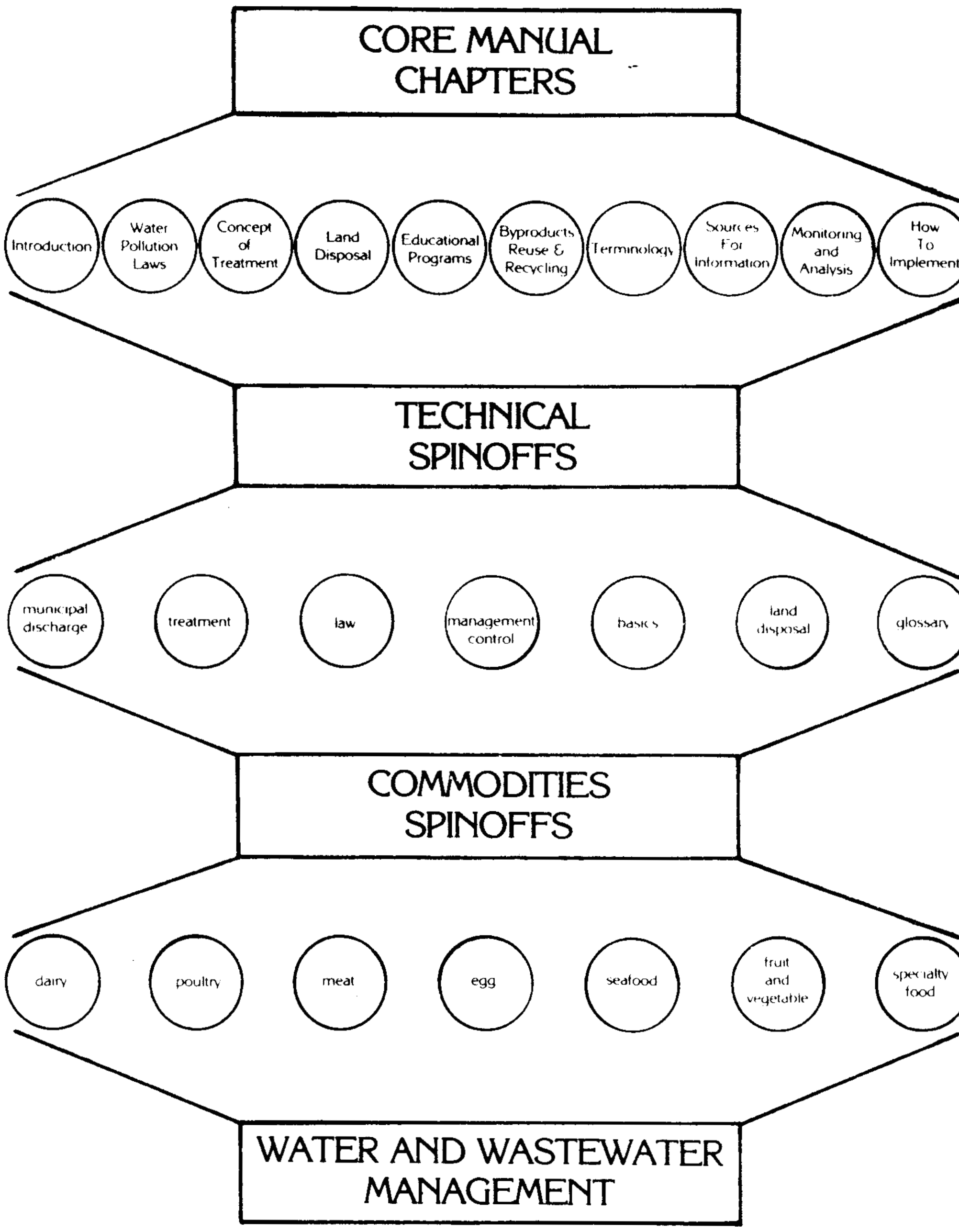
WATER AND WASTE WATER MANAGEMENT IN FOOD PROCESSING

WATER AND WASTEWATER MANAGEMENT

In Food Processing Plants - An Educational Program

The objective of this program is to increase the knowledge of food scientists, food processors, engineers, scientists, waste management specialists and other practitioners in the concepts and principles needed to properly control water use and product waste in food processing facilities. The materials are designed for individuals concerned with management of food plants, with pretreatment of food processing wastewaters, with treatment of food processing wastewaters and with the utilization or disposal of food plant residuals. The modules in this program incorporate knowledge from food science and technology, food processing, sanitary and environmental engineering, agronomy, soil science, agricultural engineering, economics and law.

The program consists of some 15 modules. Introductory material is presented in the Core Manual to introduce the program. Technical specifics are provided in 7 technical spinoffs. The application of water and waste management in specific food plants is related in 7 commodity Spinoff Manuals.



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SPINOFF ON

MEAT PROCESSING
WATER AND WASTEWATER MANAGEMENT

ROY E. CARAWAN

JAMES V. CHAMBERS   ROBERT R. ZALL

PROJECT SUPERVISOR

ROGER H. WILKOWSKE

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PREPARED BY
EXTENSION SPECIALISTS AT :
NORTH CAROLINA STATE UNIVERSITY
CORNELL UNIVERSITY
PURDUE UNIVERSITY

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PREFACE

Purpose: The main purpose of this MEAT WATER AND WASTEWATER MANAGE-MENT SPINOFF is to be a primary reference document to aid the extension specialist in assisting meat processors in meeting water pollution requirements. This document is intended as a guide, in that it attempts to provide broad coverage, but cannot be totally comprehensive on all topics. Instead , it gives general information on a wide scale, and then directs the reader to additional specific data and bibliographic information.

