In 1966 the capital investment was estimated to have increased to $900,000 and the annual operating expense to have increased to $180,000.

## Comparative Investment & Operating Expenses

Plant sizes have been determined as small, medium and large and technology levels described as old, typical and advanced.

A comparison of investment costs and operating costs for providing waste and wastewater removal facilities between plants of different sizes and technologies for the various subprocesses and removal methods will provide valuable data for determining which subprocess or method offers the most attractive opportunities for use in the future to implement the Clean Water Restoration Act.

The next several pages include comparison tables. The tables are based on investment and operating costs as experienced by industry. Land has been estimated at $300 per acre for ridge and furrow, spray irrigation and aerated lagoon installations.

Capital investment for utilization as byproduct does not necessarily require condensing or drying equipment as sufficient capacity exists in condensery; however, the more successful whey plants seem to be individual facilities. Animal feed plants are not of the same sanitary construction as those producing products for human consumption.

The management technique requires no additional capital investment. Nominal expense is incurred for educational purposes.

Economic life in relation to processing equipment represents current thinking of industry needs for return on investment and recognizes obsolescence.

Economic life in relation to removal methods represents observed useful life.

TABLE IWP 9 - 54

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of small size. Daily "net" waste quantities from plant to sewer are 32 pounds BOD (±50%) and 1,200 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 800 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks vs. Cans | 5,000 | -1,000 | 13 |
| (c) Separator - CPI vs. Manual | 25,000 | +6,000 | NA |
| (d) Pasteurize - Continuous vs. Batch | 15,000 | +2,000 | 13 |
| (e) Set - Continuous vs. Batch | NA | NA | NA |
| (f) Packaging - Automatic vs. Manual | 15,000 | +4,700 | 4 |
| (g) Piping - CIP vs. Take-apart | 12,000 | +1,000 | 13 |
| (h) Material Handling - Automatic vs. Manual | 6,000 | ±0 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 500 | $ +100 | 20 |
| (b) Spray Irrigation | 1,300 | +300 | 20 |
| (c) Aerated Lagoon | 2,200 | +400 | 20 |
| (d) Trickling Filter | 6,100 | +1,200 | 15 |
| (e) Activated Sludge | 4,100 | +800 | 15 |
| (f) Municipal Sewer | 200 | +200 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 50,000 | +9,000 | 13 |
| (i) Management Technique | -0- | -1,000 | * |

NA = Not Applicable
AH = Already installed by definition

* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-53.

TABLE IWP 9 - 55

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of small size. Daily "net" waste quantities from plant to sewer are 15.5 pounds BOD (±50%) and 1,000 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 800 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| **Subprocess:** | | | |
| (a) Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) Receive - Typical vs. Advanced | -0- | -0- | 13 |
| (c) Separator - CIP vs. Manual | 25,000 | +6,000 | 13 |
| (d) Pasteurize - Continuous Typical vs. Advanced | 4,000 | +800 | 13 |
| (e) Set - Continuous vs. Batch | NA | NA | NA |
| (f) Packaging - Automatic Typical vs. Advanced | 5,000 | -3,000 | 4 |
| (g) Piping - CIP Typical vs. Advanced | 6,000 | +500 | 13 |
| (h) Material Handling - Typical vs. Advanced | 3,000 | ±0 | 13 |
| **Removal Method:** | | | |
| (a) Ridge and Furrow | $ 400 | $ +100 | 20 |
| (b) Spray Irrigation | 1,100 | +200 | 20 |
| (c) Aerated Lagoon | 1,100 | +200 | 20 |
| (d) Trickling Filter | 5,100 | +1,000 | 15 |
| (e) Activated Sludge | 3,400 | +700 | 15 |
| (f) Municipal Sewer | 200 | +100 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 50,000 | +9,000 | 13 |
| (i) Management Technique | -0- | -400 | * |

NA = Not Applicable        * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-53.

TABLE IWP 9 - 56

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of small size. Daily "net" waste quantities from plant to sewer are 8.9 pounds BOD (±50%) and 500 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 800 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | |
| (b) Receive - Tanks | AH | NA | |
| (c) Separator - CIP vs. Manual | AH | NA | |
| (d) Pasteurize - Continuous | AH | NA | |
| (e) Set - Continuous | AH | NA | |
| (f) Packaging - Automatic | AH | NA | |
| (g) Piping - CIP | AH | NA | |
| (h) Material Handling - Automatic | AH | NA | |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 200 | $ +40 | 20 |
| (b) Spray Irrigation | 500 | +100 | 20 |
| (c) Aerated Lagoon | 600 | +100 | 20 |
| (d) Trickling Filter | 2,500 | +500 | 15 |
| (e) Activated Sludge | 1,700 | +300 | 15 |
| (f) Municipal Sewer | 200 | +50 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 50,000 | +9,000 | 13 |
| (i) Management Technique | -0- | -200 | * |

NA = Not Applicable
AH = Already Installed by definition

* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-53.

TABLE IWP 9 - 57

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of medium size. Daily "net" waste quantities from plant to sewer are 134 pounds BOD (±50%) and 6,500 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 3,400 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks vs. Cans | 5,000 | -3,500 | 13 |
| (c) Separator - CIP vs. Manual | 25,000 | +1,000 | 13 |
| (d) Pasteurize - Continuous vs. Batch | 18,000 | -1,200 | 13 |
| (e) Set - Continuous vs. Batch | NA | NA | NA |
| (f) Packaging - Automatic vs. Manual | 50,000 | -9,000 | 4 |
| (g) Piping - CIP vs. Take-apart | 32,000 | -2,400 | 13 |
| (h) Material Handling - Automatic vs. Manual | 38,000 | -7,000 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 2,400 | $ +500 | 20 |
| (b) Spray Irrigation | 6,900 | +1,400 | 20 |
| (c) Aerated Lagoon | 9,300 | +1,900 | 20 |
| (d) Trickling Filter | 32,800 | +6,600 | 15 |
| (e) Activated Sludge | 21,900 | +4,400 | 15 |
| (f) Municipal Sewer | 200 | +700 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 90,000 | ±0 | 13 |
| (i) Management Technique | -0- | -3,500 | * |

NA = Not Applicable    * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-53.

## TABLE IWP 9 - 58

## Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of medium size. Daily "net" waste quantities from plant to sewer are 66 pounds BOD (±50%) and 4,100 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 3,400 lbs/day | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) | Receive - Tanks Typical vs. Advanced | -0- | -0- | 13 |
| (c) | Separator - CIP vs. Manual | 25,000 | +1,000 | 13 |
| (d) | Pasteurize - Continuous Typical vs. Advanced | 4,000 | -800 | 13 |
| (e) | Set - Continuous vs. Batch | NA | NA | NA |
| (f) | Packaging - Automatic Typical vs. Advanced | 25,000 | -8,100 | 4 |
| (g) | Piping - CIP Typical vs. Advanced | 16,000 | +2,900 | 13 |
| (h) | Material Handling - Typical vs. Advanced | 19,000 | -2,800 | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $ 1,500 | $ +300 | 20 |
| (b) | Spray Irrigation | 4,400 | +900 | 20 |
| (c) | Aerated Lagoon | 4,800 | +1,000 | 20 |
| (d) | Trickling Filter | 20,700 | +4,200 | 15 |
| (e) | Activated Sludge | 13,800 | +2,800 | 15 |
| (f) | Municipal Sewer | 200 | +300 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Utilization as Byproduct | 90,000 | ±0 | 13 |
| (i) | Management Technique | -0- | - 1,600 | * |

NA = Not Applicable * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-53.

TABLE IWP 9 - 59

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of medium size. Daily "net" waste quantities from plant to sewer are 37.6 pounds BOD (±50%) and 2,100 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 3,400 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks | AH | NA | 13 |
| (c) Separator - CIP | AH | NA | 13 |
| (d) Pasteurize - Continuous | AH | NA | 13 |
| (e) Set - Continuous vs. Batch | AH | NA | NA |
| (f) Packaging - Automatic | AH | NA | 4 |
| (g) Piping - CIP | AH | NA | 13 |
| (h) Material Handling - Automatic | AH | NA | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 800 | $ +200 | 20 |
| (b) Spray Irrigation | 2,200 | +500 | 20 |
| (c) Aerated Lagoon | 2,600 | +500 | 20 |
| (d) Trickling Filter | 10,100 | +2,000 | 15 |
| (e) Activated Sludge | 6,800 | +1,400 | 15 |
| (f) Municipal Sewer | 200 | +200 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 90,000 | ±0 | 13 |
| (i) Management Technique | -0- | -1,700 | * |

NA = Not Applicable
AH = Already installed by definition

* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-53.

TABLE IWP 9 - 60

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of large size. Daily "net" waste quantities from plant to sewer are 613 pounds BOD (±50%) and 29,500 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 15,500 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks vs. Cans | 32,000 | + 4,300 | 13 |
| (c) Separator - CIP vs. Manual | 25,000 | + 1,000 | 13 |
| (d) Pasteurize - Continuous vs. Batch | 35,000 | - 9,900 | 13 |
| (e) Set - Continuous vs. Batch | ** | ** | ** |
| (f) Packaging - Automatic vs. Manual | 80,000 | - 22,400 | 4 |
| (g) Piping - CIP vs. Take-apart | 75,000 | - 6,400 | 13 |
| (h) Material Handling - Automatic vs. Manual | 65,000 | - 8,000 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 11,000 | $ +2,000 | 20 |
| (b) Spray Irrigation | 31,500 | +5,700 | 20 |
| (c) Aerated Lagoon | 42,300 | +7,600 | 20 |
| (d) Trickling Filter | 69,500 | +12,500 | 15 |
| (e) Activated Sludge | 46,500 | +8,400 | 15 |
| (f) Municipal Sewer | 200 | +3,100 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 380,000 | -8,000 | 13 |
| (i) Management Technique | -0- | -18,200 | * |

NA = Not Applicable    * Permanent

**Insufficient Information Available

See Reference Notes on Page IWP 9-8 and IWP 9-53.

## TABLE IWP 9 - 61

## Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of large size. Daily "net" waste quantities from plant to sewer are 301 pounds BOD (±50%) and 18,600 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 15,500 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) Receive - Tanks Typical vs. Advanced | -0- | -0- | 13 |
| (c) Separator - CIP vs. Manual | 25,000 | +1,000 | 13 |
| (d) Pasteurize - Continuous Typical vs. Advanced | 5,000 | -1,000 | 13 |
| (e) Set - Continuous vs. Batch | ** | ** | ** |
| (f) Packaging - Automatic Typical vs. Advanced | 40,000 | -22,200 | 4 |
| (g) Piping - CIP Typical vs. Advanced | 32,000 | -2,100 | 13 |
| (h) Material Handling - Typical vs. Advanced | 35,000 | -4,000 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 7,000 | $ +1,300 | 20 |
| (b) Spray Irrigation | 19,800 | +3,600 | 20 |
| (c) Aerated Lagoon | 20,800 | +3,800 | 20 |
| (d) Trickling Filter | 94,000 | +16,900 | 15 |
| (e) Activated Sludge | 62,600 | +11,300 | 15 |
| (f) Municipal Sewer | 200 | +1,500 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 380,000 | -8,000 | 13 |
| (i) Management Technique | -0- | -7,300 | * |

NA = Not Applicable

* Permanent

** Insufficient Information Available

See Reference Notes on Page IWP 9-8 and IWP 9-53.



287-032 O - 68 - 5

TABLE IWP 9 - 62

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of large size. Daily "net" waste quantities from plant to sewer are 172 pounds BOD (±50%) and 9,300 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 15,500 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks | AH | NA | 13 |
| (c) Separator - CIP | AH | NA | 13 |
| (d) Pasteurize - Continuous | AH | NA | 13 |
| (e) Set - Continuous vs. Batch | ** | ** | ** |
| (f) Packaging - Automatic | AH | NA | 4 |
| (g) Piping - CIP | AH | NA | 13 |
| (h) Material Handling - Automatic | AH | NA | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 3,500 | $ +600 | 20 |
| (b) Spray Irrigation | 9,900 | +1,800 | 20 |
| (c) Aerated Lagoon | 11,900 | +2,100 | 20 |
| (d) Trickling Filter | 47,000 | +8,500 | 15 |
| (e) Activated Sludge | 31,400 | +5,600 | 15 |
| (f) Municipal Sewer | 200 | +900 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 380,000 | -8,000 | 13 |
| (i) Management Technique | -0- | -2,800 | * |

NA = Not Applicable
AH = Already Installed by definition

* Permanent
** Insufficient Information available

See Reference Notes on Page IWP 9-8 and IWP 9-53.

The tables indicate that several subprocesses and removal methods are particularly attractive in terms of small capital investment and low annual operating expense.

The utilization of cream and whey in byproduct manufacture eliminates these materials as wastes. Because of its value, cream is always utilized; however, whey has a low economic value. The plant with condensing and drying equipment will utilize whey as a by-product if there is an economic market available; otherwise the plant with or without this equipment tends to send whey to the sewage system. The trends towards larger plants and increasing need for these materials will result in a reduction of wastes.

The application of Management Technique requires no capital investment and very little operating expense. This method results in significant economy in plant operations, and is a highly desirable practice.

Disposal of remaining waste to municipal sewers requires only nominal investment and operating cost to the plant and is attractive to the plant operation. However, if a municipality establishes a sewage rate based directly on plant waste loads, then comparative economics determine whether or not a plant should adopt further waste removal methods.

Summary of Projected Wasteloads

| Year | Waste | Gross Waste Generated Million | Removal * % | Net Waste Discharged Million |
|---|---|---|---|---|
| 1963 | Cream (Lbs. BOD) | 64.2 | 99 | .64 |
| | Whey (Lbs. BOD) | 428.6 | 48 | 222.9 |
| | Product (Lbs. BOD) | 20.4 | 15 | 17.0 |
| | Soap & Chemical (Lbs. BOD) | 2.0 | 15 | 1.7 |
| | | ST 515.2 | | ST 242.24 |
| | Water (Gallons) | 3,522 | 5 | 3,346 |

*Percentage of waste reduced or removed by process changes, waste treatment and byproducts utilization

## Summary of Projected Wasteloads

| Year | Waste | | Gross Waste Generated | Removal * | | Net Waste Discharged |
|---|---|---|---|---|---|---|
| | | | Million | % | | Million |
| 1968 | Cream (Lbs. BOD) | | 75.6 | 99 | | .76 |
| | Whey (Lbs. BOD) | | 504.5 | 53 | | 235.2 |
| | Product (Lbs. BOD) | | 23.8 | 30 | | 16.6 |
| | Soap & Chemical (Lbs. BOD) | | 2.4 | 30 | | 1.7 |
| | | ST | 606.3 | | ST | 254.26 |
| | Water (Gallons) | | 4,022 | 5 | | 3,821 |
| 1969 | Cream (Lbs. BOD) | | 76.5 | 99 | | .77 |
| | Whey (Lbs. BOD) | | 510.8 | 58 | | 214.5 |
| | Product (Lbs. BOD) | | 23.8 | 40 | | 14.2 |
| | Soap & Chemical (Lbs. BOD) | | 2.4 | 40 | | 1.4 |
| | | ST | 613.5 | | ST | 230.87 |
| | Water (Gallons) | | 3,945 | 5 | | 3,748 |
| 1970 | Cream (Lbs. BOD) | | 77.3 | 99 | | .77 |
| | Whey (Lbs. BOD) | | 516.3 | 63 | | 191.0 |
| | Product (Lbs. BOD) | | 23.9 | 50 | | 11.9 |
| | Soap & Chemical (Lbs. BOD) | | 2.4 | 50 | | 1.2 |
| | | ST | 619.9 | | ST | 204.87 |
| | Water (Gallons) | | 3,861 | 5 | | 3,668 |
| 1971 | Cream (Lbs. BOD) | | 78.7 | 99 | | .78 |
| | Whey (Lbs. BOD) | | 525.5 | 68 | | 168.2 |
| | Product (Lbs. BOD) | | 24.0 | 60 | | 9.6 |
| | Soap & Chemical (Lbs. BOD) | | 2.4 | 60 | | 1.0 |
| | | ST | 630.6 | | ST | 179.58 |
| | Water (Gallons) | | 3,800 | 5 | | 3,610 |
| 1972 | Cream (Lbs. BOD) | | 79.9 | 99 | | .80 |
| | Whey (Lbs. BOD) | | 533.6 | 75 | | 133.4 |
| | Product (Lbs. BOD) | | 24.1 | 70 | | 7.2 |
| | Soap & Chemical (Lbs. BOD) | | 2.4 | 70 | | .7 |
| | | ST | 640.0 | | | 142.1 |
| | Water (Gallons) | | 3,727 | 5 | ST | 3,541 |
| 1977 | Cream (Lbs. BOD) | | 88.3 | 99.5 | | .44 |
| | Whey (Lbs. BOD) | | 589.3 | 99.5 | | 29.5 |
| | Product (Lbs. BOD) | | 25.3 | 99.5 | | .13 |
| | Soap & Chemical (Lbs. BOD) | | 2.5 | 99.5 | | .01 |
| | | ST | 705.4 | | ST | 30.08 |
| | Water (Gallons) | | 3,390 | 5 | | 3,221 |

*Percentage of Waste Reduced or Removed by Process Changes, Waste Treatment and Byproducts Utilization

2023 - Condensed and Evaporated Milk: Establishments primarily engaged in manufacturing condensed and evaporated milk and related products, including ice cream and ice milk mix, and dry milk products.

Condensed and evaporated milk production has been declining since 1955 with a marked drop in 1965 and 1966. The trend is expected to continue.

Total farm milk production has been declining, while fluid milk, cheese and ice cream production has increased. With the exception of that portion of condensery production used for ice cream mix manufacture, the condensery industry operates by utilizing the milk remaining after the requirements of the other segments of the industry have been met.

Geographically, condenseries are located in areas of adequate supply. In 1963 there were 20 states without condenseries and five with only one. There were 64 in Wisconsin, 61 in Minnesota, 34 in Iowa, and 20 in Michigan. New York had 38, Pennsylvania 21 and California 22. No other state had more than 10.

The manufacturing process for condensed and evaporated milk may be outlined as follows:

1. Receipt: Dairy products are normally received in tank trucks and ten-gallon cans. The larger volume plants tend to receive in tank trucks and the smaller plants in cans. Larger plants may receive a small portion in cans. Dairy products normally received include milk as well as skim milk, whey, and buttermilk, which are byproducts of other processing operations. Another significant amount of receipts is in the form of liquid sugar and liquid corn syrup for use as mix ingredients (although smaller operations may receive the sugar in bag form). The liquid ingredients are pumped to storage tanks.

2. Raw (unpasteurized) Product Storage: Dairy products are stored in refrigerated tanks prior to utilization. The sugars and corn syrups are stored in heated tanks prior to use.

3. Separation: From storage a portion of the dairy products is sent through a heating device and then to a centrifugal separator in which all of the cream is separated and sent to storage for later use in ice cream mix manufacture. The skim milk is sent to pasteurization equipment.

4. Pasteurization: The milk is usually pasteurized in a continuous flow pasteurizer, although smaller plants may continue to use vat-type pasteurizers. The pasteurized milk is sent to a surge tank to adjust the difference between flow rates of the pasteurizer and of the evaporator.

5. Evaporation (condensing): Water is evaporated from the milk by heating the milk with steam in a vacuum chamber. A vacuum is maintained so that the boiling point is lowered to a point at which the product is not injured through excessive heat. The evaporator is normally a continuous flow unit, although in smaller operations batch type evaporators may be used. The continuous evaporator may have a number of "effects" which permit a significant reduction in the amount of steam necessary to produce a given amount of evaporated milk. Since the first cost of adding "effects" is significant, the tendency to have more effects occurs in the larger plants where greater economies are realized. Normally 15% of the water is removed and the evaporated milk will have 25.5% solids compared to the original milk, 12.5% solids. The evaporated (condensed) milk may be sent to (12) spray dryers or may be sent to cooling.

6. Cooling: Product from the evaporator is usually cooled in a continuous cooler, although occasionally batch cooling is used.

7. Pasteurized Storage: The cooled evaporated milk is stored in refrigerated trucks.

8. Packaging in Cans: Automatic machinery is used to fill and seal the cans.

9. Sterilize: The canned milk proceeds to the sterilizer where it is heated to a high temperature for a short period of time and then cooled to storage temperature.

10. Storage: Packaged product is inventoried in storage until needed for delivery to customers.

11. Ship Out: The finished product is drawn from storage and placed on vehicles for distribution.

12. Spray Drying: That portion of the evaporated milk to be used for powder is sent to a spray dryer. The product is pumped with a high pressure pump into a heated air screen where the remaining moisture is evaporated and the dry powder is separated. The spray dryer is a continuous form of drying under relatively low heat contact with the product. Some evaporated milk continues to be dried on roll dryers.

13. Instantizing: Powdered milk used by the consumer is usually sent through an instantizing process prior to packaging.

14. Packaging Powder: The powdered milk from the dryer or from the instantizer is packaged in bags and barrels for bulk users and in retail type packages for consumer use. The finished product is sent to Storage (10).

In addition to the evaporated milk and powdered milk process described, there is the additional fundamental process of mix-making in this type of establishment. From Step 3 above, cream is available from refrigerated storage tanks. From Step 1, dairy products and sugars.

15. Storage of Dry Ingredients: In addition to the liquid dairy and syrup ingredients, dry ingredients such as stabilizers, emulsifiers, and chocolate are needed, as well as water. The dry ingredients are held in storage prior to use.

16. Liquify Dry Ingredients: Prior to use, the ingredients are placed into solution in a mixing device and then pumped to assembly.

17. Assembly: All of the ingredients listed above are assembled in mixing tanks in the correct proportions needed for the final "mix".

18. Mix Pasteurization: The assembled mixes are pasteurized in batch quantities, although in very large plants a continuous flow pasteurizer may be used.

19. Hot Well: Those mixes that contain excess water are pumped to the hot well (which is a surge tank) and from there pumped to the evaporator.

20. Batch Evaporating Pan: Excess water is removed (as described in 5) as required by the mix formulation and will be pumped to the homogenizer.

21. Homogenizer: Mix from the batch pan or from the continuous pasteurizer is pumped to the homogenizer, a high pressure pump which breaks up fat particles within the mix to insure that they stay in suspension in the finished product.

22. Cooling: From the homogenizer the warm mix is sent through a continuous cooler, although in small plants may use a batch-type cooler.

23. Pasteurized Storage: The cooled mix is stored in refrigerated tanks until ready for further use.

24. Packaging: Generally, the finished mix is packaged in 10-gallon cans and to a lesser extent in single service plastic bag and cardboard box type containers. Occasionally large volumes of mix are shipped out in tank truck quantities to the customer.

25. Cold Storage: The canned or packaged mix is held in refrigerated storage as inventory before shipping.

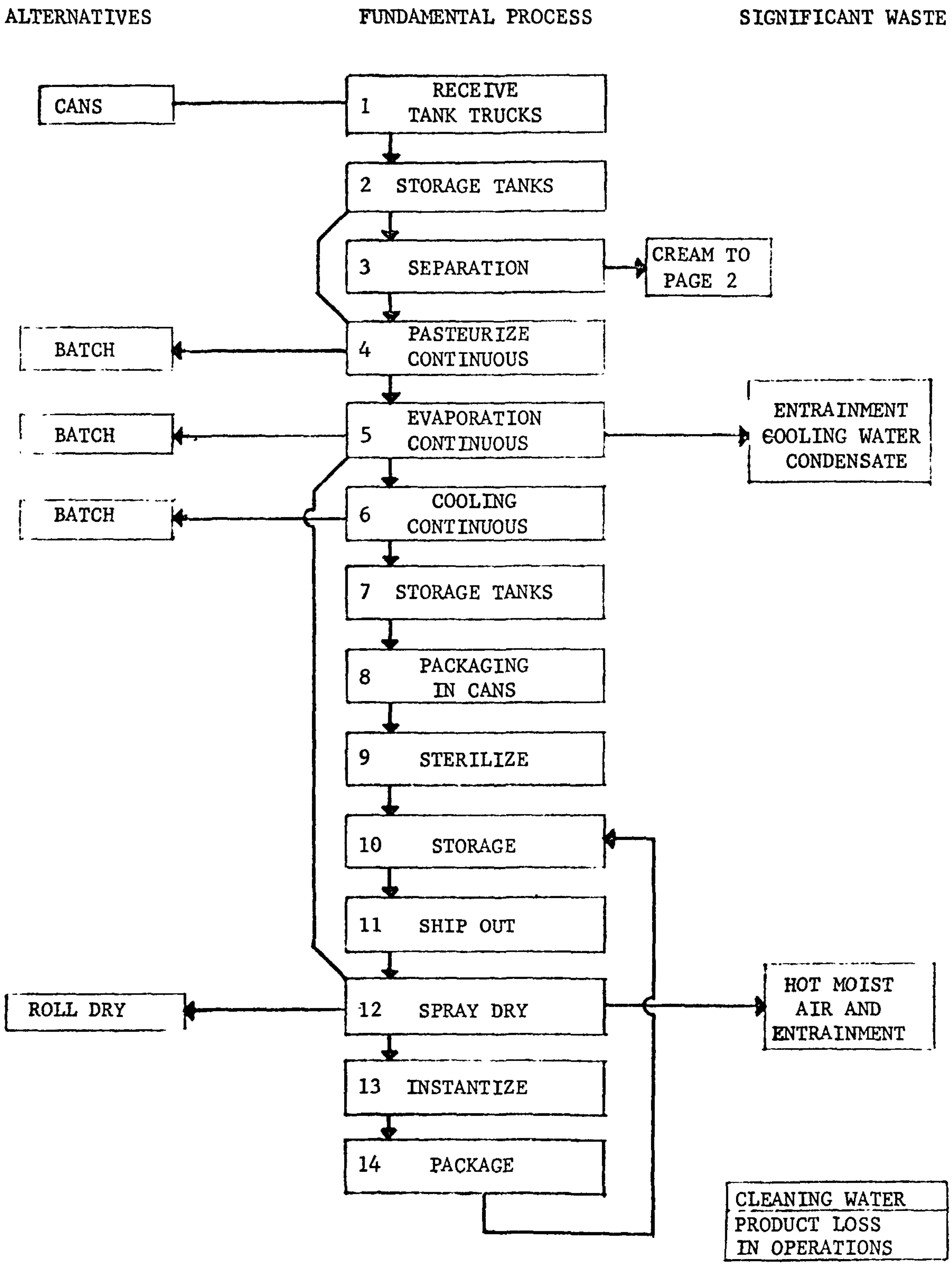
26. Shipping Out: The packaged mix is drawn from cold storage and placed on refrigerated trucks for delivery to the customer.

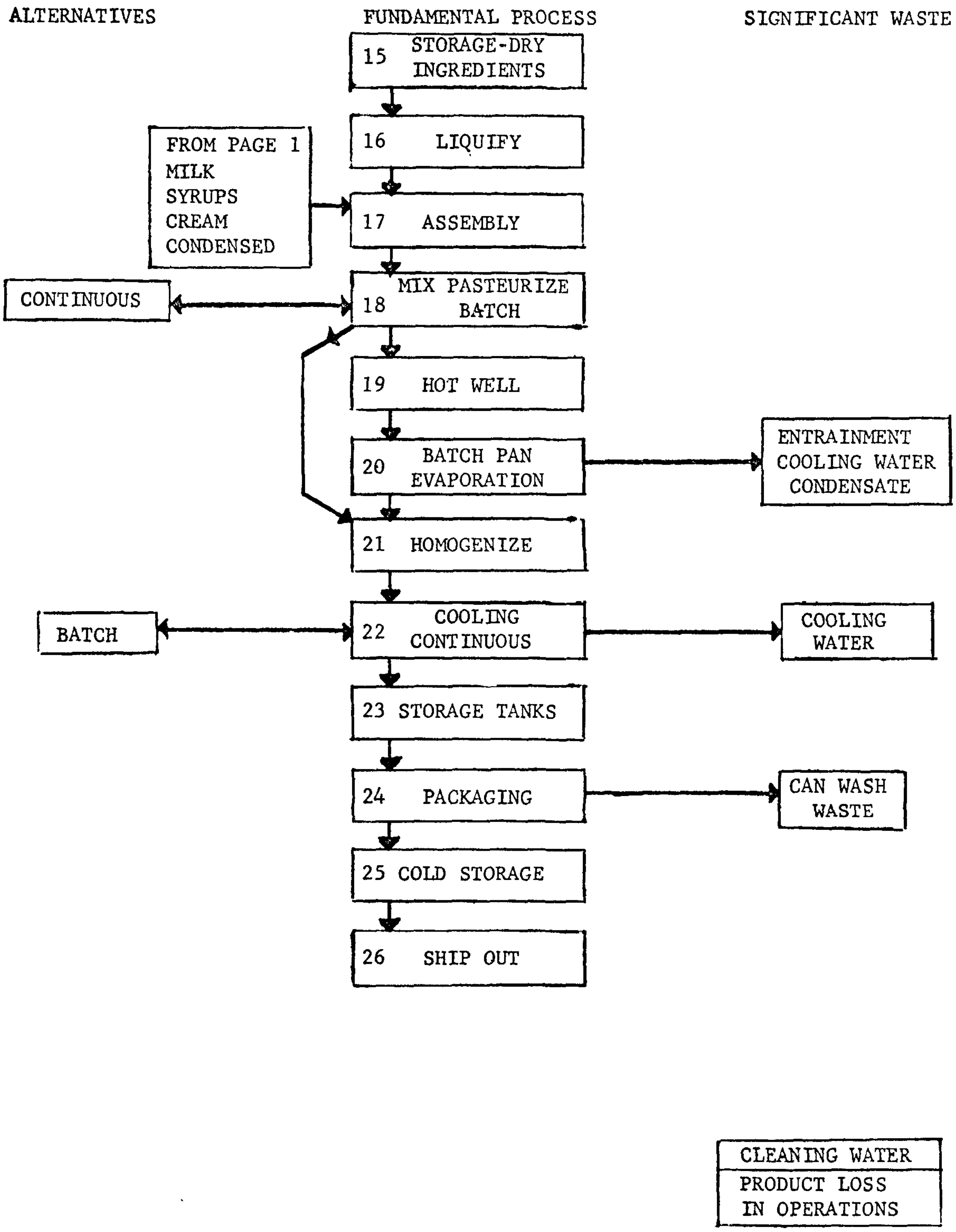
A flow diagram is included on Pages IWP 9-69 and IWP 9-70

Waste and Wastewater

The significant waste from the fundamental condensed and evaporated milk process is the miscellaneous spillage that occurs in normal processing and packaging operations, and loss that occurs from cleaning equipment at the end of the day's operation. Also, the soaps and chemical cleaning solutions used in daily sanitation procedures contribute to water waste, and are included in the computations. Shrinkage in the raw receipts and overfill of the finished product are not included in later waste quantity computation.

Significant clear water waste occurs in those plants using water for once-through cooling in their refrigeration systems and once-through condensing water in milk evaporators. The trend is toward the use of cooling towers which permit the reuse of cooling water. Wastewater figures shown represent average conditions in 1963.


ALTERNATIVES
FUNDAMENTAL PROCESS
SIGNIFICANT WASTE
CANS
1 RECEIVE TANK TRUCKS
2 STORAGE TANKS
3 SEPARATION
CREAM TO PAGE 2
BATCH
4 PASTEURIZE CONTINUOUS
BATCH
5 EVAPORATION CONTINUOUS
ENTRAINMENT COOLING WATER CONDENSATE
BATCH
6 COOLING CONTINUOUS
7 STORAGE TANKS
8 PACKAGING IN CANS
9 STERILIZE
10 STORAGE
11 SHIP OUT
ROLL DRY
12 SPRAY DRY
HOT MOIST AIR AND ENTRAINMENT
13 INSTANTIZE
14 PACKAGE
CLEANING WATER
PRODUCT LOSS IN OPERATIONS


ALTERNATIVES
FUNDAMENTAL PROCESS
SIGNIFICANT WASTE
15 STORAGE-DRY INGREDIENTS
16 LIQUIFY
FROM PAGE 1
MILK
SYRUPS
CREAM
CONDENSED
17 ASSEMBLY
CONTINUOUS
18 MIX PASTEURIZE BATCH
19 HOT WELL
20 BATCH PAN EVAPORATION
ENTRAINMENT
COOLING WATER
CONDENSATE
21 HOMOGENIZE
BATCH
22 COOLING CONTINUOUS
COOLING WATER
23 STORAGE TANKS
24 PACKAGING
CAN WASH WASTE
25 COLD STORAGE
26 SHIP OUT
CLEANING WATER
PRODUCT LOSS
IN OPERATIONS

## RECENT DEVELOPMENTS

The fundamental condensed and evaporated milk processes changed little from 1950 to 1966, and little change is forecast for 1967 to 1977. Nevertheless, several developments of interest have occurred.

The most significant change has been in the number reduction of plants. Due to economical pressures, many small plants have closed or have merged. This trend, which is expected to continue, is depicted on Page IWP 9-73.

Since 1950, bulk tank trucks have largely replaced the 10-gallon cans used in Step 1, "Receiving", of the fundamental process. The trend has occurred because the use of trucks has virtually eliminated physical labor, improved sanitation maintenance and reduced the likelihood of contamination.

Self-cleaning (CIP) separators used in Step 3 of the fundamental process are now available. Such machinery reduces the amount of manual washing required, as well as the reduction of physical labor.

Because of tremendous volume, large plants utilize continuous flow equipment, as opposed to batch type machinery. This development has tended to reduce the percentage of plant loss in operations and, consequently, has helped to minimize wastes. Greatly improved heating and refrigeration systems have reduced water needs considerably.

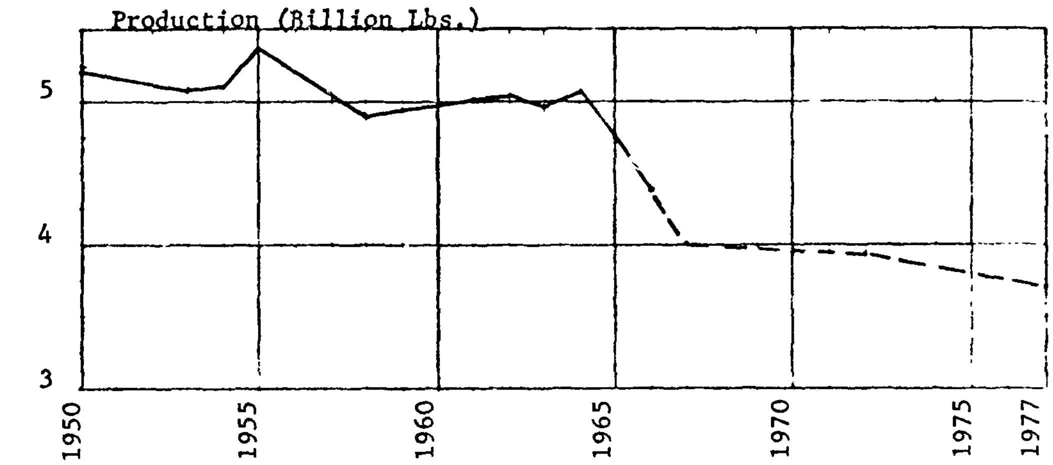
The industry is well along towards conversion from roll to spray drying, which produces a superior product.

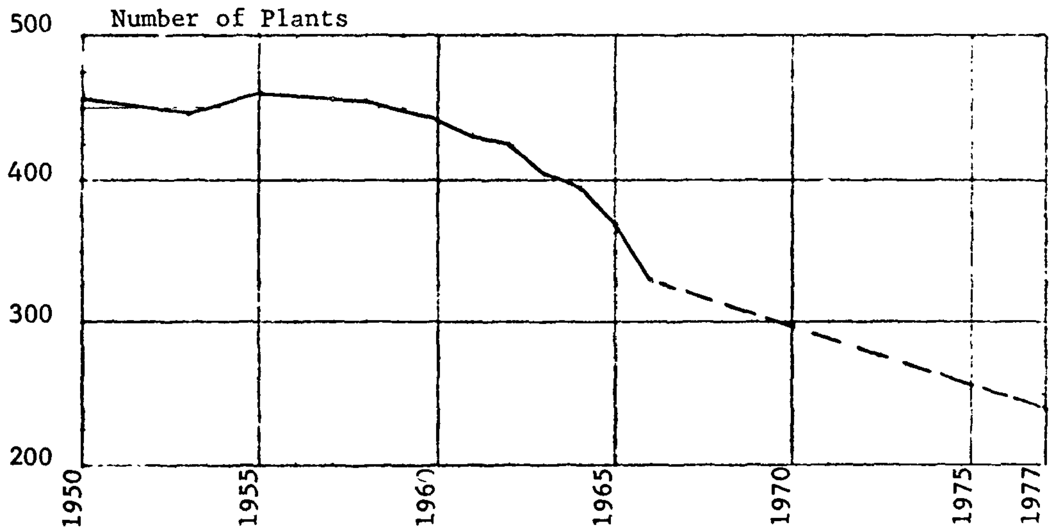
The trend in packaging is to smaller units which better serve the needs and desires of the consumer. Automatic packaging continues to replace manual methods. Not only is the amount of waste reduced, but new machinery fills more accurately.

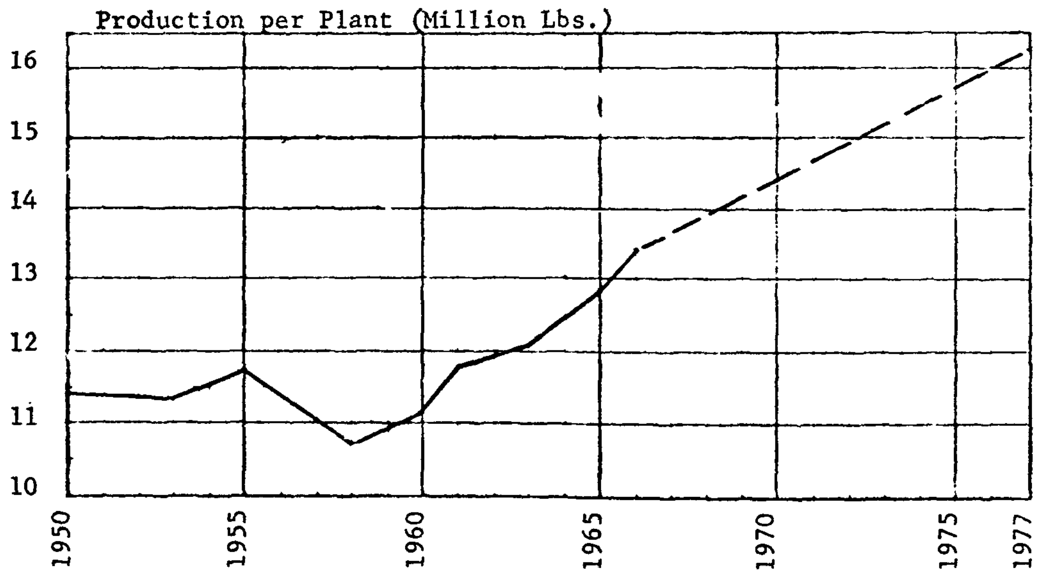
Permanent stainless steel piping systems were introduced in the early 1950's. Such systems are cleaned in place, as opposed to the daily take-apart systems formerly accepted. This type equipment reduces the quantity of soap required and, therefore, reduces waste. The fact that the systems are permanently installed has reduced plant product losses; also, sanitation and product shelf life has been increased--a factor which has tended to reduce waste.

Significant changes have occurred in material handling within plants by the introduction of sophisticated conveyors and stacking, grouping and palletization equipment. Even though machines have tended to increase individual plant wastes through the enlarged usage of water-soap lubricants, product loss and waste has been reduced because of the less likelihood of package damage.

Large quantities of dairy products have been, or will be, replaced by non-dairy products such as vegetable fat for butterfat and fish flour for milk powder.


Production (Billion Lbs.)
5
4
3
1950
1955
1960
1965
1970
1975
1977


500
Number of Plants
400
300
200
1950
1955
1960
1965
1970
1975
1977


Production per Plant (Million Lbs.)
16
15
14
13
12
11
10
1950
1955
1960
1965
1970
1975
1977

The trends may best be shown in tabular form, which follows. The reader should note that the alternative subprocesses and other industry changes have occurred over a span of years.

The process which will become prevalent is identified as P, and that which is becoming less used as S.

TABLE IWP 9 - 74

Estimated Percentage of Plants Employing Process

| | | | 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|---|---|---|
| (b) | P | Receive in Tank Trucks | -0- | 40 | 50 | 60 | 70 |
| | S | Receive in Cans | 100 | 60 | 50 | 40 | 30 |
| (c) | P | Pasteurize Continuously | 25 | 50 | 60 | 70 | 90 |
| | S | Pasteurize Batch | 75 | 50 | 40 | 30 | 10 |
| (d) | P | Spray Dry | 50 | 75 | 85 | 90 | 95 |
| | S | Roll Dry | 50 | 25 | 15 | 10 | 5 |
| (e) | P | Automatic Packaging | -0- | 20 | 25 | 35 | 45 |
| | S | Manual Packaging | 100 | 80 | 75 | 65 | 55 |
| (f) | P | CIP Piping | -0- | 40 | 50 | 60 | 70 |
| | S | Take-apart Piping | 100 | 60 | 50 | 40 | 30 |
| (g) | P | Automatic Material Handling | -0- | 50 | 60 | 70 | 80 |
| | S | Manual Material Handling | 100 | 50 | 40 | 30 | 20 |

The estimates represent the observations and opinions of people in the industry.

## Comparative Waste Control Problems

The subprocesses (Table IWP 9-74) do not require different treatment from the fundamental processes; however, the choice of subprocess is largely determined by the total volume produced. The continuous flow processes tend to have less waste per pound of finished product because of the greater productivity per piece of equipment.

Product spillage and waste during normal processing, and cleaning water and soaps represent the significant wastes for any type process used.

In order to best estimate total industry waste and wastewater, it is desirable to identify levels of technology within the industry. The following table illustrates three technological levels. The fundamental process steps from Page IWP 9-65 are used as reference for the table which follows.

TABLE IWP 9 - 75

Comparative Technology

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
|---|---|---|---|
| 1. | Receive product in 10-gallon cans | Receive bulk of dairy products in tank trucks and part of products in 10-gallon cans | Receive all products in tank trucks |
| 2. | Store product in 10-gallon cans | Products stored in tanks | Products stored in refrigerated tanks. |
| 3. | Heat and separate centrifugally | Heat and separate centrifugally | Heat and separate centrifugally |
| 4. | Pasteurize in batch quantities | Pasteurize in a continuous unit and pump to (5) | Pasteurization on a continuous basis |
| 5. | Evaporate (condense) in batch quantities | A continuous evaporator (condenser) which will have one or two effects | Evaporation (condensing) on a continuous basis through a double or triple effect pan |
| 6. | Cooling in batch quantities | Cooling in a continuous process | Cooling in a continuous process |
| 7. | Pasteurized storage in 10-gallon cans | Pasteurized storage in tanks | Refrigerated pasteurized storage |
| 8. | Packaging in cans | Packaging automatically in cans | Packaging performed automatically in high-speed can machinery |

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
| --- | --- | --- | --- |
| 9. | Sterilization of canned products in batch equipment | Cans sterilized in a continuous unit | Sterilization in a continuous sterilizer |
| 10. | Storage inventoried finished product in warehouse | Inventory finished product in storage room | Finished product stored in palletized quantities and (11) |
| 11. | Ship out | Ship out | Ship out in pallet loads |
| 12. | Drying performed on a "drum dryer" | Drying performed in a spray type unit | Spray drying utilized |
| 13. | Instantizing not used | Powder conveyed to an instantizer and then conveyed to (14) | Powder conveyed to an instantizer and in turn conveyed to (14) |
| 14. | Packaging powdered product manually | Automatic packaging machinery | Automatic packaging machinery. Packages automatically boxed and automatically palletized |
| 15. | Storage of mix ingredients in dry quantities in bag form | Storage of dry ingredients for mix, a minimum of bag ingredients and as many as possible in liquid or syrup form | Storage of mix ingredients all in liquid form in tanks |
| 16. | Liquify dry ingredients manually | Liquification of dry ingredients performed mechanically | Liquification of dry ingredients no longer necessary |
| 17. | Assemble directly into (18) | Assembly takes place in a tank on scales with ingredients measured manually | Assembly takes place in programmed automatic vat-On-weigh scales and |

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
|---|---|---|---|
| 18. | Batch pasteurizers | Mix pasteurization centrifugally in batch quantities which are pumped to (19) | A continuous mix pasteurizer which proceeds to (19) |
| 19. | Pump to hot well and then pumped to | A hot well and from there pumped to | A hot well and |
| 20. | The batch evaporating pan | The batch evaporating pan | A continuous pan |
| 21. | Homogenize and pressure pump | Homogenization by pressure pump | Homogenization by pressure pump |
| 22. | Cool in batch quantities | Cooling in a continuous cooler | Cooling in a continuous manner |
| 23. | Store pasteurized product in 10 gallon cans, which will be the same cans for (24) | Pasteurized storage in refrigerated tanks | Pasteurized product stored in refrigerated tanks |
| 24. | Packaging | Packaging of mix partially in 10 gallon cans and partially in single service bag-in-box containers | Packaging in single service containers such as bag-in-box |
| 25. | Store packaged cans in cold storage | Finished product inventoried in cold storage | Inventoried in cold storage in palletized quantities |
| 26. | Shipped out | Shipped out | Shipped out in palletized lots |
| 27. | Take-apart piping | Partial CIP piping | CIP piping |
| 28. | Manual material handling | Partial automatic material handling | Automatic material handling |



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## Size vs. Technology

In 1963 there were 427 condensed and evaporated milk plants producing 4,970,462,000 lbs. of condensed and evaporated milk. The industry considers a plant producing less than five million lbs. per year as "small", five to thirty million lbs. per year as "medium" and over thirty million lbs. as "large".

Waste and wastewater are a function of size as well as technology. TABLE IWP 9-78 represents industry (c) opinion of the relationship of size and technology.

TABLE IWP 9 - 78

Plant Statistics

1963

| | | |
|---|---|---|
| Small | 231 | 54.1% produce less than 5 million lbs. per year |
| Medium | 141 | 33.1% produce from 5 to 30 million lbs. per year |
| Large | 55 | 12.8% produce more than 30 million lbs. per year |

Total: 427 plants produced 4,970,462,000 lbs. in 1963

| Percentage Technology Levels | Percentage of Various Sizes | | |
|---|---|---|---|
| | Small Less than ½ | Medium ½ to 3 | Large More than 3 |
| 15% Older Technology | 90% | 10% | 0% |
| 80% Typical Technology | 34% | 54% | 12% |
| 5% Advanced Technology | 0% | 10% | 90% |

This relationship provides a basis for computation of overall plant wastes produced when related to unit waste production of various size plants of the three technology levels.

## Gross Waste Quantities Before Treatment or Other Disposal

In plants of advanced technology waste generated is less than in those less advanced. Waste and wastewater quantities per pound of finished product are as follows:

### TABLE IWP 9 - 79A

### Waste and Wastewater Quantities per Pound of Finished Product

| | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gallons |
|---|---|---|---|
| Older Technology | .0062 | .0006 | 4.2 |
| Typical Technology | .0046 | .0005 | 3.5 |
| Advanced Technology | .0037 | .0004 | 3.1 |

## Seasonal Waste Production Pattern

Waste quantities tend to be directly proportional to production quantities; however, wastewater is used in greater quantities in the warm months, reflecting increased refrigeration requirements. The following table illustrates this relationship.

### TABLE IWP 9 - 79B

### Percentage of Yearly Total of Product, Soap and Chemical and Wastewater

| | | | |
|---|---|---|---|
| January | 9.5 | July | 8.7 |
| February | 9.1 | August | 6.6 |
| March | 10.2 | September | 5.0 |
| April | 10.7 | October | 5.1 |
| May | 12.1 | November | 5.3 |
| June | 11.2 | December | 6.5 |

This pattern is expected to continue since peak production in condenseries occurs during peak farm milk production periods.