By presenting the fundamentals of water and waste management for meat processing, this booklet will enable the extension specialist to help processors develop effective water and waste control programs. Such programs can enable these processors to better meet current water pollution control regulations and prepare for future, more stringent regulations. Thus, this guide can be a tool to help extension specialists and food processors alleviate present misunderstandings and avoid future problems. In addition, this guide can aid in bringing together representatives from the meat industry and regulatory agencies to coordinate their mutual interest in reducing water pollution.

Audience: This guide should be valuable not only to extension specialists for which it was prepared, but also for food processors and regulatory officials charged with the review and approval of wastewater discharge from food plants not only to surface waters but also to municipal wastewater treatment systems.

Scope: The subject of this guide is the management and control of water use and waste discharge in meat processing, with emphasis on necessary legal, sanitary, environmental and energy factors. In preparing this guide, the committee has attempted to maintain a uniformity of recommendations and suggestions, despite the variety of processing plants and the disparity of requirements for pollution control throughout the country.

Limitations: No written material dealing with pollution control regulations can remain current and up-to-date with our rapidly changing regulations. Therefore, the reader is advised to check on current laws and local regulations before consideration of any pollution control project. The vast differences and complexities that exist in meat processing do not allow for a detailed information that would be applicable to any plant without modification.

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Learning Objectives :

1. Recognition of unit operations and plant practices that can or do contribute to pollution.
2. Understanding of the key elements in a water and waste control program for a meat processing plant.
3. Identification of the key federal, state and local pollution laws and regulations that affect meat processors.
4. Appreciation of the possible role of an extension specialist in assisting processors to meet water pollution control regulations .

SUMMARY

The important factors for extension specialists to consider in developing programs to assist the meat industries in meeting water pollution requirements are presented. This document includes the following: (1) role an extension specialist can play in plant pollution problems, (2) components of an effective water and waste control program in meat processing, (3) methods for monitoring and analyzing wastewaters, (4) terminology and concepts of pretreatment and treatment of meat processing wastewaters, and (5) notes for developing an effective extension program for meat processing plants.

Each meat processing plant has numerous operations that use water and discharge skin, blood, bits of flesh or rejects which can contribute to pollution and specific examples are reviewed for selected plants. The possible ways these operations can be modified or employee practices changed to reduce water use and waste are identified and discussed. The role of management in processing water and waste control is explained.

Various practices to reduce pollution after the institution of inplant water and waste management procedures are presented. These practices include pretreatment , by-product recovery and/or treatment. The most important aspects of each of these are reviewed.

The opportunities for wastewater discharge from a meat processing plant are recognized as either discharge to a municipal system or discharge directly to a stream, estuary or the ocean. The important factors to consider in municipal discharge of meat processing wastes are identified as sewer use ordinances, user charges and pretreatment. State, federal and local regulations for pretreatment are reviewed. State and local requirements for discharge limitations to meet NPDES permits or water quality criteria are listed and discussed.

Parameters of importance for meat processors for municipal or direct discharge are identified as BOD5, TSS, FOG, pH, ammonia and flow. The importance of proper sampling and analytical techniques are explained.

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INTRODUCTION

As of March 1, 1973, there were 5991 meat slaughtering plants in these 48 contiguous states and Hawaii. Of these, 1364 were federally inspected. Perhaps 85% of the plants are small (local meat lockers, etc. handling less than 43,000 kg or 100,000 lbs of animals per day) for which waste load data are almost universally unavailable. The remaining 15% of the plants account for by far the largest part -- probably greater than 90% -- of the production, and thus, of the waste load.

Meat packing plants carry out the salughtering and processing of cattle, calves, hogs, and sheep for the preparation of meat products and by-products from these animals. The plants in this industry range from plants that carry out only one operation, such as slaughtering, to full-line plants that not only slaughter, but also carry out processing to varying degrees (manufacturing of meat products such as sausages, cured hams, smoked products, etc.). The amount of processing varies considerably, because some process only a portion of their kill, while others process not only their kill, but also the kill from other plants. Most full-1 i ne plants (packinghouses) and many slaughterhouses also render by-products; edible and inedible by-products are rendered from edible fats and trimmings and from inedible materials, respectively.

While the industry is spread over much of the country, the states of Nebraska and Iowa led the nation in beef slaughter with nearly 4.7 million head each in 1972. Between them, these two states accounted for over 26 percent of the beef product ion in the nation. The other states making up the first ten in beef slaughter, each with over one million head, are Texas, California, Kansas, Colorado, Minnesota, Illinois, Wisconsin, and Ohio.

Iowa led in hog slaughter by a wide margin, slaughtering nearly 21 million animals in 1971 for nearly 25 percent of the national production. The second state, Illinois, slaughtered about 6.3 million; the rest of the first ten include in order, Minnesota, Pennsylvania, Ohio, Michigan, Indiana, Wisconsin, Virginia, and Tennessee.

There were 1374 meat processing establishments reported in the 1967 Census of Manufacturers in the U.S. The USDA Animal and Plant Health Inspection Service reported 3465 "meat only" and "meat and poultry" processing plants under Federal inspection as of June 33, 1973. An additional 168 meat processing plants were reported to be under Talmadge-Aiken inspection as of June 30, 1973. The meat processing industry had shipments totalling about $4 billion in 1972. Shipments are expected to be eight percent higher in 1974 than in 1973; this is two percent higher than recent rates of six percent growth per year.

Meat processing plants purchase animal carcasses, meat parts, and other materials and manufacture sausages, cooked meats, cured meats, smoked meats, canned meats, frozen and fresh meat cuts, natural sausage casings, and other prepared meats and meat specialities. None of the plants in this industry engages in any slaughtering on the same premises with the processing activity. These plants are all classified under industry No. 2013 in the Office of Management and Budget, Standard Industrial Classification Manual.

The product mix of plants in this industry includes virtually every possible combination of products. There are plants that specialize in one or two types of processed meat products, such as hams, fresh sausage, canned meat products or meat cuts, and plants that produce a number of products up to the full line of processed meat products. This variation in product line occurs in plants independent of the plant size.