The relationship of size and technology shown in Table IWP 9-78 permits a comparison of the number of plants of each technology level. The unit wastes from Table IWP 9-79A, when applied to the number of plants, results in Table IWP 9-80.

TABLE IWP 9 - 80

A. Older Technology: These plants process 7,000 lb. of finished product per day.

Significant Wastes - Lb. per Day

| # Plants | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gallons per Day |
|---|---|---|---|
| 64 | 43.7 | 4.4 | 29,376 |

B. Typical Technology: These plants process 37,800 lb. of finished product per day.

Significant Wastes - Lb. per Day

| # Plants | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gallons per Day |
|---|---|---|---|
| 342 | 173.1 | 17.3 | 132,854 |

C. Advanced Technology: These plants process 122,800 lb. of finished product per day.

Significant Wastes - Lb. per Day

| # Plants | Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gallons per Day |
|---|---|---|---|
| 21 | 459.7 | 46 | 383,693 |

## TABLE IWP 9 - 81-A

### Gross Waste Quantities Before Treatment or Disposal

The individual plant data (Table IWP 9-80) when multiplied by the number of plants results in gross waste quantities before treatment or disposal.

| | Significant Wastes Per Year | | |
|---|---|---|---|
| | Product Pounds BOD (Millions) | Soap & Chemical Pounds BOD (Millions) | Wastewater Gallons (Millions) |
| Older Technology | .874 | .09 | 586 |
| Typical Technology | 18.470 | 1.85 | 14,176 |
| Advanced Technology | 3.016 | .31 | 2,514 |
| Total | 22.36 | 2.25 | 17,276 |
| Individual Plant Range: | ±50% | ±50% | ±20% |

## TABLE IWP 9 - 81-B

### Projected Waste and Wastewater

The relationship between change in total production, plant size and technology change is shown in the following table:

1963 and Projected Gross Wastes and Wastewater in Millions

| | 1963 | 1968 | 1969 | 1970 | 1971 | 1972 | 1977 |
|---|---|---|---|---|---|---|---|
| Lb. Product Manufactured | 4,970 | 3,971 | 3,985 | 3,995 | 3,959 | 3,928 | 3,710 |
| Lb. BOD Product | 22.36 | 17.78 | 17.75 | 17.70 | 17.45 | 17.23 | 15.85 |
| Lb. BOD Soap and Chemicals | 2.2 | 1.8 | 1.8 | 1.8 | 1.7 | 1.7 | 1.6 |
| Subtotal | 24.56 | 19.58 | 19.55 | 19.50 | 19.15 | 18.93 | 17.45 |
| Gal. Wastewater | 17,276 | 13,113 | 12,467 | 11,804 | 11,009 | 10,241 | 6,448 |

Projections of product manufactured are based upon industry and government estimates.

## Waste Reduction Practices

The waste reduction practices utilized in the industry do not vary greatly. The various processes are all similar in nature and a common sewer piping system is used for the entire plant. The wastes other than miscellaneous chemicals are of a "biodegradable" nature.

Certain processing practices produce varying amounts of wastes. Table IWP 9-82 illustrates such relationships.

### TABLE IWP 9 - 82

### Processing Practices

The fundamental process used with the "older" technology as the reference base, described on Page IWP 9-75.

| Alternate Process | % Waste Reduction Efficiency | | |
|---|---|---|---|
| | Product | Soap & Chemical | Wastewater |
| (a) Plant - Large vs. Small | 73 | 26 | 26 |
| (b) Receive - Tanks vs. Cans | 50 | 85 | 85 |
| (c) Pasteurize - Continuous vs. Batch | 20 | 60 | 60 |
| (d) Dry - Spray vs. Roll | 10 | 70 | 80 |
| (e) Package - Automatic vs. Manual | 10 | 15 | 15 |
| (f) Piping - CIP vs. Take-apart | 50 | 40 | 40 |
| (g) Material Handling - Automatic vs. Manual | 5 | * | * |

*Increases wastewater proportionately to lubricant used.

A large plant may be created by the consolidation of several smaller facilities. The subprocesses (b-h) may be applied to any plant on an individual basis and are not dependent of each other; however, the common practice is to utilize continuous flow and automatic equipment together.

Continuous flow and automatic equipment tends to have capacity ratings that justify the use thereof only in the average to larger size plants.

## Treatment Practices

The most prevalent practice is Management Technique, i.e., closest possible supervision of day-to-day operation to eliminate processing loss--loss due to waste resulting from the initial shrinkage of the raw material as well as the overfill of the finished package.

In general, most waste that goes to plant sewers is subsequently flowed to municipal sewers; to a lesser extent, waste may be discharged directly into lakes or streams.

The disposal through use of sewage plants represents the least used treatment practice.

The following table illustrates the effectiveness of the individual treatment practice.

### TABLE IWP 9 - 83

### Treatment Practices

| Removal Method | Normal Removal Efficiency % of Total Wasteload Removed | | |
|---|---|---|---|
| | Product | Soap & Chemicals | Wastewater |
| (a) Ridge and Furrow | 95-100 | 95-100 | 4* |
| (b) Spray Irrigation | 95-100 | 95-100 | 5* |
| (c) Aerated Lagoon | 90-95 | 90-95 | 1* |
| (d) Trickling Filter | 90-95 | 90-95 | 0 |
| (e) Activated Sludge | 90-95 | 90-95 | 0 |
| (f) Municipal Sewer | 100 | 100 | 100 |
| (g) To Waterways | 100 | 100 | 100 |
| (h) Management Technique | 50-75 | 50-75 | 10-75 |

*Estimated percent of total evaporated to the atmosphere, the remainder going to waterways.

The processing technology permits any of the listed removal methods to be used at any time. Types (a) ridge and furrow; (b) spray irrigation; and (c) aerated lagoon require significant amounts of land, and the types of soil and climate determine the physical size and year-round success of each, to a large degree. In addition, they must be located at least one-half mile from residential areas because of possible seasonal odor problems.

Types (d) trickling filter and (e) activated sludge are relatively compact but require greater capital investment and have higher operating costs than the other methods.

The trend is to connect plants to municipal systems wherever possible to simplify day-to-day operations and to minimize capital investment.

Type (h) management technique is improving rapidly and involves close supervision of day-to-day operations, the utilization of preventative maintenance techniques, use of inventory control procedures and exploration of the "Zero Defects" type of thinking.

It is estimated that the following percentage of Industries' Waste will be discharged to Municipal Sewer:

| 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|
| 1 | 5 | 10 | 32 | 53 |

The discharge of condensed and evaporated milk plant wastes to municipal systems is feasible. The high BOD requirements necessitate that the capacity of a particular municipal plant be reviewed prior to the connection of a new condensed and evaporated milk plant waste load to the system.

Pretreatment is not required because of the characteristics of the waste; however, pretreatment may be required by the municipality if the municipal plant is of inadequate size.

The various practices have been utilized in varying degrees. Plant location, capital costs, operating costs and problems--all influence the type adoption.

## TABLE IWP 9 - 85

### Rate of Adoption of Waste Treatment Practices Since 1950

The rate of treatment practice adoption is shown in percentages.

| | | % of Plants Employing Listed Methods | | | | |
|---|---|---|---|---|---|---|
| | Removal Method | 1950 | 1963 | 1967 | 1972 | 1977 |
| (a) | Ridge and Furrow | U* | 8 | 10 | 15 | 15 |
| (b) | Spray Irrigation | U | 5 | 5 | 5 | 5 |
| (c) | Aerated Lagoon | U | 5 | 10 | 15 | 25 |
| (d) | Trickling Filter | U | U | U | U | U |
| (e) | Activated Sludge | U | U | U | U | U |
| (f) | Municipal Sewer | U | 5 | 10 | 32 | 53 |
| (g) | To Waterways | 98 | 73 | 58 | 30 | 0 |
| (h) | Management Technique | 40 | 50 | 60 | 65 | 70 |

*U = Under 1%

## Waste Reduction or Removal Cost Information

The Condensed and Evaporated Milk Industry has a capital investment in sewerage treatment facilities, and also has annual operating and maintenance expenditures in conjunction therewith.

The estimated capital investment in waste removal facilities in 1963 is $1,200,000 and the estimated annual operating expense is $240,000.

By 1966 the capital investment is estimated to have increased to $2,400,000 and the annual operating expense to $480,000.

## Comparative Investment & Operating Expenses

Plant sizes have been determined as Small, Medium and Large and technology levels described as Old, Typical and Advanced.

A comparison of investment cost and operating cost for providing waste and wastewater removal facilities between plants of different sizes and technologies for the various subprocesses and removal methods will provide valuable data for determining which subprocess or method offers the most attractive opportunities for use in the future to implement the Clean Water Restoration Act.

The next several pages include these comparison tables. The tables are based on investment costs and operating costs as experienced by industry. Land has been estimated at $300 per acre for Ridge and Furrow, Spray Irrigation and Aerated Lagoon installation.

Management Technique requires no additional capital investment. Nominal expense is included for educational purposes.

Economic life in relation to processing equipment represents current thinking on industry needs for return on investment and recognizes obsolescence.

Economic life in relation to removal methods represents observed useful life.

TABLE IWP 9 - 87

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of small size. Daily "net" waste quantities from plant to sewer are 25.9 pounds BOD (±50%) and 16,000 gallons of wastewater (±20%) and 65 pounds powder to air. These quantities are "gross" to waterways.

| Product = 3,800 lbs/day | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) | Receive - Tanks vs. Cans | 5,000 | -1,000 | 13 |
| (c) | Separator - CIP vs. Manual | 25,000 | +4,000 | 13 |
| (d) | Pasteurize - Continuous vs. Batch | 15,000 | +2,000 | 13 |
| (e) | Spray dry - Roll dry | 130,000 | +18,000 | 13 |
| (f) | Packaging - Automatic vs. Manual | 15,000 | +2,600 | 4 |
| (g) | Piping - CIP vs. Take-apart | 12,000 | +1,800 | 13 |
| (h) | Material Handling - Automatic vs. Manual | 10,000 | +2,400 | 4 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $ 6,000 | $ +1,200 | 20 |
| (b) | Spray Irrigation | 17,000 | +3,400 | 20 |
| (c) | Aerated Lagoon | 17,900 | +3,600 | 20 |
| (d) | Trickling Filter | 81,000 | +16,200 | 15 |
| (e) | Activated Sludge | 54,000 | 10,800 | 15 |
| (f) | Municipal Sewer | 200 | 100 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Management Technique | -0- | -2,100 | * |

NA = Not Applicable     * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-86.

TABLE IWP 9 - 88

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of small size. Daily "net" waste quantities from plant to sewer are 19.4 pounds BOD (±50%) and 13,300 gallons of wastewater (±20%) and 50 pounds powder to air. These quantities are "gross" to waterways.

| Product = 3,800 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| **Subprocess:** | | | |
| (a) Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) Receive - Typical vs. Advanced | -0- | -0- | 13 |
| (c) Separator - CIP vs. Manual | 25,000 | +4,000 | 13 |
| (d) Pasteurize - Typical vs. Advanced | 5,000 | -800 | 13 |
| (e) Spray dry - Typical vs. Advanced | 44,000 | +1,000 | 13 |
| (f) Packaging - Typical vs. Advanced | 7,500 | +1,300 | 4 |
| (g) Piping - CIP Typical vs. Advanced | 6,000 | +900 | 13 |
| (h) Material Handling - Typical vs. Advanced | 6,000 | -1,200 | 4 |
| **Removal Method:** | | | |
| (a) Ridge and Furrow | $ 5,000 | $ +1,000 | 20 |
| (b) Spray Irrigation | 14,200 | +2,800 | 20 |
| (c) Aerated Lagoon | 1,300 | +300 | 20 |
| (d) Trickling Filter | 67,500 | +13,500 | 15 |
| (e) Activated Sludge | 45,000 | +9,000 | 15 |
| (f) Municipal Sewer | 200 | +100 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Management Technique | -0- | -1,500 | * |

NA = Not Applicable        * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-86

## TABLE IWP 9 - 89

## Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of small size. Daily "net" waste quantities from plant to sewer are 15.6 pounds BOD (±50%) and 11,800 gallons of wastewater (±20%), and 42 pounds power to air. These quantities are "gross" to waterways.

| | Product = 3,800 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) | Receive - Tanks | AH | NA | 13 |
| (c) | Separator - CIP vs. Manual | AH | NA | 13 |
| (d) | Pasteurize - Continuous vs. Batch | AH | NA | 13 |
| (e) | Spray dry - Roll dry | AH | NA | 13 |
| (f) | Packaging - Automatic vs. Manual | AH | NA | 4 |
| (g) | Piping - CIP vs. Take-apart | AH | NA | 13 |
| (h) | Material Handling - Automatic vs. Manual | AH | NA | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $ 4,400 | $ +900 | 20 |
| (b) | Spray Irrigation | 12,600 | +2,500 | 20 |
| (c) | Aerated Lagoon | 1,100 | +200 | 20 |
| (d) | Trickling Filter | 60,000 | +12,000 | 15 |
| (e) | Activated Sludge | 40,000 | +8,000 | 15 |
| (f) | Municipal Sewer | 200 | +100 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Management Technique | -0- | +1,300 | * |

NA = Not Applicable
AH = Already installed by definition

* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-86.

TABLE IWP 9 - 90

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of medium size. Daily "net" waste quantities from plant to sewer are 315 pounds BOD (±50%) and 194,000 gallons of wastewater (±20%), and 736 pounds powder to air. These quantities are "gross" to waterways.

| Product = 46,200 lbs/day | Capital | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks vs. Cans | 32,000 | -14,400 | 13 |
| (c) Separator - CIP vs. Manual | 50,000 | +2,000 | 13 |
| (d) Pasteurize - Continuous vs. Batch | 35,000 | -7,200 | 13 |
| (e) Spread dry - Roll dry | 264,000 | -23,400 | 13 |
| (f) Packaging - Automatic vs. Manual | 50,000 | 22,000 | 4 |
| (g) Piping - CIP vs. Take-apart | 35,000 | -13,000 | 13 |
| (h) Material Handling - Automatic vs. Manual | 40,000 | -3,200 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 73,000 | $ +14,600 | 20 |
| (b) Spray Irrigation | 207,000 | +41,500 | 20 |
| (c) Aerated Lagoon | 21,800 | +4,400 | 20 |
| (d) Trickling Filter | 262,000 | +52,500 | 15 |
| (e) Activated Sludge | 174,500 | +35,000 | 15 |
| (f) Municipal Sewer | 200 | +1,600 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Management Technique | -0- | -25,900 | * |

NA = Not Applicable * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-86.

TABLE IWP 9 - 91

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of medium size. Daily "net" waste quantities from plant to sewer are 236 pounds BOD ($\pm$50%) and 162,000 gallons of wastewater ($\pm$20%), and 601 pounds powder to air. These quantities are "gross" to waterways.

| Product = 46,200 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) Receive - Typical vs. Advanced | -0- | -0- | 13 |
| (c) Separator - CIP vs. Manual | 50,000 | +2,000 | 13 |
| (d) Pasteurize - Typical vs. Advanced | 5,000 | -800 | 13 |
| (e) Spray dry - Typical vs. Advanced | 90,000 | -9,000 | 13 |
| (f) Packaging - Automatic Typical vs. Advanced | 25,000 | -11,000 | 4 |
| (g) Piping - CIP Typical vs. Advanced | 17,000 | -6,500 | 13 |
| (h) Material Handling - Typical vs. Advanced | 20,000 | -1,600 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 61,500 | $ +12,300 | 20 |
| (b) Spray Irrigation | 173,000 | +34,600 | 20 |
| (c) Aerated Lagoon | 16,300 | +3,300 | 20 |
| (d) Trickling Filter | 219,000 | +44,000 | 15 |
| (e) Activated Sludge | 146,000 | +29,200 | 15 |
| (f) Municipal Sewer | 200 | +1,200 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Management Technique | -0- | -19,000 | * |

NA = Not Applicable    * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-86.

## TABLE IWP 9 - 92

## Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of medium size. Daily "net" waste quantities from plant to sewer are 190 pounds BOD (±50%) and 144,000 gallons of wastewater (±20%), and 509 pounds powder to air. These quantities are "gross" to waterways.

| Product = 46,200 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks | AH | NA | 13 |
| (c) Separator - CIP vs. Manual | AH | NA | 13 |
| (d) Pasteurize - Continuous | AH | NA | 13 |
| (e) Spray dry | AH | NA | 13 |
| (f) Packaging - Automatic | AH | NA | 4 |
| (g) Piping - CIP | AH | NA | 13 |
| (h) Material Handling | AH | NA | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 54,700 | $+10,900 | 20 |
| (b) Spray Irrigation | 154,000 | +30,800 | 20 |
| (c) Aerated Lagoon | 13,100 | +2,600 | 20 |
| (d) Trickling Filter | 195,000 | +39,000 | 15 |
| (e) Activated Sludge | 130,000 | +26,000 | 15 |
| (f) Municipal Sewer | 200 | +1,000 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Management Technique | -0- | -15,500 | * |

NA = Not Applicable
AH = Already installed by definition

* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-86.

## TABLE IWP 9 - 93

## Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of large size. Daily "net" waste quantities from plant to sewer are 1,556 pounds BOD (±50%) and 654,000 gallons of wastewater (±20%), and 1,556 pounds powder to air. These quantities are "gross" to waterways.

| Product = 155,600 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| **Subprocess:** | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks vs. Cans | 64,000 | -28,000 | 13 |
| (c) Separator - CIP vs. Manual | 75,000 | -2,800 | 13 |
| (d) Pasteurize - Continuous vs. Batch | 70,000 | -15,000 | 13 |
| (e) Spray dry - Roll dry | 520,000 | -223,000 | 13 |
| (f) Packaging - Automatic vs. Manual | NA | NA | 4 |
| (g) Piping - CIP vs. Take-apart | 150,000 | -142,000 | 13 |
| (h) Material Handling - Automatic vs. Manual | 60,000 | -15,200 | 13 |
| **Removal Method:** | | | |
| (a) Ridge and Furrow | $248,000 | $ +44,600 | 20 |
| (b) Spray Irrigation | 700,000 | +126,000 | 20 |
| (c) Aerated Lagoon | 107,000 | +19,300 | 20 |
| (d) Trickling Filter | 440,000 | +79,000 | 15 |
| (e) Activated Sludge | 294,000 | +53,000 | 15 |
| (f) Municipal Sewer | 200 | +8,000 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Management Technique | -0- | -87,400 | * |

NA = Not Applicable * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-86.



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## TABLE IWP 9 - 94

### Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of large size. Daily "net" waste quantities from plant to sewer are 794 pounds BOD ($\pm$50%) and 545,000 gallons of wastewater ($\pm$20%), and 2,023 pounds powder to air. These quantities are "gross" to waterways.

| Product = 155,600 lbs/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) Receive - Typical vs. Advanced | -0- | -0- | 13 |
| (c) Separator - CIP vs. Manual | 75,000 | -2,800 | 13 |
| (d) Pasteurize - Continuous Typical vs. Advanced | 10,000 | -1,000 | 13 |
| (e) Spray dry - Typical vs. Advanced | 100,000 | -105,000 | 13 |
| (f) Packaging - Automatic Typical vs. Advanced | 50,000 | -10,000 | 4 |
| (g) Piping - CIP Typical vs. Advanced | 30,000 | -12,000 | 13 |
| (h) Material Handling - Typical vs. Advanced | 25,000 | -12,000 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $207,000 | $ +37,200 | 20 |
| (b) Spray Irrigation | 584,000 | +105,000 | 20 |
| (c) Aerated Lagoon | 55,000 | +9,900 | 20 |
| (d) Trickling Filter | 368,000 | +66,000 | 15 |
| (e) Activated Sludge | 245,000 | +44,000 | 15 |
| (f) Municipal Sewer | 200 | 4,000 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Management Technique | -0- | -64,000 | * |

NA = Not Applicable    * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-86.

## TABLE IWP 9 - 95

## Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of large size. Daily "net" waste quantities from plant to sewer are 638 pounds BOD (±50%) and 483,000 gallons of wastewater (±20%), and 1,712 pounds powder to air. These quantities are "gross" to waterways.

| Product = 155,600 lbs/day | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) | Receive - Tanks | AH | NA | 13 |
| (c) | Separator - CIP | AH | NA | 13 |
| (d) | Pasteurize - Continuous | AH | NA | 13 |
| (e) | Churn - Continuous | AH | NA | 13 |
| (f) | Packaging - Automatic | AH | NA | 4 |
| (g) | Piping - CIP | AH | NA | 13 |
| (h) | Material Handling | AH | NA | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $183,500 | $ +33,000 | 20 |
| (b) | Spray Irrigation | 516,000 | +93,000 | 20 |
| (c) | Aerated Lagoon | 44,000 | +7,900 | 20 |
| (d) | Trickling Filter | 326,000 | +58,600 | 15 |
| (e) | Activated Sludge | 217,000 | +39,000 | 15 |
| (f) | Municipal Sewer | 200 | 3,200 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Management Technique | -0- | -52,400 | * |

NA = Not Applicable
AH = Already installed by definition

* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-86.

The tables indicate that several subprocesses and removal methods are particularly attractive in terms of small capital investment and low annual operating expense.

The application of management technique requires no capital investment and very little operating expense. This method results in significant economy in plant operations, and is a highly desirable practice.

Disposal of remaining waste to municipal sewers requires only nominal investment and operating cost to the plant and is attractive to the plant operation. However, if a municipality establishes a sewage rate based directly on plant waste loads, then comparative economics determine whether or not a plant should adopt further waste removal methods.

Summary of Projected Wasteloads

| Year | Waste | | Gross Waste Generated Million | Removal * % | | Net Waste Discharged Million |
|---|---|---|---|---|---|---|
| 1963 | Product (Lb. BOD) | | 22.36 | 15 | | 19.01 |
| | Soap & Chemical (Lb. BOD) | | 2.2 | 15 | | 1.9 |
| | | ST | 24.56 | | ST | 20.91 |
| | Water (Gallons) | | 17,276 | | | 16,412 |

*Percentage of waste reduced or removed by process changes, waste treatment and byproducts utilization

Summary of Projected Wasteloads

| Year | Waste | | Gross Waste Generated Million | Removal * % | | Net Waste Discharged Million |
|---|---|---|---|---|---|---|
| 1968 | Product (Lbs. BOD) | | 17.78 | 30 | | 12.45 |
| | Soap & Chemical (Lbs. BOD) | | 1.8 | 30 | | 1.2 |
| | | ST | 19.58 | | ST | 13.65 |
| | Water (Gallons) | | 13,113 | 5 | | 12,457 |
| 1969 | Product (Lbs. BOD) | | 17.75 | 40 | | 10.65 |
| | Soap & Chemical (Lbs. BOD) | | 1.8 | 40 | | 1.1 |
| | | ST | 19.55 | | ST | 11.75 |
| | Water (Gallons) | | 12,467 | 5 | | 11,844 |
| 1970 | Product (Lbs. BOD) | | 17.70 | 50 | | 8.85 |
| | Soap & Chemical (Lbs. BOD) | | 1.8 | 50 | | .9 |
| | | ST | 19.50 | | ST | 9.75 |
| | Water (Gallons) | | 11,804 | 5 | | 11,214 |
| 1971 | Product (Lbs. BOD) | | 17.45 | 60 | | 6.98 |
| | Soap & Chemical (Lbs. BOD) | | 1.7 | 60 | | .7 |
| | | ST | 19.15 | | ST | 7.68 |
| | Water (Gallons) | | 11,009 | 5 | | 10,458 |
| 1972 | Product (Lbs. BOD) | | 17.23 | 70 | | 5.17 |
| | Soap & Chemical (Lbs. BOD) | | 1.7 | 70 | | .5 |
| | | ST | 18.93 | | | 5.67 |
| | Water (Gallons) | | 10,241 | 5 | | 9,729 |
| 1977 | Product (Lbs. BOD) | | 15.85 | 99.5 | | .079 |
| | Soap & Chemical (Lbs. BOD) | | 1.6 | 99.5 | | .008 |
| | | ST | 17.45 | | ST | .087 |
| | Water (Gallons) | | 6,448 | | | 6,126 |

*Percentage of Waste Reduced or Removed by Process Changes, Waste Treatment and By-Products Utilization

2024 - Ice Cream and Frozen Desserts: Establishments primarily engaged in manufacturing ice cream and other frozen desserts.