In 1967, the potential daily BOD generated from slaughterhouses and the meatpacking industry was estimated at 2.17 million pounds, or a population equivalent of 13 million people. The USDA places the meatpacking industry second to only the Pulp and Paper industry in terms of potential BOD pollution. In the food and kindred products industry, meatpacking ranks first in daily pollutional discharge.

Compared with other industries, the meat-packing process appears to be a topsy-turvy assembly line - - a large product is first stored, then disassembled, and finally repackaged into smaller units. The common element present in most meat processing unit operations is water. Because good quality water has historically been cheap and abundant, a copious requirement of this versatile solvent and cleansing medium is inherent in the design of common process machinery. Even in a well operated plant over a gallon of water per pound of live animal weight is used during the production operation. Despite the ingenuity demonstrated by the industry in recovering marginally profitable byproducts, the large volume of wastewater produced still contains vast quantities of organic residues. This, coupled with the intermittent production schedule, places a severe burden on wastewater treatment systems.

In processing and in quality control, the meat industry finds water an essential tool to help cleanse the product, and to convey unwanted materials. But in wastewater handling, water becomes a problem - a diluter that flushes and dissolves organic matter and carries it to the sewer. Wastewater treatment, then, is basically a processing system for separating the organic and inorganic matter from the water that collected it.

The degree of wastewater conservation, recycle and reuse, and solids and blood recovery in each individual plant depends on many factors:

- Age of the plant
- Views of management
- Whether markets or final disposal facilities for recovered blood, solids, and grease are readily available.
- Market prices of the recoverable materials.
- Local regulations regarding effluent quality and surcharge cost for plants discharging to public sewers
- The first cost, and operating costs of independent treatment if the packer discharges to a watercourse.

Variations in economics in disposing of the solids and concentrates such as paunch manure, blood, hair, casing slimes, and concentrated stick (in wet rendering) inevitably affect the diligence with which these pollutional solids are kept out of the sewer.

The goal of every wastewater control plan is to remove and convey organic sol ids using "dry" methods, without discharging those solids to the sewer, and to use an absolute minimum amount of water in the cleanup and sanitation duties that remain.

Water

Water in its pure state is a simple molecule consisting of two hydrogen atoms attached to a single atom of oxygen. The greatest quantity of water on this planet is in the oceans which contain 97.13% of the supply. The largest supply for human consumption exists as ground or subsurface waters with an 0.612% of the supply. Only a relatively small portion of the supply exists as surface water in lakes (0.009%) or streams (0.0001%). Most water pollution laws are designed to protect the water in the streams, although newer legislation looks at the total water supply.

Water Use and Wastes

Wastewaters from the production of processed meat products and the associated facilities, operations, and plant or equipment cleanup contain organic matter (including grease), suspended solids, and inorganic materials such as phosphates and salts. These materials enter the waste stream as meat and fat particles, meat extracts and juices, curing and pickling solutions, and caustic or alkaline detergents.

Wastewaters from slaughtering of animals, the processing of meat and the associated facilities and operations (stock yards, rendering, and feed manufacturing) contain organic matter (including grease), suspended solids, and inorganic materials such as phosphates and salts. These materials enter the waste stream as blood, meat and fat, meat extracts, paunch contents, bedding manure, curing and pickling solutions, and caustic or alkaline detergents.

Savings with Water and Waste Management

The authors of an extensive study of a hog slaughtering plant concluded that most equipment and processes in the plant can be modified to reduce water requirements. Also, that water borne wastes can be reduced by improved waste recovery methods and through reduced water usage. In this study, changes were instituted in the hog slaughtering plant that reduced water use by 41% and the waste load (BOD5) by 63%. The net present value of the savings for the plant over 5 years at 10% interest, were calculated to exceed $500,000.

Water management techniques also promise to provide the greatest reduction in wastewater flows. The operators of meat processing plants often do not know how much water they are using, where they are using it, when they are using it, and, in some cases, why they are using it. Water, traditionally a resource of great convenience and mi nor cost, has not occupied the attention of either managers or workers. As a result, wasteful water use practices have been common throughout the industry. It will not be possible at this time to demonstrate a cure-a1 1 technique that will eliminate water use problems; rather it will be shown where water misuse can be prevented or corrected.

Meat plants perform the functions of slaughtering and further processing before retail marketing. Many plants engage in hide tanning, rendering, canning, freezing, and processing into specialty items.

Legislation

Congress, on October 18, 1972, established PL 92-500, the Federal Water Pollution Control Act Amendments of 1972. This law was passed to create a successful mechanism to control water pollution. Authority was granted to the United States Environmental Protection Agency (EPA) to establish a permit system including pollutant discharge limitations to help abate water pollution. In fact, the law, establishes a national goal to eliminate pollutant discharges into navigable waters by 1985.

Limitations for industries were required to be established in three parts. First, a set of effluent limitations reflecting the application of the "best practicable control technology currently available" (BPT) to be achieved by July 1, 1977 were to be established. Second, limitations to be achieved by July 1, 1983 reflecting the application of the "best available technology economically achieveable" (BAT) would then be promulgated. Also, a set of effluent limitations were to be established for all new sources based on the "best available demonstrated technology." Subsequently, Congress in 1977, passed the Clean Water Act and EPA was required to replace BAT standards with "best conventional pollutant control technology" (BCT) .

To assure that the effluent limitations and water quality standards would be met, PL 92-500 established the National Pollutant Discharge Elimination System (NPDES). Although the program was developed by and is the responsibility of EPA, the various states have in most cases assumed the responsibility for the NPDES program.

Industrial facilities that discharge to municipal systems were also affected by PL 92-500. User charges and industrial cost recovery (ICR) were required of those industries in municipalities that receive federal funds. Also, effluent limitations were established for publicly owned treatment works (POTWS). These increased standards require more costly treatment processes and these costs are passed on to the users, including industrial discharges.

Meat processors must ask themselves what is happening now and what will happen in the near future. Although charges for industrial wastes began as early as 1907, as late as 1969 only about 10% of United States municipalities collected these charges. Most municipalities did not have a stringent sewer use ordinance until after 1960. Most municipalities do not have one in 1978 although state and federal pressure and encouragement will surely force most municipalities to draft such an ordinance. Key questions that must be asked by industrial dischargers is how they can get a reasonable ordinance that gives both them and the city system protection -- them in having sewage treatment, at a reasonable cost and the city in preventing illegal or toxic discharges.

INDUSTRY DESCRIPTION AND TYPICAL PLANT SCHEME

Industry Description

Meatpacking plants carry out the slaughtering and processing of cattle, calves, hogs, and sheep for the preparation of meat products and by-products from these animals. The plants in this industry range from those that carry out only one operation, such as slaughtering, to full-line plants that not only slaughter, but also carry out processing to varying degrees (manufacturing of meat products such as sausage, cured hams, smoked products, etc.). The amount of processing varies considerably, because some process only a portion of their kill, while others process not only their kill, but also the kill from other plants. Most full-line plants (packinghouses) and many slaughterhouses also render by-products; edible and inedible by-products are rendered from edible fats and trimmings and from inedible materials, respectively.

Manufacturing Processes

Stockyards and Pens

At most meatpacking plants, live animals stay in holding pens for less than one day prior to slaughter. These pens are often covered to offer protection from the elements, and are sometimes enclosed. Wastewater results from watering troughs, periodic washdown, and urine from the animals. Run-off from uncovered pens can also contribute to the waste load. These wastewaters are usually contained and enter the sewer downstream from any materials recovery processes, but before biological treatment.

Slaughtering

Slaughtering animals includes killing (stunning, sticking -- cutting the jugular vein, bleeding) and hide removal for cattle, calves and sheep, and dehairing for hogs; eviscerating; washing the carcasses, and cooling. Many plants include processing blood, viscera, and hides as sub-processes. However, all plants don't perform all operations; for example, some plants ship out blood, hides, and viscera for processing elsewhere.

Animals taken from the pens are immobilized upon entering the kill area by chemical, mechanical or electrical means. Stunned cattle are suspended by a hind leg from overhead for sticking and bleeding. Immobilized hogs are hung over a bleeding trough or placed on a conveyor with their heads hanging over the bleeding trough. During bleeding, the conveyor carrying the animal moves slowly over the trough or gutter that catches the blood so it can be collected for blood processing. Sheep, lambs, and calves are generally handled like cattle, Some blood spills or splashes outside the collecting area, especially as the carcasses are conveyed to the next operation. Clean-up operations also wash considerable amounts of blood into the sewer.

Following bleeding, the hides are removed from the cattle, usually by mechanical means. A traveling cage places the operator at the proper level for skinning and attaching the hide puller. Very small plants skin by hand. Some blood and tissue falls to the floor during this operation, and blood splashes on the walls, Much is collected, but some reaches the sewer, particularly during clean-up.

Hogs are usually not skinned, but are passed through a scalding tank of water at about 130°F, then dehaired. The hair is sometimes baled and sold for uses such as the manufacture of natural bristle brushes, and for furniture stuffing. Occasionally, it is hydrolyzed and dried for use in animal feed. Often it is disposed of as solid waste. Following dehairing, hog carcasses are singed for final hair removal , and sprayed with water to cool and wash. They are inspected and trimmed to remove any remaining hair or other flaws. Scald water and dehairing and washwater contain hair, soil and manure. The final carcass washwater is relatively clean. All of this water is discharged to the sewer.

A method is developing for skinning hogs which is similar to that used for skinning cattle. This method would eliminate the scalding and dehairing processes.

Next, the carcass is opened by hand knives and the animal is eviscerated. The heart, liver, tongue (cattle), and kidneys are removed from the viscera and washed; these are sold as edible meat or are used in meat products. Lungs may be sold for pet food. The balance of the viscera is channeled to the viscera handling subprocess. The carcass is also trimmed and inspected. Scrap trimmings go to rendering for edible or inedible by-products. Blood and tissue from the evisceration find their way directly to the sewer and are washed into the sewer during clean-up. The carcasses, cut in half for beef and hogs, and left whole for sheep and calves, are hung in a cooler where they stay at least 24 hours. Materials recovered during clean-up, particularly by dry clean-up procedures, go to inedible rendering, either on- or off-site.

Blood Processing

Handling and processing the blood is usually a part of the slaughter-house operation. However, in some cases, the blood may be shipped out of a plant for processing elsewhere. The blood may be heated to coagulate the albumin; then the albumin and fibrin are separated (such as with a screen or centrifuge) from the blood water and forwarded for further processing into products such as pharmaceutical preparations. The blood water (or "serum" remaining after coagulation) may be evaporated for animal feed, or it may be sewered. In most cases, the whole blood is sent directly to conventional blood dryers and used for animal feed.

Viscera Handling

The beef paunches may be handled either wet or dry. For wet handling, the contents of the paunches, 50 to 70 pounds of partially digested feed ("paunch manure") are washed out with water and passed over a screen. The separated solids go to solid waste handling. The liquor passing through the screen is generally sewered. In dry handling, paunch contents are dumped on a screen or other dewatering device and the solids are sent either to a dryer or to a truck for removal from the plant. In some plants, the entire paunch contents are sewered; solids are later removed at the sewage treatment plant. It is also common to scald and bleach the paunches. The paunches are then washed thoroughly if they are to be used for edible products. Hog stomach contents are normally wet processed. A new practice is to send the entire contents to processing or to haul out for disposal elsewhere.

The intestines may be sent directly to rendering or they may be hashed and washed and then sent to rendering. Often, the beef paunches, hog stomachs and intestines are washed and saved for edible products.