The ice cream industry has grown steadily over the years and this pattern is expected to continue.

Geographically, the plant locations reflect population patterns. There is a trend towards exceptionally large regional plants with distributions over wide areas.

1. Receipt: The largest volumes of products received are liquid cream, liquid condensed milk, whole milk, corn syrup and cane sugar syrup. These are normally received in tank truck quantities in liquid form, although in smaller operations cream and condensed milk may be received in cans, and corn and cane sugars in dry form.

2. Raw (unpasteurized) Product Storage: The dairy products are normally stored in refrigerated tanks and the sugar syrups in heated tanks.

3. Storage--Dry and Frozen: Ingredients such as stabilizers, emulsifiers, and chocolate powders, as well as miscellaneous quantities of sugars are stored in dry form usually in drums and bags. Cream and butter are often purchased during the surplus season of the year in the frozen form and stored frozen. Similarly, various fruits are stored frozen in sub-zero rooms.

4. Liquify: The dry and frozen ingredients are normally converted to liquid solution prior to further use. This is done in a high speed blending device in which the dry and frozen ingredients are mixed thoroughly with water or milk.

5. Assembly: The liquified ingredients, as well as the liquid dairy products and sugar syrups are assembled in batch quantities according to formulae.

6. Mix Pasteurization: Upon assembly, a given batch of mix is pasteurized. The normal method is in batch quantities, although in larger plants a continuous pasteurizer may be used.

7. Homogenization: After pasteurization is completed, the mix is homogenized in a high pressure pump which breaks up fat particles so that they will stay in suspension in the finished product.

8. Cooling: The warm mix from the homogenizer is cooled to $40^{o}$ or lower in a continuous cooler.

9. Pasteurized Storage: The cold pasteurized mix is held in refrigerated storage tanks until needed in the flavoring and freezing operations, No. 12 and 13.

10. Fruit and Nut Preparation: Frozen nuts are drawn from storage and roasted, and frozen fruits are drawn from storage, defrosted, and separated into pulp and juice.

11. Fruit and Nut Storage: The pulp fruit and the separate juice is stored in containers under refrigeration for later use in No. 12.

12. Flavoring: Mix is drawn from storage tanks, No. 9, into small mixing vats in which the liquid fruit juices are added for flavoring. At this time artificial flavors may also be added.

13. Freezing: The flavored mixes are pumped to ice cream freezers which are the industrial type of the familiar frozen custard stand freezers. In the freezer the mix is frozen on the surface of a refrigerated tube and is scraped off with sharp blades rotating at high speeds which also whip air into the mix to give it its characteristics as ice cream. Freezers are a continuous type device other than in very small plants in which batch type freezers may be used.

14. Solids Injection: The partially frozen ice cream from the freezers passes through a machine which injects nuts and fruit pulp into the stream. This partially frozen ice cream is sent to packaging equipment.

15. Packaging: The packaging machinery which is normally automatic, forms the container, injects a controlled amount of the product, and seals the package.

16. Stick Confections: A special class of packaging-freezing device is the stick confection unit. The product from the ice cream freezer, No. 13, or flavored water base mixes from No. 12, are placed in the stick confection freezer and frozen, sticks inserted, coatings applied, and the finished product packaged in a paper bag or wrapper.

17. Hardening: The partially frozen ice cream is conveyed in packages to a "hardening area" in which the product is subjected to low temperature air circulation and the freezing cycle is completed. The hardening area in a larger plant is usually a continuous "tunnel" device, cycled with the packaging; however, in smaller operations the product may be stacked in the partially frozen form in racks or on shelves and hardened in the storage area.

18. Cold Storage: The hardened ice cream is held in cold storage as inventory until ready for shipment.

19. Ship Out: The hardened ice cream is drawn from inventory and placed on refrigerated route trucks for delivery to the consumer.

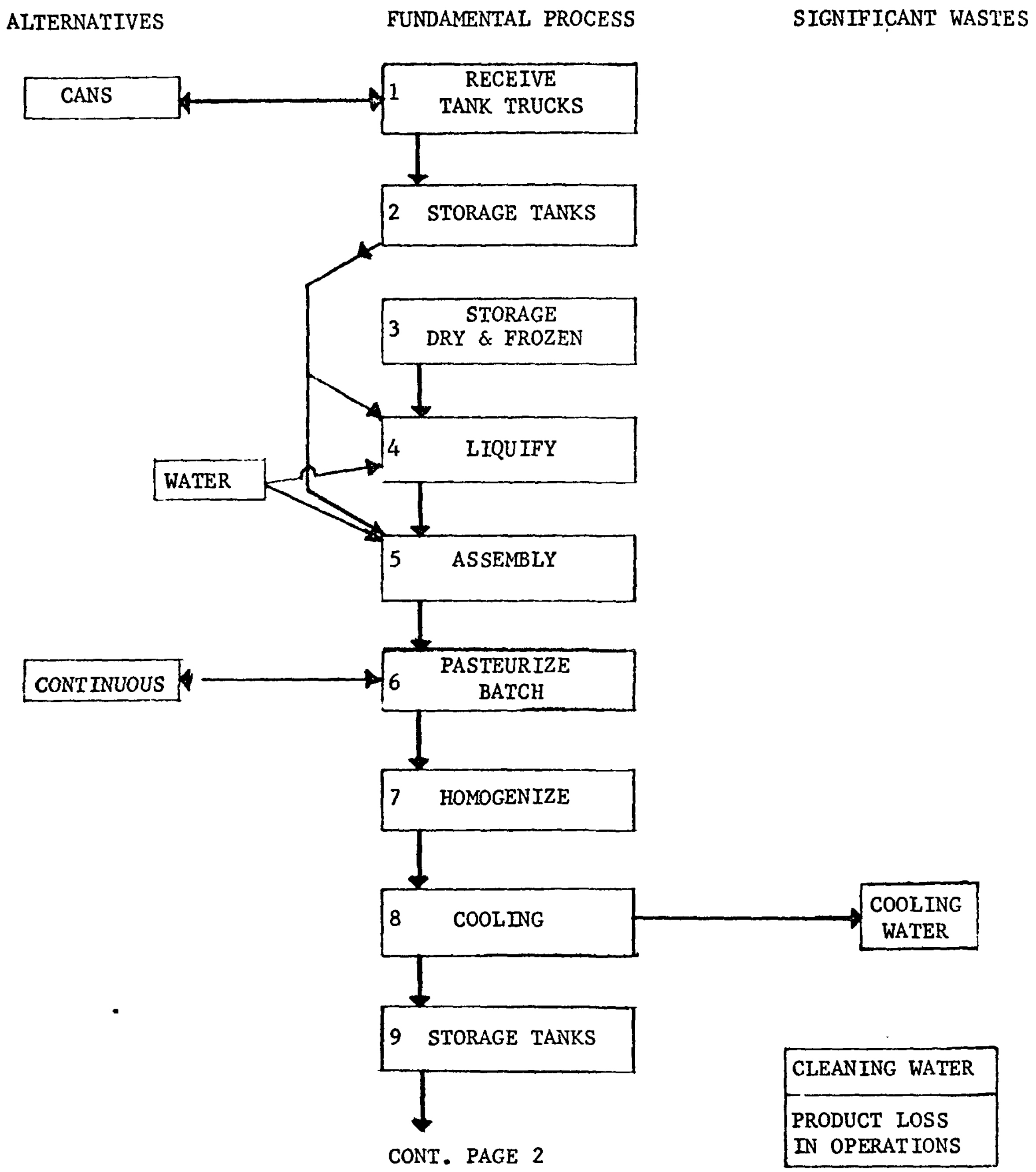
A flow diagram is included on Pages IWP 9-101 and 9-102.

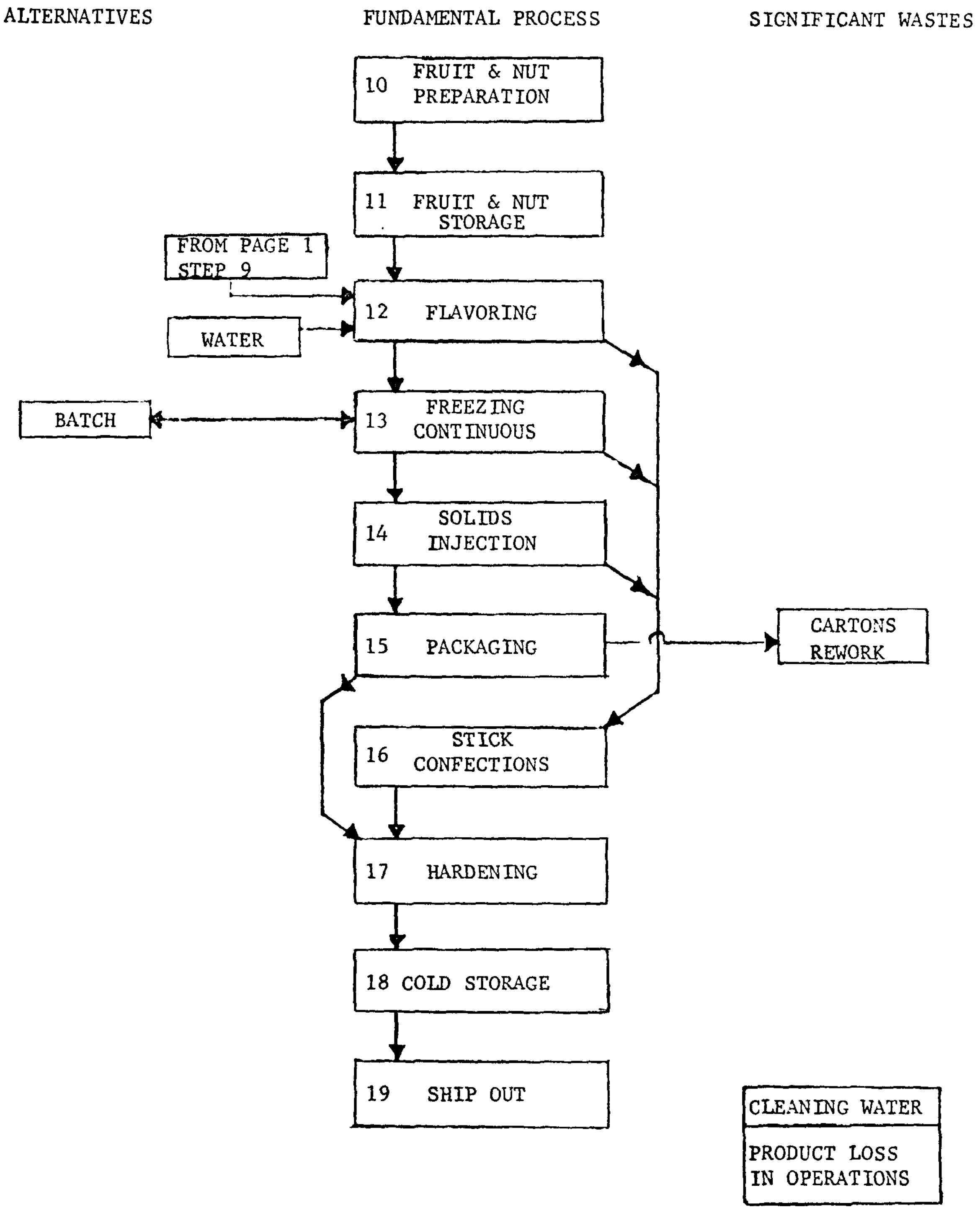
Please note that the numbering system used here is also used in comparison tables appearing later.

## Waste and Wastewater

The significant wastes derived from the fundamental ice cream and frozen desserts process are (1) the spillage which occurs in normal processing and packaging operations and (2) the wastes incurred with cleaning equipment at the end of a day's operation. Some clear water waste occurs in those plants using water for once-through cooling in their refrigeration systems. This technique is often used in rural plants with their own wells or in areas of abundant water supply.

No water that comes in contact with ice cream and frozen desserts during the manufacturing process may be reused because of the danger of contamination.


ALTERNATIVES
FUNDAMENTAL PROCESS
SIGNIFICANT WASTES
CANS
1 RECEIVE TANK TRUCKS
2 STORAGE TANKS
3 STORAGE DRY & FROZEN
4 LIQUIFY
WATER
5 ASSEMBLY
CONTINUOUS
6 PASTEURIZE BATCH
7 HOMOGENIZE
8 COOLING
COOLING WATER
9 STORAGE TANKS
CLEANING WATER
PRODUCT LOSS IN OPERATIONS
CONT. PAGE 2


ALTERNATIVES
FUNDAMENTAL PROCESS
SIGNIFICANT WASTES
10 FRUIT & NUT PREPARATION
11 FRUIT & NUT STORAGE
FROM PAGE 1 STEP 9
12 FLAVORING
WATER
BATCH
13 FREEZING CONTINUOUS
14 SOLIDS INJECTION
15 PACKAGING
CARTONS REWORK
16 STICK CONFECTIONS
17 HARDENING
18 COLD STORAGE
19 SHIP OUT
CLEANING WATER
PRODUCT LOSS IN OPERATIONS

## RECENT DEVELOPMENTS

The fundamental ice cream and frozen desserts process changed little from 1950 to 1966, and little change is forecast for 1967 to 1977. Nevertheless, several developments of interest have occurred.

The most significant change has been in the number reduction of plants. Due to economical pressures, many small plants have closed or have merged. This trend, which is expected to continue, is depicted on Page IWP 9-105.

Since 1950, bulk tank trucks have largely replaced the 10-gallon cans used in Step 1, "Receipt", of the fundamental process. The trend has occurred because the use of trucks has virtually eliminated physical labor, improved sanitation maintenance and reduced the likelihood of contamination.

Equipment has been developed to incorporate dry ingredients into water or milk, reducing the danger of contamination and labor requirements.

Batches of raw materials are now assembled by the use of load cells or scales with automatic transfer of the correct amounts of the various raw ingredients. This development results in more accuracy in the composition of the finished product, reduced manual labor requirements, and improved sanitation.

Because of tremendous volume, large plants utilize continuous flow equipment, as opposed to batch type machinery. This development has tended to reduce the percentage of plant loss in operations and, consequently, has helped to minimize wastes. Greatly improved heating and refrigeration systems have reduced water needs considerably.

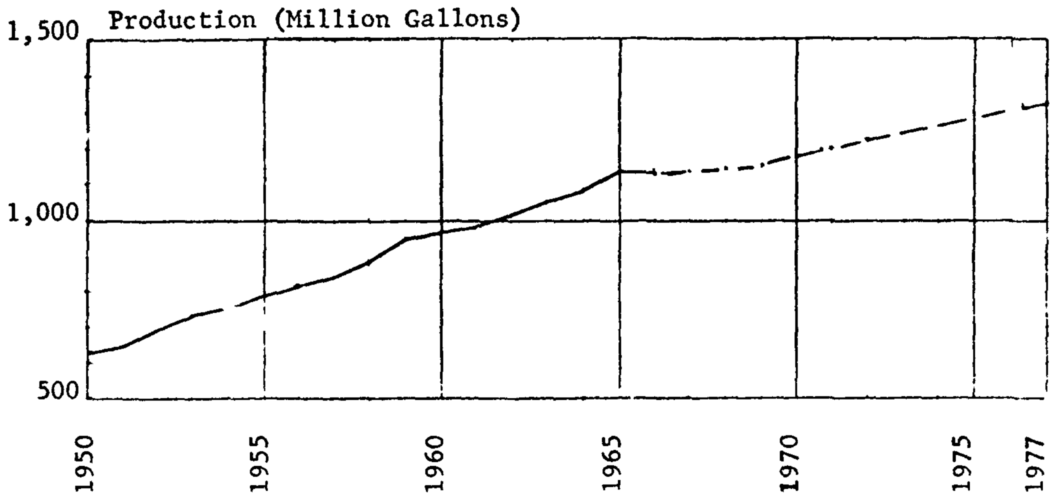
Large continuous freezers are rapidly replacing the less efficient batch freezers.

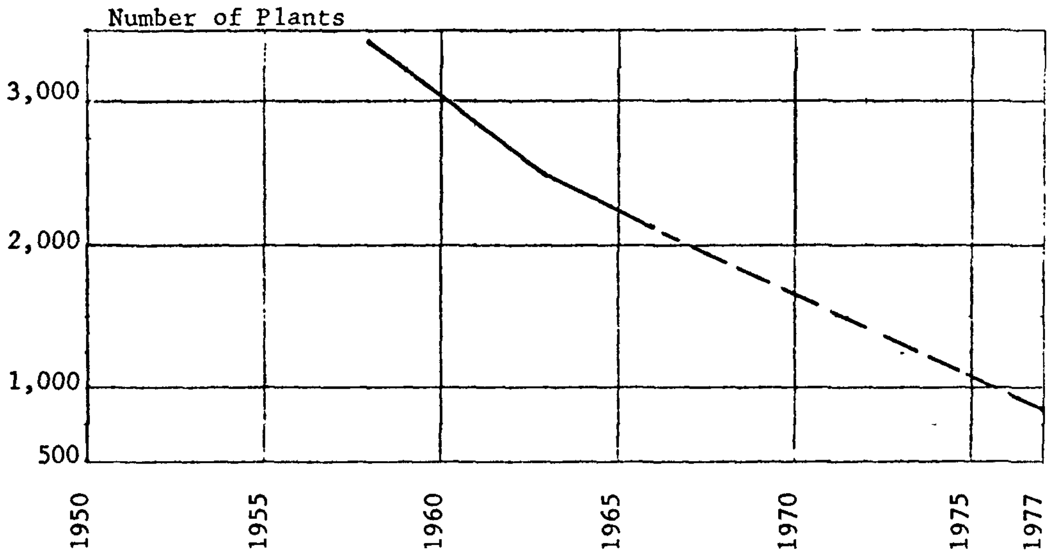
The trend in packaging is to smaller units which better serve the needs and desires of the consumer. Automatic packaging continues to replace manual methods. Not only is the amount of waste reduced, but new machinery fills more accurately.

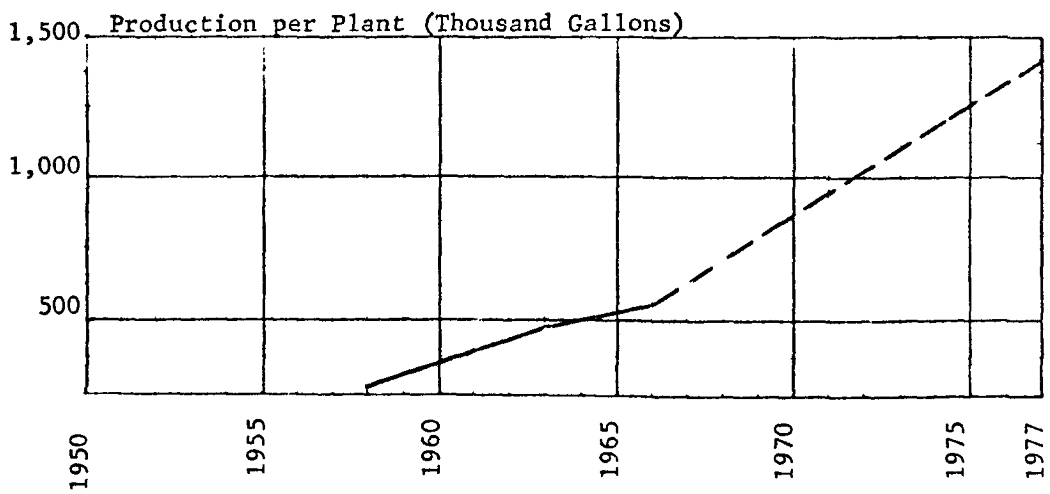
Devices have been developed which improve the texture of the finished product by rapid hardening.

Permanent stainless steel piping systems were introduced in the early 1950's. Such systems are cleaned in place, as opposed to the daily take-apart systems formerly accepted. This type equipment reduces the quantity of soap required and, therefore, reduces waste. The fact that the systems are permanently installed has reduced plant product losses; also, sanitation and product shelf life has been increased--a factor which has tended to reduce waste.

Significant changes have occurred in material handling within plants by the introduction of sophisticated conveyors and stacking, grouping and palletization equipment. Even though machines have tended to increase individual plant wastes through the enlarged usage of water-soap lubricants, product loss and waste has been reduced because of the less likelihood of package damage.


Production (Million Gallons)
1,500
1,000
500
1950
1955
1960
1965
1970
1975
1977


Number of Plants
3,000
2,000
1,000
500
1950
1955
1960
1965
1970
1975
1977


Production per Plant (Thousand Gallons)
1,500
1,000
500
1950
1955
1960
1965
1970
1975
1977

The trends may best be shown in tabular form, which follows. The reader should note that the alternative subprocesses and other industry changes have occurred over a span of years.

The process which will become prevalent is identified as P, and that which is becoming less used as S.

TABLE IWP 9 - 106

Estimated Percentage of Plants Employing Process

| | | | 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|---|---|---|
| (b) | P | Receive in Tank Trucks | -0- | 25 | 30 | 40 | 60 |
| | S | Receive in Cans | 100 | 75 | 70 | 60 | 40 |
| (c) | P | Liquify Manually | 100 | 95 | 90 | 85 | 75 |
| | S | Liquify by Machine | -0- | 5 | 10 | 15 | 25 |
| (d) | P | Assemble Manually | 100 | 98 | 97 | 95 | 90 |
| | S | Assemble Automatically | -0- | 2 | 3 | 5 | 10 |
| (e) | P | Pasteurize Batch | 100 | 98 | 97 | 95 | 90 |
| | S | Pasteurize Continuously | -0- | 2 | 3 | 5 | 10 |
| (f) | P | Freeze Continuously | 75 | 50 | 65 | 80 | 90 |
| | S | Freeze Batch | 25 | 50 | 35 | 20 | 10 |
| (g) | P | Automatic Packaging | 10 | 50 | 65 | 80 | 90 |
| | S | Manual Packaging | 90 | 50 | 35 | 20 | 10 |
| (h) | P | Hardening in Storage | 100 | 99 | 97 | 75 | 50 |
| | S | Hardening in Tunnel | -0- | 1 | 3 | 25 | 50 |
| (i) | P | CIP Piping | -0- | 20 | 30 | 40 | 60 |
| | S | Take-apart Piping | 100 | 80 | 70 | 60 | 40 |
| (j) | P | Auto. Material Handling | -0- | 2 | 3 | 5 | 10 |
| | S | Manual Material Handling | 100 | 98 | 97 | 95 | 90 |

The estimates represent the observations and opinions of people in the industry.

## Comparative Waste Control Problems

The subprocesses (Table IWP 9-106) do not require different treatment from the fundamental processes; however, the choice of subprocess is largely determined by the total volume produced. Large plants often utilize continuous flow processes because of greater productivity per piece of equipment. These processes generate less waste per pound of finished product.

Loss due to viscosity, product spillage, cleaning water and soaps--all constitute the significant wastes for any type process utilized.

In order to best estimate total industrial waste and wastewater, it is desirable to identify the existing levels of technology. The following table illustrates three technological levels. The fundamental process steps from Pages IWP 9-103 and IWP 9-104 are used as reference for the table which follows.