For example, it is common to bleach the paunches for marketing as tripe, and to recover hog casings and chitterlings (large intestines of hogs). Occasionally, paunches and stomachs are given only a brief washing and are sold as mink or pet food. Stomachs may be sent, unopened, directly to inedible rendering. Hog intestines still find some market as sausage casings and for surgical sutures. Any viscera washing or cleaning results in the contents of stomachs, intestines, etc., and a considerable amount of grease being discharged to the sewer.

Hide Processing

Hides may be processed wet or dry. Wet processing involves hide demanuring, washing, and defleshing, followed by a brine cure in a brine vat or raceway. The cure time may be as short as 12 hours. In dry curing, the washed, defleshed hides are packed with salt and stacked in the curing room. Often hides are only salted and hauled to other plants or to tanneries for washing, defleshing and curing. Washing may be done by batches in a rotating screen, or in a tumbler similar to a large concrete mixer. Defleshing is usually done by passing the hide through rotating scraper knives. In very small plants both may be done by hand. Some effort is being made toward transferring some of the tannery operations to the slaughtering plant; this allows ensuing wastes to be channeled into animal feed. On the other hand, some specialty plants have come into being that take the green, unwashed hides from the slaughtering operation and deflesh, clean, and cure them as an intermediate step before they go to the tannery. Hide processing leads to significant loads of blood, tissue, and dirt being sewered. The curing operation contributes salt (sodium chloride) to the wastewater.

Cutting

Meat cutting may be considered part of the "processing operation", and is often performed in a separate part of the building. It also may be carried out in plants that do no further processing. The latter is particularly true in the case of beef plants. In the cutting area, the carcasses are cut either for direct marketing of smaller sections or individual cuts, or for further processing in the processing operations. Trimmings from this operation that do not go into products such as sausages and canned meats, go to rendering of edible fats and tallows. Inedible materials are rendered for inedible fats and solids. There is always some material that reaches the floor, and a considerable amount that adheres to saw blades or conveyor systems. This includes meat, bone dust, fat tissues, and blood that can be recovered for inedible rendering. Much of this, however, is washed to the sewer during cleanup.

Meat Processing

The edible portion resulting from slaughtering and cutting may be processed in a variety of ways. These include manufacturing many varieties of sausages, hams, bacon, canned meats, pickled meats, hamburger, portional Cuts, etc. Processing edible products is complex and varies from plant to plant. Some beef cuts are delivered to curing rooms for preparation of corned beef. Hog carcasses are cut up and hams, sides, and shoulders are generally sent to curing. Some loins may be deboned and cured for products such as Canadian bacon; most loins are packaged without curing for the retail market. An average of about 400 kg of edible "processed" products are obtained from processing 1000 kg LWK (live weight killed) in meat processing operations. This number can vary and may be much higher in some hog operations. But when edible rendered products such as lard, and fresh pork products such as loins are excluded, the value is reasonable. Further, the value of 400 kg processed product per 1000 kg LWK (or a ratio of processed products to LWK of 0.4) forms a natural break point in categorizing packinghouses. Products to LWK ratios of less than 0.4 are low-processing packinghouses; high-processing packinghouses have a ratio of at least 0.4.

The curing operation involves injecting a salt and sugar solution into the meat, usually with a multineedle injection machine. Some curing is done by soaking the meat in a curing solution. Smoking is achieved in smokehouses operated at elevated temperatures. Smoked flavors are also obtained by soaking meat in a "liquid smoke" solution; injecting this solution into the meat will also result in a smoked flavor. Spills from cooking equipment, cure solution spills during injection, and particles sewered during clean-up all contribute to the waste load.

Rendering

Rendering separates fats and water from tissue. Two types of rendering, wet or dry, may be used for either edible or inedible products. A type of dry rendering process called "low temperature" rendering is coming into common use, particularly for edible rendering. Edible trimmings from the cutting operations that by-pass products such as sausages and canned meats, go to rendering for preparation of edible fats and tallows.

Inedible product processing is conducted in an area separate from processing involving edible products. These inedible ingredients are used mostly in animal feed.

The materials to be rendered are normally passed through a grinder. For inedible rendering, this includes bones, offal (usually without cleaning), condemned animals, etc. From there the material is fed to a continuous rendering operation, or to a blow tank that can be pressurized periodically to feed batch cookers. Economics usually dictate the type of process used.

Wet rendering is usually carried out in pressure tanks with 40 to 60 psi steam added directly. The fat phase is separated from the water phase after cooking. The solids in the water phase are screened out, leaving what is called tankwater. Tankwater is frequently evaporated to a thick protein-rich material known as "stick", which is added to animal feeds.

Dry rendering is done either in vessels that are open to atmospheric pressure or closed and under a vacuum. The material is cooked until all of the free moisture in the tissue is driven off. The cooked material is then screened to remove the fat from the solid proteinaceous residue. Dry rendering can be either a batch or continuous operation, depending upon the equipment used. Batch operations are conducted in moderate-sized agitated vessels; continuous operations are conducted in either agitated vessels that are large enough to provide sufficient retention time for water evaporation, or in multistage evaporators. Dry batch rendering is the most widely used rendering process.

'Low temperature rendering is a fairly recent development used primarily to produce edible products. In this process, the material to be rendered is first finely. ground. The mass is then heated to just above the melting point of the fat. Centrifugation is used to remove the non-fatty material, and the fat is further clarified in a second centrifuge. The water phase may be further treated in other types of equipment for grease and solids recovery.

Spills from cooking equipment, collection tanks, and discharges from equipment washdown further contribute to total waste discharges. However, rendering operations serve to recover a number of materials, (e.g., grease, fats, offal tissue) which might otherwise dramatically increase total plant waste loads. Since grease is not as easily biodegraded as some other organics, its removal by rendering from waste flows allows subsequent biological waste treatment to proceed more efficiently.

Categorizing the Industry

It is important to become familiar with how the industry is categorized in order to see the differences in waste products between the categories. The rationale behind the categorization method was to clearly define various operations within the industry in terms of their relative complexity, and the volume and type of products they produced. This section outlines the categories and explains their differences.

The meat packing industry consist of two major groups: Slaughter-houses and packinghouses as defined below.

A slaughterhouse is a plant that slaughters animals and whose main product is fresh meat as whole, half, or quarter carcasses or smaller meat cuts.

A packinghouse is a plant that both slaughters and processes fresh meat to cured, smoked, canned and other prepared meat products. Processed meat products are limited to: chopped beef, meat stew, canned meats, bacon, hams (boneless, picnic, water added), franks, weiners, bologna, hamburger, luncheon meat loaves, and sausages.

Each of these two major groups has been further divided into two segments giving a total of four categories.

1) A Simple Slaughterhouse is defined as a slaughterhouse that does very limited, if any, by-product processing. Such processing involves usually no more than two operations such as rendering, paunch and viscera handling, blood processing, or hide or hair processing.

2) A Complex Slaughtehouse is defined as a slaughterhouse that does extensive by-product processing. This usually involves at least three of the operations described above under "Simple Slaughterhouse".

3) A Low-Processing Packinghouse is defined as a packinghouse that processes no more than the total live weight killed (LWK) at that plant, normally processing less than the total kill.

4) A High-Processing Packinghouse is defined as a packinghouse that processes both the animals slaughtered at the site, and additional carcasses brought in from outside sources.

The difference between the four categories and the relationships between them are shown schematically in Figure 1. Note that a plant which processes meat into canned, smoked, and cured products is significantly different from a plant that does no processing. Thus, there is a clear distinction between a packinghouse --- a plant that both slaughters and processes --- and a slaughterhouse.

A general flowsheet of a typical full-line packinghouse is shown in Figure 2. Remember that such a plant is a "packinghouse" rather than a "slaughterhouse" by virtue of the "processing" step. At a packinghouse processing will include a wide range and volume of products. Less complete plants, or those that are specialty plants, would operate on appropriate parts of the Figure 2 flowsheet. Primary processes through cooling of carcasses are typical of all slaughterhouses, or abattoirs. The secondary processes of blood processing, hide processing, and rendering may or may not be carried out in the slaughterhouse. Most pork plants include processing to some extent; many beef plants, however, are only abattoirs. A slaughterhouse may have all of the operations of a packinghouse, except for the processing, cutting and deboning steps, as noted in Figure 1. Such a slaughterhouse, based on high wasteload from secondary processes, would be termed a "complex" slaughterhouse. A slaughterhouse may also be very simple; the simplest kind, with no secondary processes, is shown in Figure 3. If the plant has relatively few secondary processes, and those processes are the type that give a low waste load, the plant is termed a "simple" slaughterhouse.

The meat packing operations begin when the animals arrive at the plant and carry through the shipping of the product to the wholesale trade