TABLE IWP 9 - 107

Comparative Technology

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
|---|---|---|---|
| 1. | Receive product in 10-gallon cans | Receive almost all of product in tank truck quantities but continuing to receive a small amount of canned products | Receive all products in tank truck quantities and (2) |
| 2. | Store all products in 10-gallon cans | Store all products in refrigerated tanks | Store in tanks |
| 3. | Storage of dry and frozen products in bag or unit quantities | Storage of dry and frozen ingredients, most products in bag or unit quantities except the liquid sugars and corn syrups would be utilized | Storage of dry and frozen ingredients at an absolute minimum. Almost all products stored in tank quantities |
| 4. | Liquification of dry and frozen ingredients manually | Liquification performed in (5) | Liquification performed in an automatic machine |
| 5. | Assembly of ingredients directly into (6) | The assembly vat. Product pumped from assembly vat into (6) | Assembly takes place in a programmed automatic vat on weigh scales and pumped to (6) |
| 6. | Batch type mix pasteurizers | Batch pasteurizers | Continuous mix pasteurizers |

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
|---|---|---|---|
| 7. | Homogenize in a high speed pressure pump | Homogenization in a high pressure pump continuously | Homogenization in a continuous high pressure pump |
| 8. | Cool in batch quantities | Cooling performed in a continuous manner with ammonia D.X. | Cooling with regeneration in a continuous manner, and product pumped to (9) |
| 9. | Store pasteurized products in 10-gallon cans | Pasteurized product stored in refrigerated tanks | Refrigerated storage tanks |
| 10. | Fruit and nut preparation manually and product stores in (11) | Fruit and nut preparation performed with machine assistance | Fruit and nut preparation essentially manual with semi-automatic machine assistance |
| 11. | 10-gallon cans or unit quantities | Stored in 10-gallon cans or unit quantities | Fruit juices stored in tanks and pumped, and nuts stored in wheeled containers |
| 12. | Flavoring performed in 10-gallon cans or in | Flavoring performed in small mixing vats adjacent to (13) | Flavoring performed in either large pasteurized storage vats (9) or in small mixing vats adjacent to (13) |
| 13. | Batch freezers | The automatic continuous freezers | The continuous automatic ice cream freezers |
| 14. | Solids injected directly into barrel of batch freezers | Solids injected by machine | Solids injected by machine |
| 15. | Packaging performed by hand | Packaging in some automatic machinery and some still performed by hand | Packaging in all automatic machinery |
| 16. | Stick confections made on manual devices | Stick confections made in small size semi-automatic machinery and hand packaged | Stick confections made and packaged on all automatic machinery |

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
|---|---|---|---|
| 17. | Hardening performed by stacking product on shelves or in wire baskets in the open storage room in the same place that (18) is held | Hardening takes place in the same area as inventory storage (18) | Hardening performed in an automatic "freezing tunnel" and product conveyed to (18) |
| 18. | Inventory is held | Inventory performed by placing product in wire baskets or on shelves in this area | Cold storage where it is handled in a palletized manner |
| 19. | Ship out | Ship out | Product shipped out in pallet loads or some other form of unit load quantities |
| 20. | Take-apart piping | Partial CIP piping | CIP piping |
| 21. | Manual materials handling | Partial automatic materials handling | Automatic materials handling |



287-032 O - 68 - 8

## Size vs. Technology

In 1963 there were 2,512 ice cream plants producing 1,052,986,000 gallons of ice cream. The industry considers a plant producing under 50,000 gallons per year as "small", 50,000 to one million gallons as "medium", and over one million gallons as "large".

Waste and wastewater are a function of size as well as technology. TABLE IWP 9-110 represents industry (C) opinion of the relationship of size and technology.

### TABLE IWP 9-110

### Plant Statistics

### 1963

| | | |
|---|---|---|
| Small | 1,269 | 50% produce less than 50,000 gallons per year |
| Medium | 992 | 40% produce 50,000 to 1,000,000 gallons per year |
| Large | 251 | 10% produce more than 1,000,000 gallons per year |
| Total | 2,512 | plants produced 1,052,986,000 gallons in 1963 |

Overall industry average: 419,200 gallons per year

| Percentage Technology Levels | Percentage of Various Sizes | | |
|---|---|---|---|
| | Small Less than .05 | Medium .05 to 1 | Large Over 1 |
| 46% Older Technology | 98% | 2% | 0% |
| 60% Typical Technology | 11 | 77 | 12 |
| 4% Advanced Technology | 0 | 0 | 100 |

This relationship provides a basis for conputation of overall plant wastes produced when related to unit waste production of various size plants of the three technology levels.

## Gross Waste Quantities Before Treatment or Other Disposal

In plants of advanced technology, waste generated is less than in those plants less advanced. Waste and wastewater per pound of finished product are as follows:

### TABLE IWP 9 - 111-A

### Waste and Wastewater Quantities per Gallon Product

| | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gallons |
|---|---|---|---|
| Older Technology | .0073 | .0007 | 12.0 |
| Typical Technology | .0032 | .0003 | 8.0 |
| Advanced Technology | .0015 | .0002 | 6.2 |

This data represents industry operating experience. Ice Cream wastes are similar for all levels of technology because the basic process is similar for all levels.

## Seasonal Waste Production Pattern

Waste quantities tend to be directly proportional to production quantities; however, wastewater is used in greater quantities in the warm months, reflecting increased refrigeration requirements. The following table illustrates this relationship.

### TABLE IWP 9 - 111-B

### Percentage of Yearly Total

| | Product | Soap & Chemical | Wastewater |
|---|---|---|---|
| January | 5.9 | 4.5 | 4.5 |
| February | 6.0 | 4.6 | 4.6 |
| March | 7.5 | 6.5 | 6.5 |
| April | 8.7 | 9.3 | 9.3 |
| May | 9.8 | 11.0 | 11.0 |
| June | 10.6 | 12.5 | 12.5 |
| July | 11.8 | 14.2 | 14.2 |
| August | 11.2 | 13.8 | 13.8 |
| September | 8.5 | 9.1 | 9.1 |
| October | 8.0 | 6.8 | 6.8 |
| November | 6.3 | 4.8 | 4.8 |
| December | 5.7 | 4.5 | 4.5 |

This seasonal variation is not expected to change. One may note that summer month production is almost twice that of winter months. Summer sales are even greater, since some items such as popsicles can be stored for several months.

The relationship of plant size and technology shown in Table IWP 9-110 permits a comparison of the number of plants of each technology level. The unit wastes from Table IWP 9-111-A when applied to the number of plants results in Table IWP 9-112.

TABLE IWP 9 - 112

Gross Waste Quantities for Average Size Plants

A. Older Technology: These plants process 240 gallons of finished product per day.

Significant Wastes - Lb. BOD per Day

| # Plants | Product | Soap & Chemicals | Wastewater Gal. per Day |
|---|---|---|---|
| 1,156 | 8.76 | 0.88 | 3,009 |

B. Typical Technology: These plants process 1,700 gallons of finished product per day.

Significant Wastes - Lb. BOD per Day

| # Plants | Product | Soap & Chemicals | Wastewater Gal. per Day |
|---|---|---|---|
| 1,256 | 27.3 | 2.7 | 13,141 |

C. Advanced Technology: These plants process 9,700 gallons of finished product per day.

Significant Wastes - Lb. BOD per Day

| # Plants | Product | Soap & Chemicals | Wastewater Gal. per Day |
|---|---|---|---|
| 100 | 70.8 | 7.1 | 62,733 |

TABLE IWP 9 - 113-A

Gross Waste Quantities Before Treatment or Disposal

The individual plant data (Table IWP 9-112) when multiplied by the number of plants results in gross waste quantities before treatment or disposal.

| | Significant Wastes Per Year | | |
|---|---|---|---|
| | Product Pounds BOD (Millions) | Soap & Chemicals Pounds BOD (Millions) | Wastewater Gallons (Millions) |
| Older Technology | 3,212 | .32 | 1,083 |
| Typical Technology | 10,804 | 1.08 | 4,290 |
| Advanced Technology | 2,336 | .23 | 1,958 |
| Total | 16,352 | 1.63 | 7,331 |
| Individual Plant Range | ± 50% | ± 50% | ± 20% |

TABLE IWP 9 - 113-B

Projected Waste and Wastewater

The relationship between change in total production, plant size and technology changes is shown in the following table:

1963 and Projected Gross Wastes and Wastewater in Millions

| | 1963 | 1968 | 1969 | 1970 | 1971 | 1972 | 1977 |
|---|---|---|---|---|---|---|---|
| Gal. Product Mfg. | 1,053 | 1,153 | 1,167 | 1,182 | 1,200 | 1,219 | 1,317 |
| Lb. BOD Product | 16.35 | 17.71 | 17.75 | 17.79 | 17.87 | 17.97 | 18.40 |
| Lb. BOD Soap and Chemicals | 1.6 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 |
| Subtotal | 17.95 | 19.51 | 19.55 | 19.59 | 19.67 | 19.77 | 20.20 |
| Gal. Wastewater | 7,331 | 7,786 | 7,637 | 7,488 | 7,351 | 7,214 | 6,418 |

Projections of product manufactured are based upon industry and government estimates.

## Waste Reduction Practices

The waste reduction practices utilized in the industry do not vary greatly. A common sewer piping system can be used for the entire plant. The wastes other than miscellaneous chemicals are of a "biodegradable" nature.

Certain processing practices produce varying amounts of wastes. Table IWP 9-114 illustrates such relationships.

### TABLE IWP 9 - 114

### Processing Practices

The fundamental process used with the "older" technology as the reference base, described on Page IWP 9-107 (A).

| Alternate Process | % Waste Reduction Efficiency | | |
|---|---|---|---|
| | Product | Soap & Chemical | Wastewater |
| (a) Plant - Large vs. Small | 80 | 50 | 48 |
| (b) Receive - Tanks vs. Cans | 65 | 80 | 85 |
| (c) Liquify - Automatic vs. Manual | 12 | 5 | 5 |
| (d) Assemble - Automatic vs. Manual | 7 | * | * |
| (e) Pasteurize - Continuous vs. Batch | 10 | 40 | 60 |
| (f) Freeze - Continuous vs. Batch | 10 | 10 | 10 |
| (g) Package - Automatic vs. Manual | 10 | * | * |
| (h) Hardening - Storage vs. Tunnel | 25 | 0 | 0 |
| (i) Piping - CIP vs. Take-apart | 25 | 50 | 50 |
| (j) Material Handling - Automatic vs. Manual | 5 | ** | ** |

*Adds wastewater as extra equipment must be cleaned.
**Adds wastewater proportional to lubricant used.

A large plant may be created by the consolidation of several smaller facilities. The subprocesses (b-h) may be applied to any plant on an individual basis and are not dependent on each other; however, the common practice is to utilize continuous flow and automatic equipment together.

Continuous flow and automatic equipment tend to have capacity ratings which justify the use thereof only in the average to larger size plants. Continuous churns are rare even in the largest of plants because of initial cost and because very high production capacities do not permit flexibility of operation.

## Treatment Practices

The most prevalent practice is Management Technique, i.e., closest possible supervision of day-to-day operation to eliminate processing loss--loss due to waste resulting from the initial shrinkage of the raw material as well as overfill of the finished package.

Most waste that goes to sewers is sent to municipal sewer and, to a lesser extent, is sent directly to water courses.

Company owned treatment plants represent the least used treatment practice.

The following table illustrates effectiveness of the various treatment practices as observed in the industry.

### TABLE IWP 9 - 115

### Treatment Practices

| Removal Method | Normal Removal Efficiency % of Total Wasteload Removed | | |
|---|---|---|---|
| | Product | Soap & Chemicals | Wastewater |
| (a) Ridge and Furrow | 95-100 | 95-100 | 4* |
| (b) Spray Irrigation | 95-100 | 95-100 | 5* |
| (c) Aerated Lagoon | 90-95 | 90-95 | 1* |
| (d) Trickling Filter | 90-95 | 90-95 | 0 |
| (e) Activated Sludge | 90-95 | 90-95 | 0 |
| (f) Municipal Sewer | 100 | 100 | 0 |
| (g) To Waterways | 100 | 100 | 0 |
| (h) Utilization as Byproduct | 99.5 | NA | 99.5 |
| (i) Management Technique | 50-75 | 50-75 | 10-75 |

*Estimated percent of total evaporated to the atmosphere; the remainder goes to waterways.

Assuming optimum conditions, the removal methods (supra) could be employed in any given plant; however, the utilization of the ridge and furrow, spray irrigation, and aerated lagoon type processes require significant amounts of land. Furthermore, soil and climate limit both the physical size of a treatment plant as well as the choice of the treatment process.

The trickling filter and activated sludge processes are relatively compact; however, these types require greater capital investment and have higher operating costs than the other methods.

The trend is to connect plants to municipal systems wherever possible in order to simplify day-to-day operations and to minimize capital investment.

The management technique is now being widely accepted and involves close supervision of day-to-day operations, the utilization of preventative maintenance techniques, and the use of inventory control procedures.

It is estimated that the following percentages of industrial waste have been or will be discharged to a municipal sewer:

| 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|
| 50 | 70 | 80 | 90 | 98 |

The high BOD requirements of ice cream and frozen desserts plant wastes necessitate that the capacity of a particular municipal plant be reviewed prior to the connection of a new plant wasteload to the system.

Pretreatment is not usually required because of the characteristics of the waste; however, pretreatment may be required if the municipal plant is of inadequate size.

The various practices have been utilized in varying degrees. Plant location, capital costs, operating costs and problems--all influence the type adoption.

TABLE IWP 9 - 117

Rate of Adoption of Waste Treatment Practices Since 1950

The rate of adoption of treatment practice is shown in percentages.

| | Removal Method | % of Plants Employing Listed Methods | | | | |
|---|---|---|---|---|---|---|
| | | 1950 | 1963 | 1967 | 1972 | 1977 |
| (a) | Ridge and Furrow | U* | U | U | U | U |
| (b) | Spray Irrigation | U | U | U | U | U |
| (c) | Aerated Lagoon | U | U | U | U | U |
| (d) | Trickling Filter | U | U | U | U | U |
| (e) | Activated Sludge | U | U | U | U | U |
| (f) | Municipal Sewer | 70 | 75 | 80 | 90 | 98 |
| (g) | To Waterways | 26 | 21 | 16 | 6 | 0 |
| (h) | Utilization as Byproduct | U | U | U | U | U |
| (i) | Management Technique | 40 | 55 | 65 | 75 | 85 |

*U = Under 1%

## Waste Reduction or Removal Cost Information

The ice cream industry has a capital investment in sewerage treatment facilities, and also has annual operating and maintenance expenditures in conjunction therewith.

The estimated capital investment in waste removal facilities in 1963 is $750,000 and the estimated annual operating expense if $150,000.

By 1966 the capital investment is estimated to have increased to $1,000,000 and the annual operating expense to $200,000.

## Comparative Investment and Operating Expense

Plant sizes have been determined as small, medium and large and technology levels described as old, typical and advanced.

A comparison of investment cost and operating cost for providing waste and wastewater removal facilities between plants of different sizes and technologies for the various subprocesses and removal methods will provide valuable data for determining which subprocess or method offers the most attractive opportunities for use in the future to implement the Clean Water Restoration Act.

The next several pages include these comparison tables. The tables are based on investment costs and operating costs as experienced by industry. Land has been estimated at $300 per acre for the ridge and furrow, spray irrigation and aerated lagoon installation.

Management technique requires no additional capital investment. Nominal expense is included for educational purposes.

Economic life in relation to processing equipment represents current thinking on industry needs for return on investment and recognizes obsolescence.

Economic life in relation to removal methods represents observed useful life.

There are no small plants of typical or advanced technology.

TABLE IWP 9 -119

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of small size. Daily "net" waste quantities from plant to sewer are .35 pounds BOD (±50%) and 560 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 47 gals/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| **Subprocess:** | | | |
| (a) Plant - Large vs. Small | $ -20% | $ -25% | 13 |
| (b) Receive - Tanks vs. Cans | 5,000 | +1,500 | 13 |
| (c) Liquify - Auto vs. Manual | 6,000 | +1,800 | 13 |
| (d) Assemble - Auto vs. Manual | NA | NA | 13 |
| (e) Pasteurize - Continuous vs. Batch | 9,500 | +2,000 | 13 |
| (f) Freeze - Continuous vs. Batch | 13,000 | +3,400 | 13 |
| (g) Packaging - Automatic vs. Manual | NA | NA | 4 |
| (h) Hardening - Storage vs. Tunnel | NA | NA | 13 |
| (i) Piping - CIP vs. Take-apart | 5,500 | +1,200 | 13 |
| (j) Material Handling - Automatic vs. Manual | NA | NA | 13 |
| **Removal Method:** | | | |
| (a) Ridge and Furrow | $ 300 | $ +100 | 20 |
| (b) Spray Irrigation | 600 | +150 | 20 |
| (c) Aerated Lagoon | 500 | +150 | 20 |
| (d) Trickling Filter | NA | NA | NA |
| (e) Activated Sludge | NA | NA | NA |
| (f) Municipal Sewer | 200 | +100 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Management Technique | -0- | +450 | * |

NA = Not Applicable * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-118.

TABLE IWP 9 -120

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of medium size. Daily "net" waste quantities from plant to sewer are 6.3 pounds BOD (±50%) and 11,000 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 890 gals/day | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) | Receive - Tanks vs. Cans | 5,000 | -0- | 13 |
| (c) | Liquify - Auto vs. Manual | 5,000 | -600 | 13 |
| (d) | Assemble - Auto vs. Manual | 25,000 | -2,200 | 13 |
| (e) | Pasteurize - Continuous vs. Batch | 14,000 | +1,600 | 13 |
| (f) | Freeze - Continuous vs. Batch | 32,000 | -3,800 | 13 |
| (g) | Packaging - Automatic vs. Manual | 62,000 | -2,400 | 4 |
| (h) | Hardening - Storage vs. Tunnel | 30,000 | +800 | 13 |
| (i) | Piping - CIP vs. Take-apart | 12,000 | -6,400 | 13 |
| (j) | Material Handling - Automatic vs. Manual | 8,000 | -2,000 | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $ 4,200 | $ +800 | 20 |
| (b) | Spray Irrigation | 11,800 | +2,400 | 20 |
| (c) | Aerated Lagoon | 500 | +100 | 20 |
| (d) | Trickling Filter | 56,000 | +11,200 | 15 |
| (e) | Activated Sludge | 37,200 | +7,500 | 15 |
| (f) | Municipal Sewer | 200 | +200 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Management Technique | -0- | -500 | * |

NA = Not Applicable * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-118.

TABLE IWP 9 - 121

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of medium size. Daily "net" waste quantities from plant to sewer are 2.9 pounds BOD (±50%) and 6,400 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 890 gals/day | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) | Receive - Typical vs. Advanced | -0- | -0- | 13 |
| (c) | Liquify - Auto vs. Manual | 5,000 | -200 | 13 |
| (d) | Assemble - Auto vs. Manual | 25,000 | +1,400 | 13 |
| (e) | Pasteurize - Continuous vs. Batch | 14,000 | +2,200 | 13 |
| (f) | Freeze - Continuous vs. Typical vs. Advanced | 7,500 | -600 | 13 |
| (g) | Packaging - Automatic Typical vs. Advanced | 25,000 | -3,400 | 4 |
| (h) | Hardening - Storage vs. Tunnel | 30,000 | +1,800 | 13 |
| (i) | Piping - CIP Typical vs. Advanced | 6,000 | -3,200 | 13 |
| (j) | Material Handling - Typical vs. Advanced | 4,000 | -1,000 | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $ 2,400 | $ +500 | 20 |
| (b) | Spray Irrigation | 6,900 | +1,400 | 20 |
| (c) | Aerated Lagoon | 500 | +100 | 20 |
| (d) | Trickling Filter | 32,400 | +6,500 | 15 |
| (e) | Activated Sludge | 21,600 | +4,300 | 15 |
| (f) | Municipal Sewer | 200 | -0- | * |
| (g) | To Waterways | -0- | +200 | * |
| (h) | Management Technique | -0- | -200 | * |

NA = Not Applicable    * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-118.

## TABLE IWP 9 -122

### Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of medium size. Daily "net" waste quantities from plant to sewer are 1.4 pounds BOD (±50%) and 5,500 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 890 gals/day | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) | Receive - Tanks | AH | NA | 13 |
| (c) | Liquify - Auto vs. Manual | AH | NA | 13 |
| (d) | Assemble - Auto vs. Manual | AH | NA | 13 |
| (e) | Pasteurize - Continuous | | | |
| (f) | Freeze - Continuous | AH | NA | 13 |
| (g) | Packaging - Automatic | AH | NA | 4 |
| (h) | Hardening - Storage vs. Tunnel | AH | NA | 13 |
| (i) | Piping - CIP | AH | NA | 13 |
| (j) | Material Handling | AH | NA | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $ 2,100 | $ +400 | 20 |
| (b) | Spray Irrigation | 5,900 | +1,200 | 20 |
| (c) | Aerated Lagoon | 500 | +100 | 20 |
| (d) | Trickling Filter | 27,900 | +5,600 | 15 |
| (e) | Activated Sludge | 18,600 | +3,700 | 15 |
| (f) | Municipal Sewer | 200 | +200 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Management Technique | -0- | -100 | * |

NA = Not Applicable
AH = Already installed by definition

* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-118.

TABLE IWP 9 - 123

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of large size. Daily "net" waste quantities from plant to sewer are 31.1 pounds BOD (±50%) and 78,000 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = 9,700 gals/day | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) | Receive - Tanks vs. Cans | 5,000 | -6,300 | 13 |
| (c) | Liquify - Auto vs. Manual | 7,000 | -700 | 13 |
| (d) | Assemble - Auto vs. Manual | 25,000 | -9,700 | 13 |
| (e) | Pasteurize - Continuous vs. Batch | 25,000 | -400 | 13 |
| (f) | Freeze - Continuous Typical vs. Advanced | 10,000 | -100 | 13 |
| (g) | Packaging - Automatic Typical vs. Advanced | 50,000 | -10,800 | 4 |
| (h) | Hardening - Storage vs. Tunnel | 65,000 | 5,300 | 13 |
| (i) | Piping - CIP vs. Take-apart | 55,000 | -5,700 | 13 |
| (j) | Material Handling - Automatic vs. Manual | 15,000 | -200 | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $ 29,600 | $ +5,300 | 20 |
| (b) | Spray Irrigation | 83,500 | +15,000 | 20 |
| (c) | Aerated Lagoon | 2,200 | +400 | 20 |
| (d) | Trickling Filter | 126,000 | 22,700 | 15 |
| (e) | Activated Sludge | 84,000 | +15,100 | 15 |
| (f) | Municipal Sewer | 200 | +300 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Management Technique | -0- | -4,100 | * |

NA = Not Applicable * Permanent

There are no large plants of typical technology.

See Reference Notes on Page IWP 9-8 and IWP 9-118.

TABLE IWP 9 -124

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of large size. Daily "net" waste quantities from plant to sewer are 14.6 pounds BOD (±50%) and 60,140 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| | Product = 9,700 gals/day | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -20% | $ -25% | 13 |
| (b) | Receive - Tanks | AH | NA | 13 |
| (c) | Liquify - Auto vs. Manual | AH | NA | 13 |
| (d) | Assemble - Auto vs. Manual | AH | NA | 13 |
| (e) | Pasteurize - Continuous | AH | NA | 13 |
| (f) | Freeze - Continuous | AH | NA | 13 |
| (g) | Packaging - Automatic | AH | NA | 13 |
| (h) | Hardening - Storage vs. Tunnel | AH | NA | 13 |
| (i) | Piping - CIP | AH | NA | 13 |
| (j) | Material Handling - Automatic | AH | NA | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $ 22,800 | $ +4,100 | 20 |
| (b) | Spray Irrigation | 64,000 | +11,500 | 20 |
| (c) | Aerated Lagoon | 1,000 | +200 | 20 |
| (d) | Trickling Filter | 169,000 | +30,400 | 15 |
| (e) | Activated Sludge | 112,500 | +20,200 | 15 |
| (f) | Municipal Sewer | 200 | +700 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Management Technique | -0- | -1,600 | * |

NA = Not Applicable
AH = Already installed by definition

* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-118.

The tables indicate that several subprocesses and removal methods are particularly attractive in terms of small capital investment and low annual operating expense.

The application of Management Technique requires no capital investment and very little in operating expense. The method results in significant economy in plant operations, and is a highly desirable technique.

Disposal of remaining waste to municipal sewers requires only nominal investment and operating cost to the plant and is attractive to the plant operation. However, if a municipality establishes a sewage rate based directly on plant waste loads, then comparative economics determine whether or not a plant should adopt further waste removal methods.