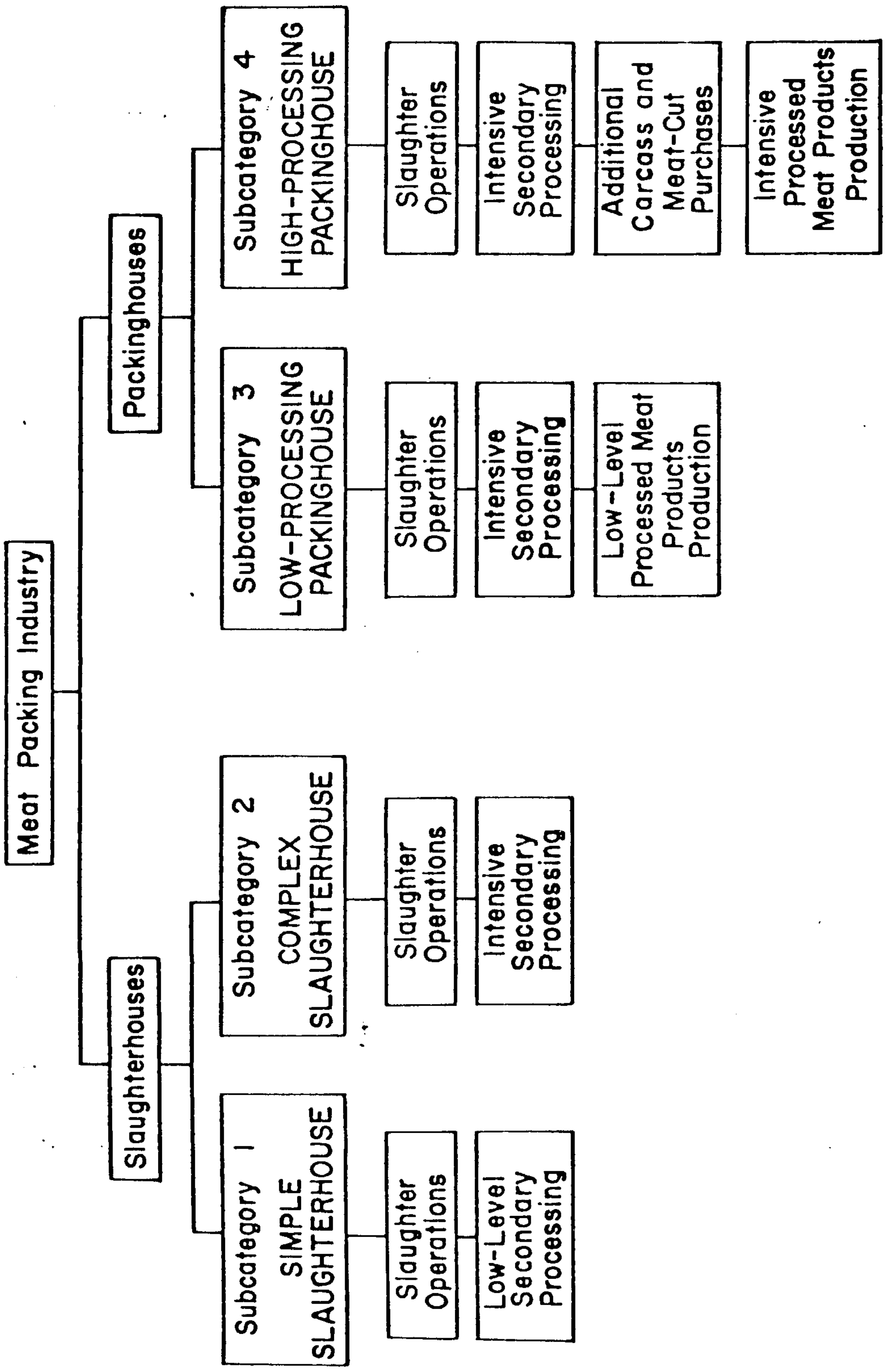

Figure 1. Categorization of Meat Packing

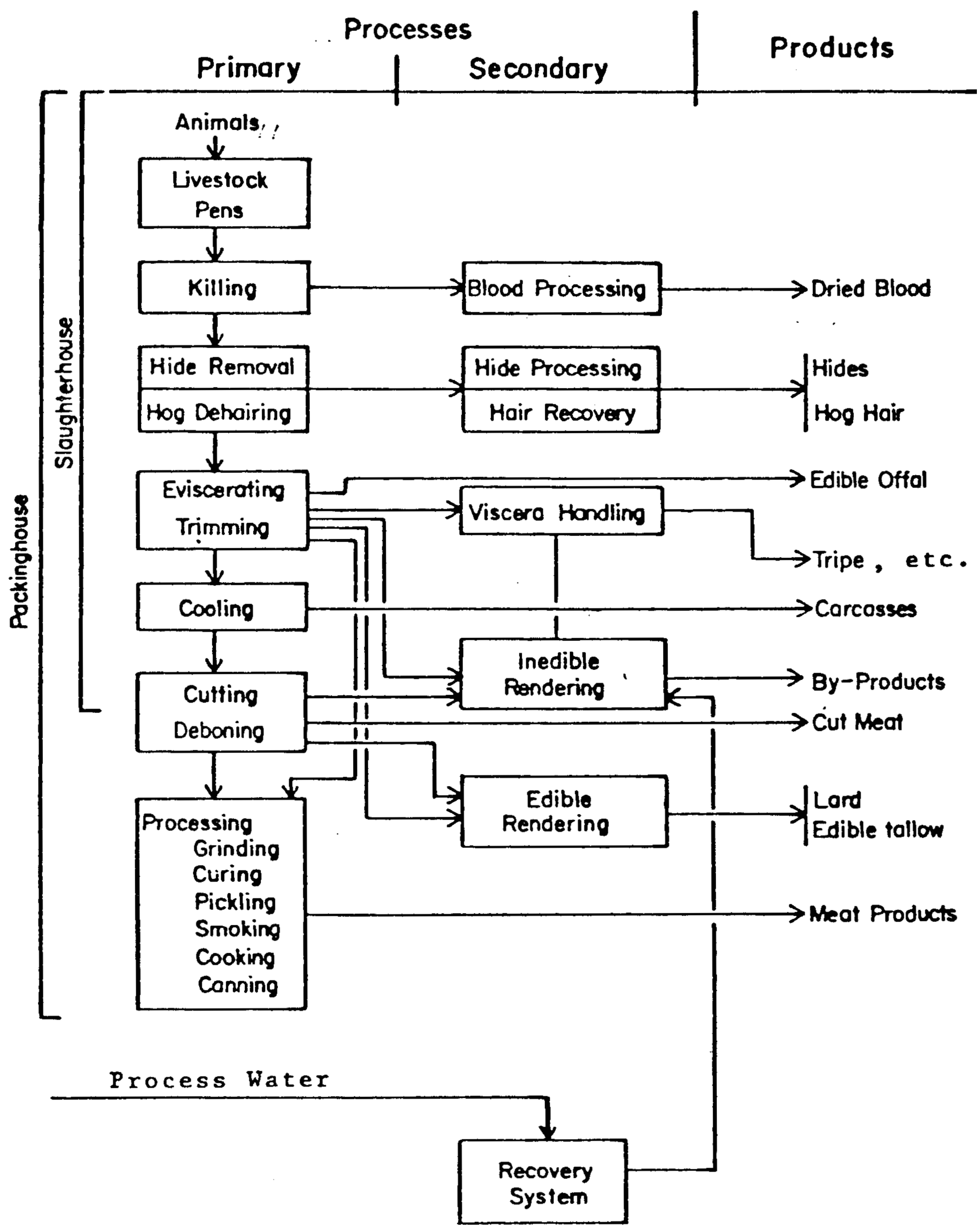

Figure 2. Process Flow in a Packing Plant

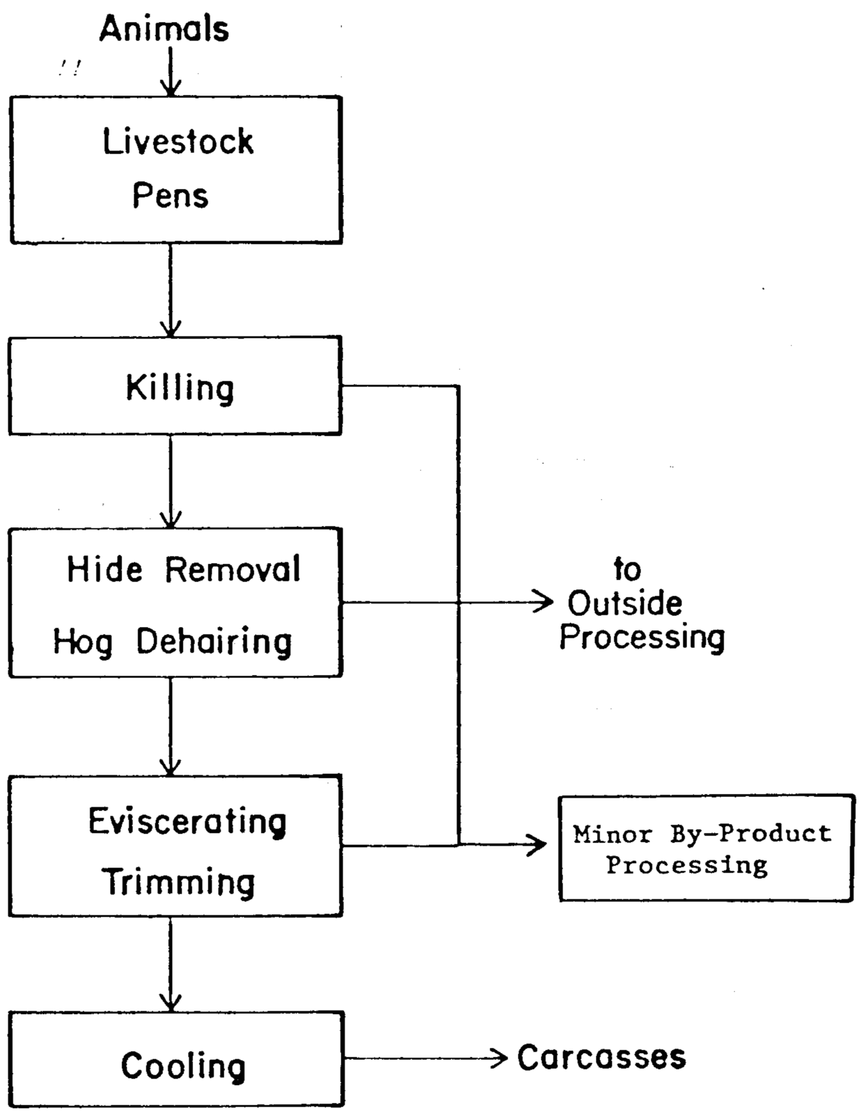

Figure 3. Process Flow for Slaughterhouse

WASTEWATER CHARACTERIZATION IN THE MEAT PROCESSING INDUSTRY

Introduction

Whenever food, in any form, is handled, processed, packaged and stored, there will always be an inherent generation of wastewater. The quantity of this processing wastewater that is generated and its general quality (i.e., pollutant strength, nature of constituents), has both economic and environmental consequences with respect to its treatability and disposal.

The economics of the wastewater lie in the amount of product loss from the processing operations and the cost of treating this waste material. The cost for product loss is self evident, however, the cost for treating the wastewater depends on its specific characteristics. Two significant characteristics which dictate the cost for treatment are the daily volume of discharge and the relative strength of the wastewater. Other characteristics become important as system operations are affected and specific discharge limits are identified (i.e., fat, oils and greases [FOG]).

The environmental consequences in not adequately removing the pollutants from the waste stream can have serious ecological ramifications. For example, if inadequately treated wastewater were to be discharged to a stream or river, an eutrophic condition would develop within the aquatic environment due to the discharge of biodegradable, oxygen consuming compounds. If this condition were sustained for a sufficient amount of time, the ecological balance of the receiving stream, river or lake (i.e., aquatic microflora, plants and animals) would be upset. Continual depletion of the oxygen in these water systems would also result in the development of obnoxious odors and unsightly scenes.

Wastewater Characterization

Major wastewater characteristics of concern to the meat processing industry are pollutant parameters, process waste point sources, types of wastes and wastewater loading factors as influenced by production. These will be considered in the following discussion.

Pollutant parameters of importance to the meat industry are biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved sol ids, suspended sol ids, FOG and color and water useage. Minimizing the concentrations of the water useage will go a long way toward reducing the sewer use costs or decrease the cost of operating a pretreatment or treatment system. Depending on the wastewater characteristic profile as discharged from a meat processing plant, any number of waste reduction options may have to be initiated to meet the ultimate discharge requirement of the receiving stream.