Summary of Projected Wasteloads

| Year | Waste | Gross Waste Generated Million | Removal * % | Net Waste Discharged Million |
|---|---|---|---|---|
| 1963 | Product (Lbs. BOD) | 16.35 | 75 | 4.09 |
| | Soap & Chemical (Lbs. BOD) | 1.6 | 75 | .4 |
| | ST | 17.95 | ST | 4.49 |
| | Water (Gallons) | 7,331 | 5 | 6,964 |

*Percentage of waste reduced or removed by process changes, waste treatment and byproducts utilization



287-032 O - 68 - 9

Summary of Projected Wasteloads

| Year | Waste | | Gross Waste Generated Million | Removal * % | | Net Waste Discharged Million |
|---|---|---|---|---|---|---|
| 1968 | Product (Lbs. BOD) | | 17.71 | 82 | | 3.19 |
| | Soap & Chemical (Lbs. BOD) | | 1.8 | 82 | | .3 |
| | | ST | 19.51 | | ST | 3.49 |
| | Water (Gallons) | | 7,786 | 5 | | 7,397 |
| 1969 | Product (Lbs. BOD) | | 17.75 | 85 | | 2.66 |
| | Soap & Chemical (Lbs. BOD) | | 1.8 | 85 | | .3 |
| | | ST | 19.55 | | ST | 2.96 |
| | Water (Gallons) | | 7,637 | 5 | | 7,255 |
| 1970 | Product (Lbs. BOD) | | 17.79 | 88 | | 2.13 |
| | Soap & Chemical (Lbs. BOD) | | 1.8 | 88 | | .2 |
| | | ST | 19.59 | | ST | 2.33 |
| | Water (Gallons) | | 7,488 | 5 | | 7,114 |
| 1971 | Product (Lbs. BOD) | | 17.87 | 90 | | 1.79 |
| | Soap & Chemical (Lbs. BOD) | | 1.8 | 90 | | .2 |
| | | ST | 19.67 | | ST | 1.99 |
| | Water (Gallons) | | 7,351 | 5 | | 6,983 |
| 1972 | Product (Lbs. BOD) | | 17.97 | 92 | | 1.44 |
| | Soap & Chemical (Lbs. BOD) | | 1.8 | 92 | | .1 |
| | | ST | 19.77 | | ST | 1.54 |
| | Water (Gallons) | | 7,214 | 5 | | 6,853 |
| 1977 | Product (Lbs. BOD) | | 18.40 | 99.5 | | .092 |
| | Soap & Chemical (Lbs. BOD) | | 1.8 | 99.5 | | .01 |
| | | ST | 20.20 | | ST | .102 |
| | Water Gallons) | | 6,418 | 5 | | 6,097 |

*Percentage of Waste Reduced or Removed by Process Changes, Waste Treatment and Byproducts Utilization

# 2026 FLUID MILK

2026 - Fluid Milk: Establishments primarily engaged in processing (pasteurizing, homogenizing, vitaminizing, bottling) and distributing fluid milk and cream and related products, including cottage cheese.

The fluid milk industry has grown steadily over the years and this trend is expected to continue.

Geographically, population patterns govern plant locations. There is a trend towards exceptionally large regional plants with distributions over wide areas.

The manufacturing process for fluid milk may be outlined as follows:

1. Receipt: Raw milk is received in tank truck quantities, although a few smaller plants continue to receive milk in 10-gallon cans.

2. Raw Milk Storage: Raw milk is pumped from receiving to refrigerated storage tanks until needed. Milk from raw milk storage proceeds to No. 11, the byproducts department, or to clarification.

3. Clarification: Raw milk is clarified (strained) in a centrifugal device although in smaller plants mechanical filters may be used.

4. Pasteurization: The clarified milk is usually pasteurized in a continuous flow pasteurizer, although batch type units may be used in smaller plants.

5. Homogenization: The pasteurized product is homogenized in a pressure pump which breaks up the butterfat particles to keep them in suspension.

6. Deodorization: The homogenized milk is usually subjected to a vacuum steam injection treatment to remove off-odors and off-flavors. Where the flavors and odors are not serious, the use of steam may be eliminated and only a vacuum treatment used. In some areas the milk supply is of such quality that milk "grading" can be done during receiving so that deodorization is not necessary.

7. Pasteurized Storage: The pasteurized product is cooled after leaving the previous treatments and is sent to storage tanks and held until needed in packaging.

8. Packaging: Milk is packaged or bottled on automatic machines in a number of different type containers, including glass bottles, paper cartons, plastic bottles, and plastic bags in cardboard box units. In the packaging operation, the packages are usually placed in wire or plastic cases and conveyed to a refrigerated cold storage area.

9. Cold Storage: The packaged product is held in cold storage until needed for shipping.

10. Ship Out: The packaged product is drawn from cold storage and placed into refrigerated trucks for delivery.

Returning to the raw milk storage, we can proceed with the fundamental process for byproducts.

11. Separation: The raw milk is separated into cream and skim milk in a centrifugal device and the two products sent to refrigerated storage.

12. Cream Storage: Cream is normally stored in refrigerated tanks, but occasionally may be stored in cans.

13. Blending: Cream is blended with whole milk and miscellaneous additives placed in the cream at this time to make the various grades of cream for bottling.

14. Pasteurization: The blended products are generally pasteurized in batch quantities, although in larger plants a continuous pasteurizer may be used, such as in No. 4.

15. Homogenization: The pasteurized product is homogenized as in No. 5.

16. Cooling: The homogenized product is cooled in batches, although in larger plants this may be a continuous process.

17. Skim Milk: Skim milk from the separation process, No. 11, is stored in refrigerated tanks and is used as follows:

A portion is returned to the raw milk storage tanks to standardize the product to a controlled percentage of butterfat.

A portion is sent to pasteurization, No. 4, and continues through Steps 5, 6, and 7, to packaging, No. 8.

Skim milk is used also in other products, as follows:

18. Cultured Products: Skim milk is processed into buttermilk and yogurt in batch type processors and sent to packaging, No. 8.

19. Skim for Cheese: Skim milk is drawn from storage tank (16) and pasteurized as in No. 5, and sent to cottage cheese vats.

20. Cottage Cheese Vat: The pasteurized product is cooled in pasteurizers to the desired "setting" temperature and pumped into cheese vats. In the cheese vats the skim milk is innoculated with a bacterial "culture". At the end of a controlled period of time, the curd resulting from the setting is cut into small pieces and cooked in the vat. At the end of the cooking period, the whey is drained off and becomes available for byproduct manufacture or is sent to waste. The curd from the set-cooking vat is washed with potable water to complete the removal of whey and to perform a cooling function. This water goes to waste. In large plants, the washing and draining may occur in a separate piece of machinery.

21. Cheese Dressing: Cream dressing is made under byproducts Steps 13 through 15, and pumped to the cheese and blended. In small plants the curd and dressings are mixed in cans and stored until packaged.

22. Packaging: The completed cheese is pumped to packaging where it is placed in containers and sent to (9) cold storage.

A flow diagram is included on Page IWP 9-131.

## Waste and Wastewater

The significant waste from the fundamental fluid milk process is whey. This waste product may be converted to valuable byproducts through evaporating the moisture and drying the residue to a powder form for human consumption or animal feed.

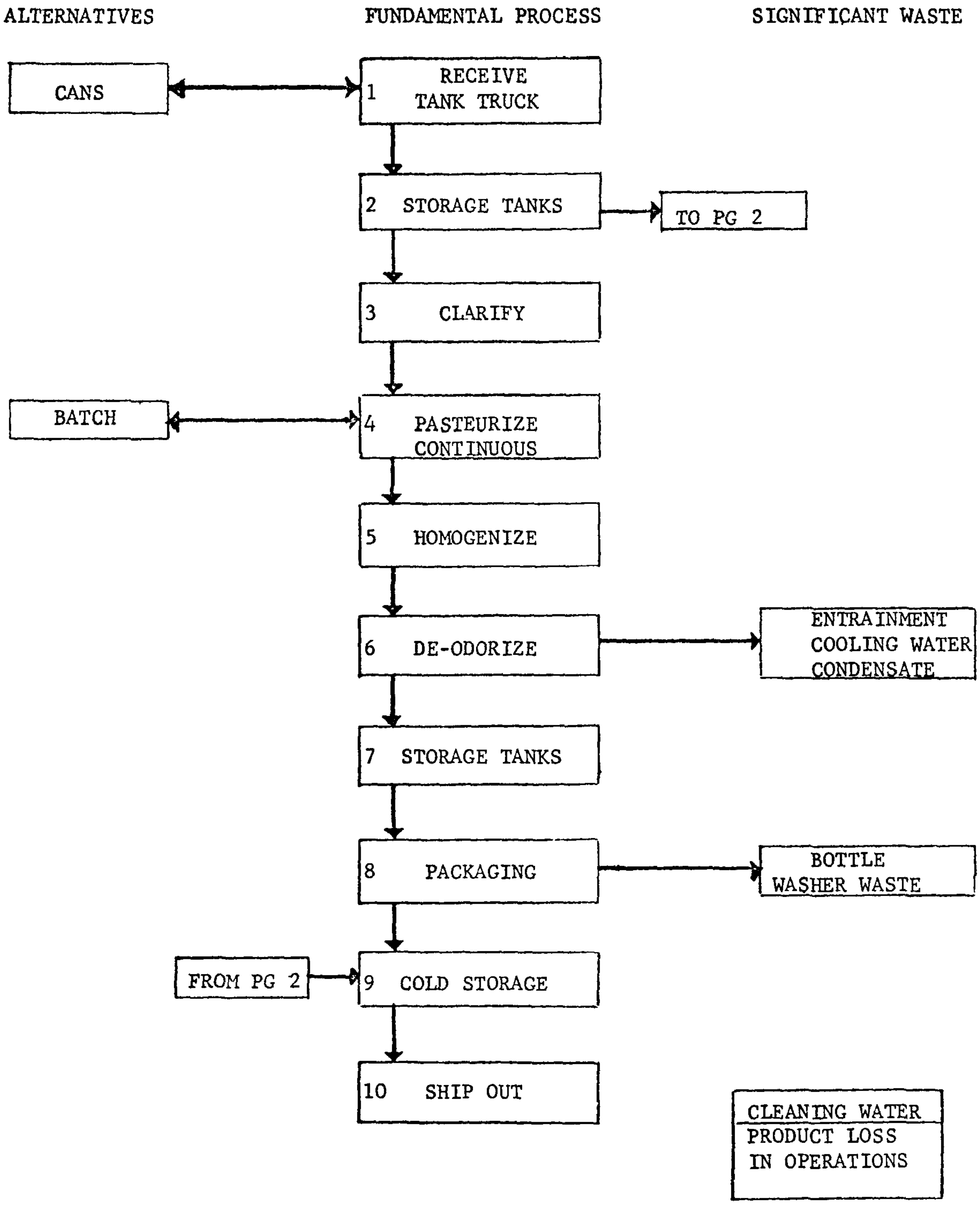
If whey is sent to the plant disposal system, the material becomes a most difficult waste problem because of the high protein and acidic content. Approximately 54% of the solids in the raw material remains in the whey resulting in a BOD of 3.2%.

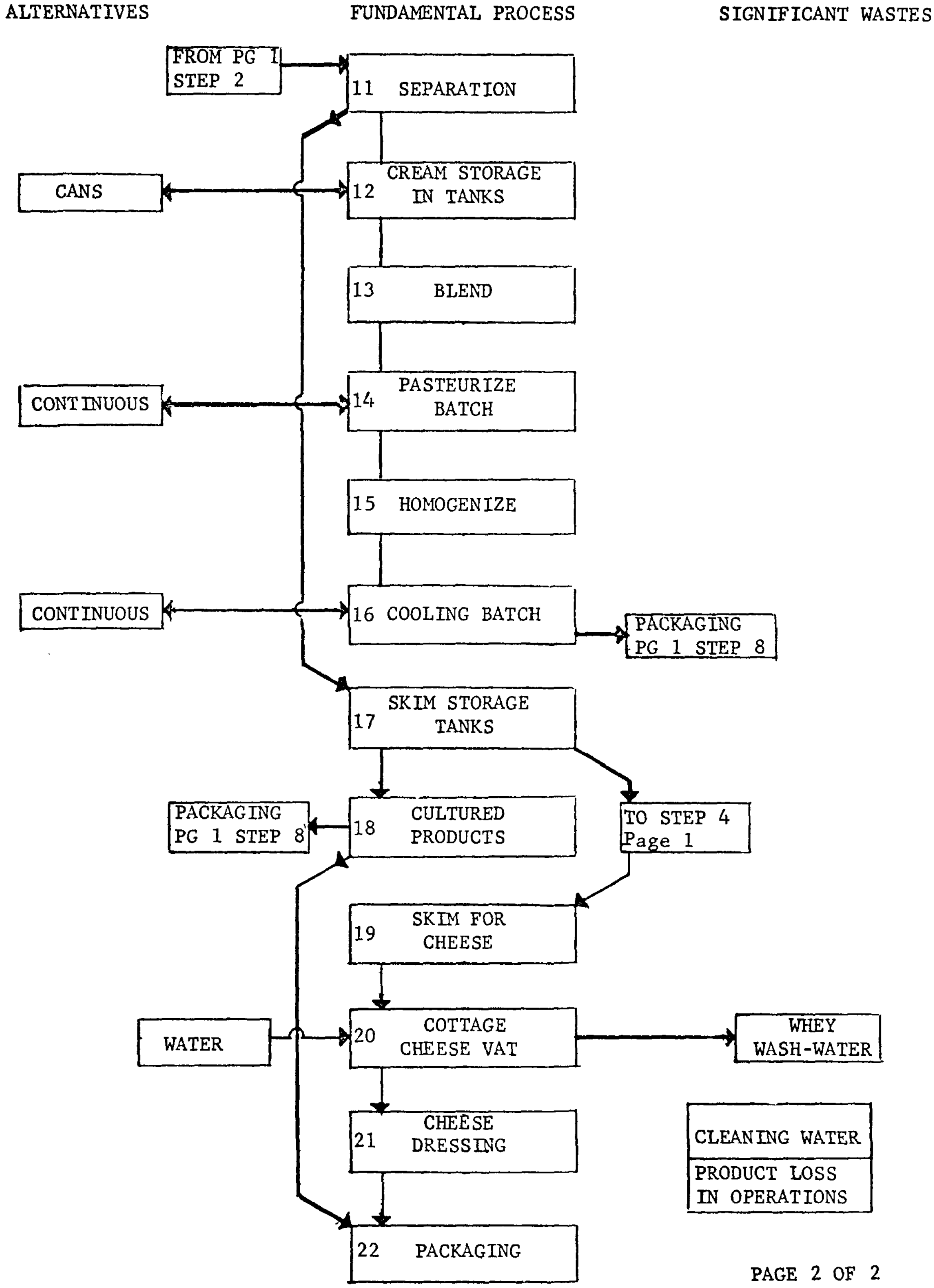
To date, whey processing remains a problem to the industry. Recent research has shown that mechanical screens are ineffective in separating whey waste; on a small scale, expensive centrifuging has been utilized effectively. Whey contains .9% to 1% albumin which, if heated and treated with acid, will result in removal of 60% to 70%. This processing, however, reduces the BOD load by only 20% to 25% and has proven to be too expensive for normal processing use. The most practical utilization of whey has been through the facilities of drying plants; however, these operate either at the breakeven point or with only a slight profit.

Less significant sources of wastes are (1) the spillage which occurs in normal processing and packaging operations and (2) the wastes incurred with cleaning equipment at the end of a day's operation. Some clear water waste occurs in those plants using water for once-through cooling in their refrigeration systems. This technique is often used in rural plants with their own wells or in areas of abundant water supply.

No water that comes in contact with the product during the manufacturing process may be reused because of the danger of contamination.

2026 FLUID MILK




ALTERNATIVES
FUNDAMENTAL PROCESS
SIGNIFICANT WASTES
FROM PG 1 STEP 2
11 SEPARATION
CANS
12 CREAM STORAGE IN TANKS
13 BLEND
CONTINUOUS
14 PASTEURIZE BATCH
15 HOMOGENIZE
CONTINUOUS
16 COOLING BATCH
PACKAGING PG 1 STEP 8
17 SKIM STORAGE TANKS
PACKAGING PG 1 STEP 8
18 CULTURED PRODUCTS
TO STEP 4 Page 1
19 SKIM FOR CHEESE
WATER
20 COTTAGE CHEESE VAT
WHEY WASH-WATER
21 CHEESE DRESSING
CLEANING WATER
PRODUCT LOSS IN OPERATIONS
22 PACKAGING

RECENT DEVELOPMENTS

The fundamental fluid milk process has changed little from 1950 to 1966 and little change is forecast for 1967 to 1977. Nevertheless, several developments of interest have occurred.

The most significant change has been in the number reduction of plants. Due to economical pressures, many small plants have closed or have merged. This trend, which is expected to continue, is depicted on Page IWP 9-135.

Since 1950, bulk tank trucks have largely replaced the 10-gallon cans used in Step 1, "Receipt", of the fundamental process. The trend has occurred because the use of trucks has virtually eliminated physical labor, improved sanitation maintenance and reduced the likelihood of contamination.

Self-cleaning (CIP) separators used in Step 3 of the fundamental process are now available. Such machinery reduces the amount of manual washing required, as well as the reduction of physical labor.

Because of tremendous volume, large plants utilize continuous flow equipment, as opposed to batch type machinery. This development has tended to reduce the percentage of plant loss in operations and, consequently, has helped to minimize wastes. Greatly improved heating and refrigeration systems have reduced water needs considerably.

In the early 1950's, vacuum deodorizing equipment became available and is now used in many areas to eliminate feed, onion and other off-flavors. This equipment has tended to increase plant product losses.

The trend in packaging is to smaller units which better serve the needs and desires of the consumer. Automatic packaging continues to replace manual methods. Not only is the amount of waste reduced, but new machinery fills more accurately.

The processing of certain cultured products is the only significant process change to occur since 1950. In the processing of sour cream, the use of chemical means as opposed to biological cultures is used in a small way and reduces the time of the process, but does not change the amount of waste.

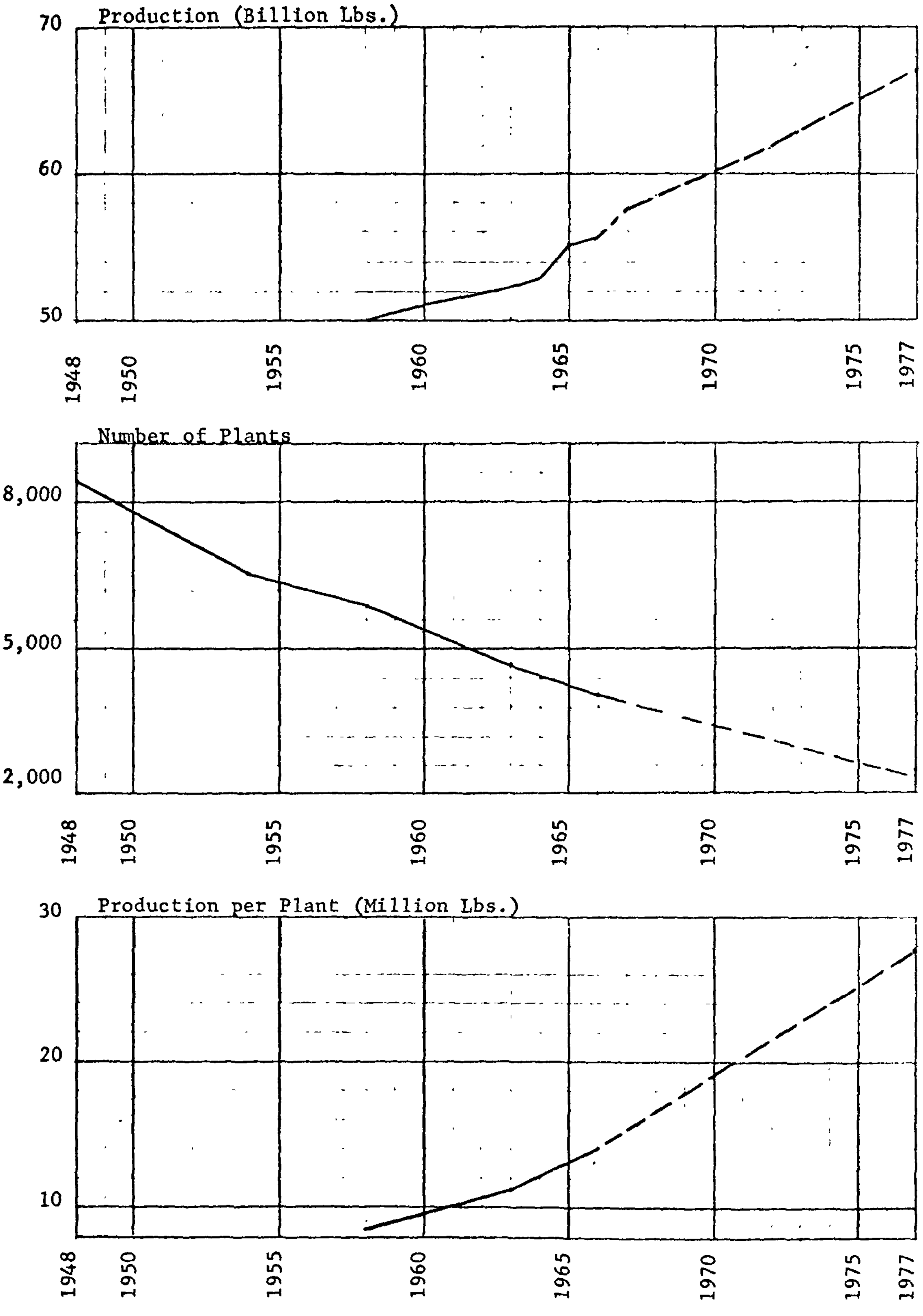
Research work is underway to develop continuous setting methods. However, commercial production does not appear imminent.

Hot pack sour cream and cottage cheese is now in use in a small way. In this process the packages are filled with the product prior to culture growth. The growth takes place in the package, and thus eliminates this step in the batch process, thus theoretically reducing waste. The actual plants utilizing this method are experiencing increased waste during the technological development of machinery.

Permanent stainless steel piping systems were introduced in the early 1950's. Such systems are cleaned in place, as opposed to the daily take-apart systems formerly accepted. This type equipment reduces the quantity of soap required and, therefore, reduces waste. The fact that the systems are permanently installed has reduced plant product losses; also, sanitation and product shelf life has been increased--a factor which has tended to reduce waste.

Significant changes have occurred in material handling within plants by the introduction of sophisticated conveyors and stacking, grouping and palletization equipment. Even though machines have tended to increase individual plant wastes through the enlarged usage of water-soap lubricants, product loss and waste has been reduced because of the less likelihood of package damage.

A large amount of dairy product manufacture has been replaced by non-dairy products especially in coffee creamers in which vegetable fat is substituted for butterfat.



Production (Billion Lbs.)
70
60
50
1948
1950
1955
1960
1965
1970
1975
1977
Number of Plants
8,000
5,000
2,000
1948
1950
1955
1960
1965
1970
1975
1977
Production per Plant (Million Lbs.)
30
20
10
1948
1950
1955
1960
1965
1970
1975
1977

The trends may best be shown in tabular form, which follows. The reader should note that the alternative subprocesses and other industry changes have occurred over a span of years.

The process which will become prevalent is identified as P, and that which is becoming less used as S.

TABLE IWP 9 - 136

Estimated Percentage of Plants Employing Process

| | | | 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|---|---|---|
| (b) | P | Receive in Tank Trucks | -0- | 50 | 60 | 70 | 90 |
| | S | Receive in Cans | 100 | 50 | 40 | 30 | 10 |
| (c) | P | Centrifuge Manually | 100 | 100 | 99 | 92 | 85 |
| | S | Clean-in-Place | -0- | -0- | 1 | 8 | 15 |
| (d) | P | Pasteurize Continuously | 30 | 50 | 60 | 70 | 90 |
| | S | Pasteurize Batch | 70 | 50 | 40 | 30 | 10 |
| (e) | P | Deodorizer Installed | -0- | 10 | 15 | 20 | 25 |
| | S | Not Installed | 100 | 90 | 85 | 80 | 75 |
| (f) | P | Package Automatically | 70 | 80 | 85 | 90 | 92 |
| | S | Package Manually | 30 | 20 | 15 | 10 | 8 |
| (g) | P | Sour Cream - Biologically | 100 | 100 | 98 | 96 | 90 |
| | S | Sour Cream - Chemically | -0- | -0- | 2 | 4 | 10 |
| (h) | P | Batch Set Cottage Cheese | 100 | 100 | 100 | 98 | 95 |
| | S | Continuous Set Cottage Cheese | -0- | -0- | -0- | 2 | 5 |
| (i) | P | Cold Pack Cultured Products | 100 | 100 | 99 | 97 | 93 |
| | S | Hot Pack Cultured Products | -0- | -0- | 1 | 3 | 7 |
| (j) | P | Welded Piping | -0- | 20 | 40 | 60 | 95 |
| | S | Take-Apart Piping | 100 | 80 | 60 | 40 | 5 |
| (k)* | P | Automatic Material Handling | -0- | 60 | 50 | 65 | 85 |
| | S | Manual Material Handling | 100 | 40 | 50 | 35 | 15 |

The estimates represent the observations and opinions of people in the industry.

*Almost all plants have conveyors of some type. This heading indicated utilization of casers, stackers, palletization devices, etc.

## Comparative Waste Control Problems

The subprocesses (Table IWP 9-136) do not require different type treatment from the fundamental processes; however, the choice of subprocesses is largely determined by the total volume produced. The continuous flow processes tend to have less waste per pound of finished product because of the greater productivity per piece of equipment.

The whey from cottage cheese manufacture, product spillage and waste during normal processing, and cleaning water and soaps represent the significant wastes for all processes and subprocesses.

In order to best estimate total industry waste and wastewater, it is desirable to identify levels of technology within the industry. The following table illustrates three technological levels. The fundamental process steps from Page IWP 9-127 are used as reference for the table which follows.

TABLE IWP 9 - 137

Comparative Technology

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
|---|---|---|---|
| 1. | Receive products in 10-gallon cans | Receive almost all products in tank trucks, although a certain amount in 10-gallon cans | Receive all products in tank truck quantities |
| 2. | Store in refrigerated tanks | Store in refrigerated tanks | Store in refrigerated tanks |
| 3. | Clarify, using strainers | Clarify in a centrifugal device | Clarify in a centrifugal device |
| 4. | Pasteurize in batch quantities | Pasteurize in a continuous manner | Pasteurize in a continuous manner |
| 5. | Homogenize in a continuous pressure pump | Homogenize in a continuous pressure pump | Homogenization in a continuous pressure |
| 6. | Deodorization not used | Deodorize in steam vacuum equipment | Deodorize in steam vacuum equipment |
| 7. | Pasteurized storage in surge tanks, and (8) | Pasteurized refrigerated storage tanks | Pasteurized refrigerated storage tanks |
| 8. | Packaging in small commercial size automatic or semi-automatic machinery | Package in automatic machinery, place containers into cases manually and stack manually on slow speed lines and automatically on high speed lines | All packaging takes place on fully automatic machinery and finished packages placed in cases automatically, stacked automatically and |

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
|---|---|---|---|
| 9. | Product sent to cold storage and handled in case quantities | Cold storage, where product is inventoried in stack quantities | Product sent to cold storage where stacked cases are handled in unit or pallet quantities, are then |
| 10. | Ship out in cases handled on an individual basis or stacks | Shipped out in stack quantities | Shipped out in unit or pallet quantities |
| | BYPRODUCTS: | | |
| 11. | Separation for by-products occurs in a centrifugal device | Separation for by-products performed in a centrifugal device | Separation in the advanced plant will take place in a separator located within the pasteurizer (4), so arranged that the milk blends, and skim milks come out of the pasteurizer in two streams already completely pasteurized and homogenized at the correct fat content to be sent directly to (7), pasteurized storage tanks, and then to packaging. The skim milk out of the advanced pasteurizer would be sent to (18) |
| 12. | Cream stored in 10-gallon cans | Cream sent to refrigerated storage tanks | |
| 13. | Blending of various creams takes place in small vats, usually the same vat as (14) | Blending takes place in refrigerated storage tanks | |
| 14. | Batch pasteurization | Pasteurization of by-products would occur in a smaller plant in batch quantities and in a large plant on a continuous pasteurizer | |
| 15. | Homogenization on a continuous pressure pump | Homogenization in a continuous pressure pump | |
| 16. | Cooling in batch quantities | Cooling in a continuous manner and then product pumped to pasteurized surges (7) for packaging | |
| 17. | Skim milk for the separation process may be stored in 10-gallon cans in a small plant and in small vats in larger plants | Skim milk from the separator is normally sent directly to storage tanks for later use | |

| | (a) Older Technology | (b) Typical Technology | (c) Advanced Technology |
|---|---|---|---|
| CULTURED PRODUCTS: | | | |
| 18. | Cultured products in small plants made in 10-gallon cans and the larger plant in batch quantities | For cultured products skim milk is pumped directly to the batch-type processors | Skim milk out of advanced pasteurizer is sent to the cultured products batch processors, or (19) |
| 19. | Skim for cheese would be pumped directly from the batch pasteurizer to (20), the cottage cheese vat | Skim for cottage cheese would be pumped directly to the cottage cheese vat from continuous pasteurizer | The cottage cheese vats at the correct temperature for innoculation |
| 20. | Setting, cooking, draining whey and washing of curds would all take place in cottage cheese vat, which would be a manual type | Cottage cheese vat is equipped with mechanical agitation and pushers; however, curd cutting, cooking and whey draining and washing would normally occur in this vat, as will (21) | Product will be set, cut and cooked in cottage cheese vat; however, the mixture of curd whey will be pumped to a separate draining device which will also have provision for washing and will be located on a weighing device so that cheese dressing may be applied |
| 21. | Cheese dressing would be made in a batch processor and mixed with the cheese in 100# cans, stored until cream is absorbed by the curd and is ready for packaging | Application of cheese dressing | Cheese dressing may be applied in known weight quantities and mixed mechanically at this point. The finished product will be pumped to (22) |
| 22. | Product transferred by hand to semi-automatic machinery or filled by hand and finished product sent to (9), cold storage | Products from the cheese vats will be pumped to semi-automatic packaging machinery where it is manually cased and sent to (9), cold storage | Automatic packaging machinery from which it will be packed automatically and sent in conveyor quantities or pallet quantities to cold storage (19) |
| 23. | Take-apart piping | Partial CIP piping | CIP piping |
| 24. | Manual material handling | Partial automatic material handling | Automatic material handling |

## Size vs. Technology

In 1963 there were 4,619 fluid milk plants producing 52,200,000,000 lbs. of milk and 829,500,000 lbs. of creamed cottage cheese. The industry considers a plant producing less than 2 million lbs. per year as "small", from 2 to 20 million lbs. as "medium" and more than 20 million lbs. as "large".

Waste and wastewater are a function of size as well as technology. TABLE IWP 9-140 represents industry (C) opinion of the relationship of size and technology.

TABLE IWP 9 - 140

Plant Statistics

1963

| | | |
|---|---|---|
| Small | 2,671 | 57.8% produce less than 2 million pounds per year |
| Medium | 1,448 | 31.4% produce from 2 to 20 million pounds per year |
| Large | 500 | 10.8% produce more than 20 million pounds per year |
| Total: | 4,619 | plants produced 52,200,000,000 lbs. of milk and 829,500,000 lbs. of creamed cottage cheese in 1963 |

| Percentage Technology Levels | Percentage of Various Sizes: Small Less than 2 | Medium 2 to 20 | Large More than 20 |
|---|---|---|---|
| 20% Older Technology | 98% | 2% | 0% |
| 70% Typical Technology | 51 | 42 | 7 |
| 10% Advanced Technology | 0 | 1 | 99 |

This relationship provides a basis for computation of overall plant wastes produced when related to unit waste production of various size plants of the three technology levels.

## Gross Waste Quantitites Before Treatment or Other Disposal

Industry (C) has observed that in plants of advanced technology waste production is less than in those less advanced. Unit waste and wastewater quantities per pound of finished product are as follows:

### TABLE IWP 9 - 141-A

#### Waste and Wastewater Quantities per Pound of Finished Product

2026 - Fluid Milk:

A. Fluid Milk

| | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gallons |
|---|---|---|---|
| Older Technology | .0026 | .0003 | 5.0 |
| Typical Technology | .0010 | .0001 | 3.5 |
| Advanced Technology | .0005 | .0001 | 2.0 |

B. Cottage Cheese

| | Whey Pounds BOD | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gallons |
|---|---|---|---|---|
| Older Technology | .128 | .012 | .0012 | 53.2 |
| Typical Technology | .128 | .008 | .0008 | 48.4 |
| Advanced Technology | .128 | .002 | .0002 | 35.1 |

This data represents industry operating experience. Whey is similar for all levels of technology because the basic process is similar for all levels; however, the other wastes are affected by plant size and technology.

## Seasonal Waste Production Pattern

Waste quantities tend to be directly proportional to production quantities; however, wastewater is used in greater quantities in the warm months, reflecting increased refrigeration requirements. The following table illustrates the relationship.

### TABLE IWP 9 - 141-B

#### Percentage of Yearly Total of Whey, Product, Soap & Chemical and Wastewater

| | W-P-S & C | Wastewater | | W-P-S & C | Wastewater |
|---|---|---|---|---|---|
| January | 7.7 | 7.4 | July | 8.6 | 9.7 |
| February | 7.9 | 7.6 | August | 8.3 | 9.6 |
| March | 10.1 | 8.2 | September | 8.3 | 8.6 |
| April | 8.9 | 8.0 | October | 7.8 | 7.6 |
| May | 8.9 | 8.8 | November | 7.5 | 7.5 |
| June | 8.8 | 9.6 | December | 7.2 | 7.4 |



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Cottage cheese consumption is historically greatest during the Lenten season. This peaking will tend to reduce due to the lifting of certain religious restrictions on the Catholic population.

Milk consumption tends to drop during the summer months; however, production of fruit drinks increases during these months so that total plant volume tends to increase. Also milk production tends to be much heavier towards the end of the week to accommodate the end-of-week consumer shopping pattern. These patterns are expected to continue.

The relationship of plant size and technology shown in Table IWP 9-140 permits a comparison of the number of plants in each technology level. The unit wastes from Table IWP 9-141-A when applied to the number of plants results in Table IWP 9-143.

## TABLE IWP 9 - 143

### Gross Waste Quantities for Average Size Plants

A. Older Technology: These plants process 6,000 lb. of milk and 96 lb. of creamed cottage cheese per day.

Significant Wastes - Lb. per Day

| # Plants | Whey Pounds BOD | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gal. per Day |
|---|---|---|---|---|
| 924 | 12.28 | 15.99 | 1.6 | 4,220 |

B. Typical Technology: These plants process 34,500 lb. of milk and 560 lb. of creamed cottage cheese per day.

Significant Wastes - Lb. per Day

| # Plants | Whey Pounds BOD | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gal. per Day |
|---|---|---|---|---|
| 3,464 | 71.68 | 44.59 | 4.5 | 17,745 |

C. Advanced Technology: These plants process 183,600 lb. of milk and 3,000 lb. of creamed cottage cheese per day.

Significant Wastes - Lb. per Day

| # Plants | Whey Pounds BOD | Product Pounds BOD | Soap & Chemicals Pounds BOD | Wastewater Gal. per Day |
|---|---|---|---|---|
| 231 | 384 | 112.5 | 11.2 | 55,515 |

TABLE IWP 9 - 144-A

Gross Waste Quantities Before Treatment or Disposal

The individual plant data (Table IWP 9-143) when multiplied by the number of plants results in gross waste quantities before treatment, disposal or utilization in byproduct manufacture.

Significant Wastes Per Year

| | Whey Pounds BOD (Millions) | Product Pounds BOD (Millions) | Soap & Chemicals Pounds BOD (Millions) | Wastewater Gallons (Millions) |
|---|---|---|---|---|
| Older Technology | 3.55 | 4.61 | .46 | 1,215 |
| Typical Technology | 77.47 | 48.18 | 4.82 | 19,179 |
| Advanced Technology | 27.68 | 8.10 | .81 | 1,586 |
| Total | 108.70 | 60.89 | 6.09 | 21,980 |
| Individual Plant Range | ± 50% | ± 50% | ± 50% | ± 20% |

TABLE IWP 9 - 144-B

Projected Waste and Wastewater

The relationship among change in total production, plant size and technology change is shown in the following table:

1963 and Projected Gross Wastes and Wastewater in Millions

| | 1963 | 1968 | 1969 | 1970 | 1971 | 1972 | 1977 |
|---|---|---|---|---|---|---|---|
| Lb. Product Mfd. | 52,200 | 58,658 | 59,363 | 60,117 | 61,074 | 62,031 | 66,990 |
| Lb. BOD Whey | 108.7 | 121.2 | 121.7 | 122.3 | 123.3 | 124.3 | 129.0 |
| Lb. BOD Product | 60.88 | 67.88 | 68.18 | 68.42 | 69.07 | 69.62 | 72.25 |
| Lb. BOD Soap & Chemicals | 6.1 | 6.8 | 6.8 | 6.8 | 6.9 | 7.0 | 7.2 |
| Subtotal | 175.68 | 195.88 | 196.68 | 197.52 | 199.27 | 200.92 | 208.45 |
| Gal. Wastewater | 21,982 | 24,207 | 23,998 | 23,796 | 23,661 | 23,509 | 22,567 |

Projections of product manufactured are based upon industry and government estimates.

## Waste Reduction Practices

The waste reduction practices utilized in the industry do not vary greatly. Wastes from the various processes and subprocesses are all similar in nature and thus a common sewer piping system is used for the entire plant. The wastes other than miscellaneous chemicals are of a "biodegradable" nature.

Certain processing methods produce varying amounts of wastes. Table IWP-145 illustrates these relationships.

### TABLE IWP 9 - 145

### Processing Practices

The fundamental process used with the "older" technology as the reference base, described on Page IWP 9-137.

| Alternate Process | % Waste Reduction Efficiency | | |
|---|---|---|---|
| | Product | Soap & Chemical | Wastewater |
| (a) Plant - Large vs. Small | 80 | 50 | 60 |
| (b) Receive - Tanks vs. Cans | 50 | 80 | 85 |
| (c) Separate - CIP vs. Manual | -0- | -0- | -0- |
| (d) Pasteurize - Continuous vs. Batch | 20 | 50 | 60 |
| (e) Deodorize vs. Not | * | -0- | * |
| (f) Package - Automatic vs. Manual | 10 | -0- | -0- |
| (g) Culture - Chemical vs. Biological | -0- | -0- | -0- |
| (h) Cheese Set - Batch vs. Continuous | ** | ** | ** |
| (i) Package Cultured Products - Hot vs. Cold | 2 *** | -0- | 2 |
| (j) Piping - CIP vs. Takedown | 50 | 40 | 44 |
| (k) Material Handling - Automatic vs. Manual | 10 | **** | **** |

*Increases product loss 0 to 1.5% of volume and wastewater 0 to 2% of volume.
**Theoretically less -- no operating data available.
***Theoretically less -- initial operating data indicates 300% increase.
****Increases wastewater proportionate to lubricant used.

A large plant may be created by the consolidation of several smaller facilities. The other subprocesses (b-k) listed above may be applied to any plant on an individual basis and are not dependent on each other; however, the common practice is to utilize continuous flow and automatic equipment together.

Continuous flow and automatic equipment tends to have capacity ratings that justify the use thereof only in the average to larger size plants.



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## Treatment Practices

The utilization of whey for byproduct manufacture is the treatment method being given the greatest amount of attention; however, a relatively small amount is being so used.

The most prevalent practice is Management Technique, i.e., that closest possible supervision of day-to-day operation to eliminate processing loss--loss due to waste resulting from the initial shrinkage of the raw material as well as the overfill of the finished package.

In general, most waste that goes to plant sewers is subsequently flowed to municipal sewers; to a lesser extent, waste may be discharged directly into lakes or streams.

The disposal through use of sewage plants represents the least used treatment practice.

The following table illustrates the effectiveness of the individual treatment practices.

TABLE IWP 9 - 146

Treatment Practices

| Removal Method | | Normal Removal Efficiency % of Total Wasteload Removed | | |
|---|---|---|---|---|
| | | Whey & Product | Soap & Chemicals | Wastewater |
| (a) | Ridge and Furrow | 95-100 | 95-100 | 4 * |
| (b) | Spray Irrigation | 95-100 | 95-100 | 5 * |
| (c) | Aerated Lagoon | 90-95 | 90-95 | 1 |
| (d) | Trickling Filter | 90-95 | 90-95 | -0- |
| (e) | Activated Sludge | 90-95 | 90-95 | -0- |
| (f) | Municipal Sewer | 100 | 100 | -0- |
| (g) | To Waterways | 100 | 100 | -0- |
| (h) | Utilization as Byproduct | 99.5 | NA | 99.5 |
| (i) | Management Technique | -0- | 40 | 40 |

*Estimated percent of total evaporated to the atmosphere, the remainder going to waterways.

NA = Not Applicable

Assuming optimum conditions, the removal methods (supra) could be employed in any given plant; however, the utilization of the ridge and furrow, spray irrigation, and aerated lagoon type processes require significant amounts of land. Furthermore, soil and climate limit both the physical size of a treatment plant as well as the choice of the treatment process.

The trickling filter and activated sludge processes are relatively compact; however, these types require greater capital investment and have higher operating costs than the other methods.

The trend is to connect plants to municipal systems wherever possible in order to simplify day-to-day operations and to minimize capital investment.

The utilization of whey in byproduct manufacture will tend to increase because of increasing relative value and need for these products.

The management technique is now being widely accepted and involves close supervision of day-to-day operations, the utilization of preventative maintenance techniques, and the use of inventory control procedures.

It is estimated that the following percentages of industrial waste have been or will be discharged to a municipal sewer:

| 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|
| 50 | 70 | 80 | 90 | 98 |

The discharge of fluid milk plant wastes to municipal systems is entirely feasible. The high BOD requirements necessitate that the capacity of a particular municipal plant be reviewed prior to the connection of a new fluid milk plant waste load to the system.

Pretreatment is not required because of the characteristics of the waste; however, pretreatment may be required if the municipal plant is of inadequate size.

The various practices have been utilized in varying degrees. Plant location, capital costs, operating costs and problems--all influence the type adoption.

TABLE IWP 9 - 147

Rate of Adoption of Waste Treatment Practices Since 1950

The rate of treatment practice adoption is shown in percentages.

| | Removal Method | % of Plants Employing Listed Methods 1950 | 1963 | 1967 | 1972 | 1977 |
|---|---|---|---|---|---|---|
| (a) | Ridge and Furrow | U* | U | U | U | U |
| (b) | Spray Irrigation | U | U | U | U | U |
| (c) | Aerated Lagoon | U | U | U | U | U |
| (d) | Trickling Filter | U | U | U | U | U |
| (e) | Activated Sludge | U | U | U | U | U |
| (f) | Municipal Sewer | 50 | 70 | 80 | 90 | 98 |
| (g) | To Waterways | 26 | 21 | 16 | 6 | -0- |
| (h) | Utilization of Whey as Byproduct | 10 | 30 | 40 | 70 | 100 |
| (i) | Management Technique | 40 | 55 | 65 | 75 | 80 |

*U = Under 1%

## Waste Reduction or Removal Cost Information

The milk industry has a capital investment in sewerage treatment facilities, and also has annual operating and maintenance expenditures in conjunction therewith. Both are rather modest considering the size of the industry.

The estimated capital investment in waste removal facilities in 1963 was $2,000,000 and the estimated annual operating expense was $400,000.

By 1966 the capital investment was estimated to have increased to $2,600,000 and the annual operating expense to have increased to $520,000.

## Comparative Investment & Operating Expenses

Plant sizes have been determined as small, medium and large and technology levels described as old, typical and advanced.

A comparison of investment cost and operating cost for providing waste and wastewater removal facilities between plants of different sizes and technologies for the various subprocesses and removal methods will provide valuable data for determining which subprocess or method offers the most attractive opportunities for use in the future to implement the Clean Water Restoration Act.

The next several pages include these comparison tables. The tables are based on investment costs and operating costs as experienced by the industry. Land has been estimated at $300 per acre for ridge and furrow, spray irrigation and aerated lagoon installation.

Management technique requires no additional capital investment. Nominal expense is included for educational purposes.

Economic life in relation to processing equipment represents current thinking on industry needs for return on investment and recognizes obsolescence.

Economic life in relation to removal methods represents observed useful life.

## TABLE IWP 9 - 150

### Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of small size. Daily "net" waste quantities from plant to sewer are 257 pounds BOD (±50%) and 4,900 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = Milk lbs. 5,300<br>Cottage Cheese 85 | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | **Subprocess:** | | | |
| (a) | Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) | Receive - Tanks vs. Cans | 5,000 | -900 | 13 |
| (c) | Separator - CIP vs. Manual | 25,000 | +6,000 | 13 |
| (d) | Deodorize vs. Not | 7,000 | +2,300 | 13 |
| (e) | Pasteurize - Continuous vs. Batch | 10,000 | -600 | 13 |
| (f) | Packaging - Automatic Older vs. Typical | 8,000 | -800 | 4 |
| (g) | Culture - Chemical vs. Biological | -0- | -400 | NA |
| (h) | Cheese Set - Continuous vs. Batch | NA | NA | NA |
| (i) | Pack Culture Products - Hot vs. Cold | 10,000 | +2,000 | 13 |
| (j) | Piping - CIP vs. Take-apart | 12,000 | -1,900 | 13 |
| (k) | Material Handling - Automatic vs. Manual | 8,000 | ±0 | 13 |
| | **Removal Method:** | | | |
| (a) | Ridge and Furrow | $ 1,500 | $ +300 | 20 |
| (b) | Spray Irrigation | 4,200 | +800 | 20 |
| (c) | Aerated Lagoon | 14,200 | +2,800 | 20 |
| (d) | Trickling Filter | 19,900 | +4,000 | 15 |
| (e) | Activated Sludge | 13,300 | +2,700 | 15 |
| (f) | Municipal Sewer | 200 | +1,300 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Utilization as Byproduct | 20,000 | +4,000 | 13 |
| (i) | Management Technique | -0- | -1,100 | * |

NA = Not Applicable     * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-149.

## TABLE IWP 9 - 151

## Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of small size. Daily "net" waste quantities from plant to sewer are 68 pounds BOD (±50%) and 2,700 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = Milk lbs. 5,300 / Cottage Cheese 85 | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | Subprocess: | | | |
| (a) | Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) | Receive - Tanks vs. Cans | 5,000 | -200 | 13 |
| (c) | Separator - CIP Vs. Manual | 25,000 | +6,000 | 13 |
| (d) | Deodorize vs. Not | 7,000 | +2,300 | 13 |
| (e) | Pasteurize - Continuous | AH | NA | 13 |
| (f) | Packaging | AH | NA | 4 |
| (g) | Culture - Chemical vs. Biological | -0- | -400 | NA |
| (h) | Cheese Set - Continuous vs. Batch | NA | NA | NA |
| (i) | Pack Culture Products - Hot vs. Cold | 10,000 | +2,000 | 13 |
| (j) | Piping - CIP Typical vs. Advanced | 6,000 | -900 | 13 |
| (k) | Material Handling - Automatic vs. Manual | 8,000 | ±0 | 13 |
| | Removal Method: | | | |
| (a) | Ridge and Furrow | $ 800 | $ +200 | 20 |
| (b) | Spray Irrigation | 2,300 | +500 | 20 |
| (c) | Aerated Lagoon | 3,700 | +800 | 20 |
| (d) | Trickling Filter | 11,000 | +2,200 | 15 |
| (e) | Activated Sludge | 7,300 | +1,500 | 15 |
| (f) | Municipal Sewer | 200 | +300 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Utilization as Byproduct | 20,000 | +4,000 | 13 |
| (i) | Management Technique | -0- | -200 | * |

NA = Not Applicable * Permanent

AH = Already installed by definition

See Reference Notes on Page IWP 9-8 and IWP 9-149.

There are no small plants of advanced technology.

TABLE IWP 9 - 152

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the older technology and of medium size. Daily "net" waste quantities from plant to sewer are 1,912 pounds BOD (±50%) and 36,500 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = Milk lbs. 39,500<br>Cottage Cheese 630 | | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|---|
| | **Subprocess:** | | | |
| (a) | Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) | Receive - Tanks vs. Cans | 10,000 | -6,400 | 13 |
| (c) | Separator - CIP vs. Manual | 25,000 | +4,000 | 13 |
| (d) | Deodorize vs. Not | 10,000 | +8,000 | 13 |
| (e) | Pasteurize - Continuous vs. Batch | 15,000 | -3,300 | 13 |
| (f) | Packaging - Automatic Older vs. Typical | 34,000 | -6,300 | 4 |
| (g) | Culture - Chemical vs. Biological | -0- | -800 | NA |
| (h) | Cheese Set - Continuous vs. Batch | NA | NA | NA |
| (i) | Pack Culture Products - Hot vs. Cold | 25,000 | -3,000 | 13 |
| (j) | Piping - CIP vs. Take-apart | 38,000 | -6,600 | 13 |
| (k) | Material Handling - Automatic vs. Manual | 45,000 | 11,800 | 13 |
| | **Removal Method:** | | | |
| (a) | Ridge and Furrow | $ 10,900 | $ +2,200 | 20 |
| (b) | Spray Irrigation | 31,500 | +6,300 | 20 |
| (c) | Aerated Lagoon | 105,000 | +21,000 | 20 |
| (d) | Trickling Filter | 69,000 | +13,800 | 15 |
| (e) | Activated Sludge | 46,000 | +9,200 | 15 |
| (f) | Municipal Sewer | 200 | +9,600 | * |
| (g) | To Waterways | -0- | -0- | * |
| (h) | Utilization as Byproduct | 40,000 | +4,000 | 13 |
| (i) | Management Technique | -0- | -11,000 | * |

NA = Not Applicable          * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-149.

TABLE IWP 9 - 153

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of medium size. Daily "net" waste quantities from plant to sewer are 502 pounds BOD (±50%) and 19,600 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = Milk lbs. 39,500<br>Cottage Cheese 630 | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) Receive - Tanks vs. Cans | 10,000 | -2,400 | 13 |
| (c) Separator - CIP vs. Manual | 25,000 | +4,000 | 13 |
| (d) Deodorize - Typical vs. Advanced | 10,000 | +8,000 | 13 |
| (e) Pasteurize - Continuous Typical vs. Advanced | 5,000 | -300 | 13 |
| (f) Packaging - Automatic Typical vs. Advanced | 24,000 | -3,100 | 4 |
| (g) Culture - Chemical vs. Biological | -0- | -800 | NA |
| (h) Cheese Set - Continuous vs. Batch | NA | NA | NA |
| (i) Pack Culture Products - Hot vs. Cold | 25,000 | -3,000 | 13 |
| (j) Piping - CIP vs. Take-apart | 19,000 | -2,500 | 13 |
| (k) Material Handling - Typical vs. Advanced | 25,000 | -4,700 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 5,900 | $ +1,200 | 20 |
| (b) Spray Irrigation | 16,700 | +3,300 | 20 |
| (c) Aerated Lagoon | 27,600 | +5,500 | 20 |
| (d) Trickling Filter | 79,500 | +15,900 | 15 |
| (e) Activated Sludge | 53,000 | +10,600 | 15 |
| (f) Municipal Sewer | 200 | +2,500 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 40,000 | +6,000 | 13 |
| (i) Management Technique | -0- | -4,000 | * |

NA = Not Applicable * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-149.

## TABLE IWP 9 - 154

### Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of medium size. Daily "net" waste quantities from plant to sewer are 271 pounds BOD (±50%) and 15,300 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = Milk lbs. 39,500 / Cottage Cheese 630 | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -15% | $ -20% | 13 |
| (b) Receive - Tanks | AH | NA | 13 |
| (c) Separator - CIP | AH | NA | 13 |
| (d) Deodorize vs. Not | AH | NA | 13 |
| (e) Pasteurize - Continuous | AH | NA | 13 |
| (f) Packaging - Automatic | AH | NA | 4 |
| (g) Culture - Chemical vs. Biological | -0- | -800 | NA |
| (h) Cheese Set - Continuous vs. Batch | NA | NA | 13 |
| (i) Pack Culture Products - Hot vs. Cold | 60,000 | -7,000 | 13 |
| (j) Piping - CIP | AH | NA | 13 |
| (k) Material Handling - Automatic | AH | NA | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 4,600 | $ +900 | 20 |
| (b) Spray Irrigation | 13,000 | +2,600 | 20 |
| (c) Aerated Lagoon | 14,900 | +3,000 | 20 |
| (d) Trickling Filter | 62,000 | +12,400 | 15 |
| (e) Activated Sludge | 41,300 | +8,200 | 15 |
| (f) Municipal Sewer | 200 | +1,400 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 40,000 | +6,000 | 13 |
| (i) Management Technique | -0- | -2,500 | * |

NA = Not Applicable
AH = Already installed by definition
* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-149.

## TABLE IWP 9 - 155

### Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the typical technology and of large size. Daily "net" waste quantities from plant to sewer are 2,439 pounds BOD (±50%) and 95,300 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = Milk lbs. 191,000 / Cottage Cheese 3,100 | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) Receive - Tanks vs. Cans | 32,000 | -9,400 | 13 |
| (c) Separator - CIP vs. Manual | 25,000 | +3,000 | 13 |
| (d) Deodorize vs. Not | 15,000 | +23,000 | 13 |
| (e) Pasteurize - Continuous Typical vs. Advanced | 5,000 | -800 | 13 |
| (f) Packaging - Automatic Typical vs. Advanced | 48,000 | -3,700 | 4 |
| (g) Culture - Chemical vs. Biological | -0- | -3,200 | NA |
| (h) Cheese Set - Continuous vs. Batch | NA | NA | NA |
| (i) Pack Culture Products - Hot vs. Cold | 60,000 | -7,000 | 13 |
| (j) Piping - CIP vs. Take-apart | 95,000 | -22,300 | 13 |
| (k) Material Handling - Typical vs. Advanced | 28,000 | -5,300 | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $ 28,600 | $ +5,200 | 20 |
| (b) Spray Irrigation | 81,000 | +14,600 | 20 |
| (c) Aerated Lagoon | 134,000 | +24,100 | 20 |
| (d) Trickling Filter | 103,000 | +18,500 | 15 |
| (e) Activated Sludge | 68,500 | +12,300 | 15 |
| (f) Municipal Sewer | 200 | +12,200 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 90,000 | ±0 | 13 |
| (i) Management Technique | -0- | 29,600 | * |

NA = Not Applicable  * Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-149.

There are no large plants of older technology.

TABLE IWP 9 - 156

Comparative Costs

(For Providing Waste & Wastewater Removal Facilities)

The plant illustrated is representative of the advanced technology and of large size. Daily "net" waste quantities from plant to sewer are 1,317 pounds BOD (±50%) and 74,200 gallons of wastewater (±20%). These quantities are "gross" to waterways.

| Product = Milk lbs. 191,000<br>Cottage Cheese 3,100 | Capital Costs | Annual Operating & Maintenance Expenditure | (Years) Economic Life |
|---|---|---|---|
| Subprocess: | | | |
| (a) Plant - Large vs. Small | $ -10% | $ -15% | 13 |
| (b) Receive - Tanks vs. Cans | AH | NA | 13 |
| (c) Separator - CIP | AH | NA | 13 |
| (d) Deodorize vs. Not | AH | NA | 13 |
| (e) Pasteurize - Continuous | AH | NA | 13 |
| (f) Packaging - Automatic | AH | NA | 4 |
| (g) Culture - Chemical Set | AH | NA | NA |
| (h) Cheese Set - Continuous | NA | NA | NA |
| (i) Pack Culture Products - Hot Pack | AH | NA | 13 |
| (j) Piping - CIP | AH | NA | 13 |
| (k) Material Handling - Automatic | AH | NA | 13 |
| Removal Method: | | | |
| (a) Ridge and Furrow | $22,200 | $ +4,000 | 20 |
| (b) Spray Irrigation | 63,000 | +11,400 | 20 |
| (c) Aerated Lagoon | 72,000 | +13,000 | 20 |
| (d) Trickling Filter | 97,000 | +17,500 | 15 |
| (e) Activated Sludge | 64,500 | +11,600 | 15 |
| (f) Municipal Sewer | 200 | +6,600 | * |
| (g) To Waterways | -0- | -0- | * |
| (h) Utilization as Byproduct | 90,000 | ±0 | 13 |
| (i) Management Technique | -0- | -14,600 | * |

NA = Not Applicable
AH = Already installed by definition

* Permanent

See Reference Notes on Page IWP 9-8 and IWP 9-149.

The tables indicate that several subprocesses and removal methods are particularly attractive in terms of small capital investment and low annual operating expense.

The utilization of whey in byproduct manufacture eliminates this material as a waste. The plant with condensing and drying equipment will utilize whey as a byproduct if there is a market available; otherwise the plant with or without this equipment tends to send whey to the sewage system.

The application of management technique requires no capital investment and very little operating expense, and results in significant economy in plant operations, and is a highly desirable practice.

Disposal of remaining waste to municipal sewers requires only nominal investment and operating cost at the plant and is attractive to the plant operation. However, if a municipality establishes a sewage rate charge based directly on plant waste loads, then comparative economics determine whether or not the plant should adopt further waste removal methods.

Summary of Projected Wasteloads

| Year | Waste | | Gross Waste Generated | Removal * | | Net Waste Discharged |
|---|---|---|---|---|---|---|
| | | | Million | % | | Million |
| 1963 | Whey (Lb. BOD) | | 108.7 | 80 | | 21.74 |
| | Product (Lb. BOD) | | 60.88 | 80 | | 12.18 |
| | Soap & Chemical (Lb. BOD) | | 6.1 | 80 | | 1.2 |
| | | ST | 175.68 | | ST | 35.12 |
| | Water (Gallons) | | 21,982 | | | 20,883 |

*Percentage of waste reduced or removed by process changes, waste treatment and byproducts utilization.

Summary of Projected Wasteloads

| Year | Waste | Gross Waste Generated Million | Removal * % | | Net Waste Discharged Million |
|---|---|---|---|---|---|
| 1968 | Whey (Lbs. BOD) | 121.2 | 87 | | 15.76 |
| | Product (Lbs. BOD) | 67.88 | 87 | | 8.82 |
| | Soap & Chemical (Lbs. BOD) | 6.8 | 87 | | .9 |
| | ST | 195.88 | | ST | 25.48 |
| | Water (Gallons) | 24,207 | 5 | | 22,997 |
| 1969 | Whey (Lbs. BOD) | 121.7 | 89 | | 13.39 |
| | Product (Lbs. BOD) | 68.18 | 89 | | 7.50 |
| | Soap & Chemical (Lbs. BOD) | 6.8 | 89 | | .7 |
| | ST | 196.68 | | ST | 21.59 |
| | Water (Gallons) | 23,998 | 5 | | 22,798 |
| 1970 | Whey (Lbs. BOD) | 122.3 | 91 | | 11.01 |
| | Product (Lbs. BOD) | 68.42 | 91 | | 6.16 |
| | Soap & Chemical (Lbs. BOD) | 6.8 | 91 | | .6 |
| | ST | 197.52 | | ST | 17.77 |
| | Water (Gallons) | 23,796 | 5 | | 22,606 |
| 1971 | Whey (Lbs. BOD) | 123.3 | 93 | | 8.63 |
| | Product (Lbs. BOD) | 69.07 | 93 | | 4.83 |
| | Soap & Chemical (Lbs. BOD) | 6.9 | 93 | | .5 |
| | ST | 199.27 | | ST | 13.96 |
| | Water (Gallons) | 23,661 | 5 | | 22,478 |
| 1972 | Whey (Lbs. BOD) | 124.3 | 95 | | 6.22 |
| | Product (Lbs. BOD) | 69.62 | 95 | | 3.48 |
| | Soap & Chemical (Lbs. BOD) | 7.0 | 95 | | .3 |
| | ST | 200.92 | | ST | 10.00 |
| | Water (Gallons) | 23,509 | 5 | | 22,334 |
| 1977 | Whey (Lbs. BOD) | 129.0 | 99.5 | | .65 |
| | Product (Lbs. BOD) | 72.25 | 99.5 | | .036 |
| | Soap & Chemical (Lbs. BOD) | 7.2 | 99.5 | | .004 |
| | ST | 208.45 | | ST | .690 |
| | Water (Gallons) | 22,567 | 5 | | 21,439 |

*Percentage of Waste Reduced or Removed by Process Changes, Waste Treatment and Byproducts Utilization

# REFERENCE SOURCES

A. Federal and State

1. Department of Agriculture
   Dr. A. C. Manchester
   Mr. A. G. Mathis

2. Bureau of Census

3. State of Wisconsin, Department of Natural Resources
   Mr. Theodore Wisniewski

B. Associations and Committees

1. Dairy Industry Waste Committee

2. Dairy and Food Industries Supply Association, Inc.

   Mr. Fred C. Messemer
   Mrs. G'Schwend

3. Evaporated Milk Association
   Mr. Fred Greiner

C. Industry

1. Mr. A. G. Larsen
   The Great Atlantic & Pacific Tea Co.
   New York, New York

2. Mr. Orville Karhl
   Beatrice Foods
   Chicago, Illinois

3. Dr. H. Howard
   Borden Company
   New York, New York

4. Mr. H. S. Christianson
   Carnation Company
   Los Angeles, California

5. Mr. J. E. Crowley
   Crowley's Milk Company
   Binghampton, New York

6. Mr. G. A. Houran
   Delaval Separator Company
   Poughkeepsie, New York

7. Mr. Joseph Maldari
   Foremost Dairies, Inc.
   San Francisco, California

8. Mr. Tetherow
   Knudsen Creamery of California
   Los Angeles, California

9. Michigan Milk Producers Association
   Detroit, Michigan

10. Mr. J. W. Rugaber
    Pet Milk Company
    St. Louis, Missouri

11. Mr. L. J. Fox
    Safeway Stores, Inc.
    Oakland, California

12. Dr. Gordon Harding
    Mr. Frank McKee
    National Dairies Research Laboratory
    Glenview, Illinois

13. Mr. Kenneth Burke
    Sealtest Dairies, Southern Division
    Charlotte, North Carolina

14. Mr. R. B. Barrett
    Klenzade Products
    Beloit, Wisconsin

15. Land-O-Lakes Creameries, Inc.
    Minneapolis, Minnesota

and many individual companies

D. <u>Publications and Books</u>

1. Industrial Waste Guide - Dairy Industry
   Waste Committee Publication

2. Sewerage and Sewerage Treatment - Wiley

and many trade journal articles

E. <u>Johnson Associates International</u>
   reported operational experience from more than 155 processing facilities (approximately 350 plants as described in the Profile).

## SUMMARY

## SCOPE OF MATERIAL COVERED

Industrial Waste Profile IWP-9 Dairies is a qualitative and quantitative description of wastes and wastewater generated in the Dairy Industry identified in SIC Code as 202 Dairy Products.

The Industry is examined in its important major subdivisions identified by SIC Code as follows:

2021 Creamery Butter - Establishments primarily engaged in manufacturing creamery butter.

2022 Cheese, Natural and Processed - Establishments primarily engaged in manufacturing all types of natural cheese (except cottage cheese - Industry 2026), processed cheese, cheese foods, and cheese spreads.

2023 Condensed and Evaporated Milk - Establishments primarily engaged in manufacturing condensed and evaporated milk and related products, including ice cream mix and ice milk mix made for sale as such and dry milk products.

2024 Ice Cream and Frozen Desserts - Establishments primarily engaged in manufacturing ice cream and other frozen desserts.

2026 Fluid Milk - Establishments primarily engaged in processing, packaging and distributing fluid milk and cream, cottage cheese, and related products.

The Profile is prepared for the Base Year of 1963 which permits correlation with 1963 Census of Manufacturers data for production and water use.

The waste and wastewater estimates are developed from actual plant operating experience, are correlated with manufacturing processes and are augmented by waste reduction and removal cost estimates.

Projections of waste and wastewater for future years are developed in detail.

Government statistics show that total milk production has declined steadily since 1964, but the U. S. Department of Agriculture prognosticates that production is at or near the minimum and will tend to increase in the future in proportion to population growth.

The number of processing plants has decreased more rapidly than production; production per plant, however, has increased rapidly. This trend will continue because the cost per unit of product in the larger technologically advanced plants is significantly less than in the smaller less advanced plants.

Waste and wastewater production per pound of product is lower in a large plant than in a small plant, and is also lower in a technologically advanced plant than in one less advanced.

Dairy wastes are similar in all of the five processing groups. The most significant wastes include: product loss in the process stream, water, soap and chemicals used in sanitation procedures, cooling water, skim milk and buttermilk from butter manufacture and cream and whey from cheese manufacture.

Product loss during processing can never be reduced to zero; however, the industry finds that large technologically advanced plants have process stream product waste of 1/2%, compared to a waste of 1 to 1-1/2% in the typical plant, and to 2-1/2% waste in the small plants of older technology. This reduction in waste represents a considerable financial saving and is a contributing factor in the trend towards the consolidation and building of large plants (labor costs being the primary factor). Plant management technique has as much to do with process stream loss reduction as does plant size or technology. One should note that this resultant waste is in addition to the "shrinkage" in receipts of raw product and "loss" due to overfill, which when combined with process waste comprise the plant "loss".

Water, soap and chemicals used for sanitation represent waste and wastewater volume that is proportionately less for large technologically advanced plants than for small, less advanced plants. Most soaps now used are of the "biodegradable" type which decompose readily during sewage treatment. Advancing technology in sanitation has resulted in the use of welded stainless steel lines, "cleaned in place" (CIP) product piping systems, and automation of many processes which greatly improve total plant sanitation. These in turn improve product shelf life and reduce waste. The design and operation of the sanitation systems has much to do with the quantities of wastes produced, which if not properly operated, can actually result in increased wastes in technologically advanced plants. The trend, however, is toward the reduction in the amount of soap and chemicals used.

Cooling water waste is created by cooling products in processing equipment or by use in the refrigeration systems. The availability and cost of cooling water determines whether a "once-through" usage is employed as opposed to recirculation through cooling towers and evaporative condensers. The latter reduce water requirements by 95%. As water becomes scarce or expensive, the use of recirculation equipment will increase.

Skim milk and buttermilk from butter manufacture and cream and whey from cheese manufacture are wastes which can be utilized in by-product manufacture. The great bulk of the skim milk and buttermilk from butter manufacture is currently used in the manufacture of condensed and powdered products. As butter plants increase in size, the individual plant output of these products grows in volume and becomes more economical to use in by-product manufacture. Cream from the cheese manufacturing process is always utilized because of the great value of this product. On the other hand, whey does not have great commercial value. Some uses for whey have been developed, but the greatest incentive toward whey utilization has been the penalties imposed on industry when untreated whey is sent to waterways.

Whey comprises the largest sewerage load (BOD) that is not economically subject to reduction in volume through utilization in by-product manufacture. There are relatively few whey drying plants. The plants which are operating are doing so at a "breakeven point" or at a slight profit. If whey becomes more valuable because milk production increases at a slower rate than consumption, then whey processing plants will tend to become more profitable; however, until products derived from whey increase in value, the municipal incentives and penalties will determine how whey is utilized.

Past and projected industry aggregate wastes prior to reduction through utilization in by-product manufacture are as follows:

| Waste Before Reduction (In Millions) | 1963 | 1968 | 1972 | 1977 |
|---|---|---|---|---|
| Total Milk Production Pounds | 125,000 | 122,200 | 127,200 | 133,700 |
| Product (Lb. BOD) | 130.09 | 136.14 | 138.03 | 141.10 |
| Soap & Chemical (Lb. BOD) | 13.0 | 13.6 | 13.8 | 14.1 |
| Cream, Skim & BM (Lb. BOD) | 4,195.2 | 3,781.6 | 4,000.9 | 4,321.3 |
| Whey (Lb. BOD | 537.3 | 625.7 | 657.9 | 718.3 |
| Total Theoretical Load (Lb. BOD) | 4,875.59 | 4,557.04 | 4,810.63 | 5,194.80 |
| Wastewater (Gallons) | 59,847 | 57,601 | 52,547 | 45,805 |

The wastes that are not reduced as previously described, are sent to waterways.

| Net Waste to Waterways (In Millions) | 1963 | 1968 | 1972 | 1977 |
|---|---|---|---|---|
| Product (Lb. BOD) | 60.9 | 47.4 | 20.0 | 8.0 |
| Soap & Chemical (Lb. BOD) | 6.1 | 4.7 | 2.0 | .82 |
| Cream, Skim & BM (Lb. BOD) | 620.2 | 334.3 | 196.9 | 21.6 |
| Whey (Lb. BOD) | 244.6 | 251.0 | 139.6 | 31.1 |
| Total Sewerage Load | 931.8 | 637.4 | 358.5 | 61.52 |
| Total Wastewater (Gallons) | 35,971 | 31,725 | 27,586 | 22,077 |

These net wastes must be treated to eliminate water pollution. The wastes may be treated biologically in standard sewage treatment plants. Dairy wastes have a high sewage (BOD) demand in relation to volume, but are generally low in suspended solids.

Special attention has been given to treatment of cheese whey because of small amount of cheese curd carried by the whey as well as the large volume involved.

Most dairy plants are not large enough in size to justify the cost of an industrial plant treatment system as this may represent an excessively large capital investment compared to total investment in plant (10 to 20%).

The proper operation of a treatment plant requires qualified technical personnel, thus causing the individual plant treatment system to be high in operating cost.

It is preferable to discharge dairy plant wastes to municipal systems where possible. In rural areas, lagoons can be used for large plant waste treatment and ridge and furrow and irrigation systems for waste from smaller plants.

Treatment plants become necessary only when municipal incentives and penalties are established.

The following table summarizes the information developed in the individual chapters.

| | 1963 | 1968 | 1972 | 1977 |
|---|---|---|---|---|
| Total Milk Production (Billion Lb.) | 125.0 | 122.2 | 127.2 | 133.7 |
| Total No. of Plants | 10,142 | 7,600 | 6,350 | 4,861 |
| Technological Advance: | | | | |
| (1) % increase in plant size | -- | 45.8 | 83.9 | 161.6 |
| (2) % plants becoming technologically advanced | -- | 56 | 94 | 100 |
| (3) % process waste reduced by advance | -- | 5 | 9 | 14 |
| Utilization of Waste in By-product Manufacture: | | | | |
| (1) % skim milk from butter manufacture | 85 | 91 | 95 | 99.5 |
| (2) % buttermilk from butter manufacture | 85 | 91 | 95 | 99.5 |
| (3) % cream from cheese manufacture | 99 | 99 | 99 | 99.5 |
| (4) % whey from cheese manufacture | 48 | 53 | 75 | 99.5 |
| Estimated Development of Sewage Treatment Practices: | | | | |
| (1) Plants in municipalities | | | | |
| (a) % to municipal sewer | 98 | 98 | 98 | 99 |
| (b) % to plant operated systems | 2 | 2 | 2 | 1 |
| (2) Rural plants | | | | |
| (a) % to ridge and furrow | 8 | 11 | 22 | 33 |
| (b) % to spray irrigation | 4 | 5 | 8 | 11 |
| (c) % to aerated lagoons | 8 | 11 | 22 | 56 |
| (d) % to waterways untreated | 80 | 73 | 48 | 0 |
| Net Waste to Waterways: (Million Lb. BOD) | 931.8 | 637.4 | 358.5 | 61.52 |
| Total Wastewater: (Million Gallons) | 35,971 | 31,725 | 27,586 | 22,077 |



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