Sampling

Of equal importance is the problem of obtaining a truly representative sample of the stream effluent. The samples may be required not only for the 24 hr effluent loads, but to determine the peak load concentrations, the duration of peak loads and the occurrence of variation throughout the day. Assuming that a sample can be taken from the effluent drain which will be representative of the liquid in the weir or flume, there are a number of different ways of obtaining a 24 hr composite.

(a) A time-proportional method, which involves taking a sample at a set time interval , e.g., every 1 min, or every 30 min; the greater the frequency of sampling, the more representative will be the sample;

(b) A volume proportional method, in which a small sample is taken from the drain after a known volume, e.g., 1000/1, has passed through the flow measuring device;

(c) A flow proportional method, in which a sample is taken from the drain at a particular time but proportional to the flow passing the particular device at the time the sample is taken; and

(d) A combination method, in which the sample is taken proportional to both time and volume.

Obtaining good results will depend upon certain details. Among these are the following:

(a) Insuring that the sample taken is truly representative of the waste stream.

(b) Using proper sampling techniques.

(c) Protecting the samples until they are analyzed.

The first of these requirements, obtaining a sample which is truly representative of the waste stream, may be the source of significant errors. This is especially apparent in the case of "grab" or non-composite samples. It must be remembered that waste flows can vary widely both in magnitude and composition over a 24-hour period. Also, composition can very within a given stream at any single time due to a partial settling of suspended solids or the floating of light materials. Because of the lower velocities next to the walls of the flow channel, materials will tend to deposit in these areas. Samples should therefore be taken from the waste stream where the flow is well mixed. Since suitable points for sampling in sewer systems are limited, numerous ideal locations are not usual.

The usual method for accounting for variations in flow and waste constituents and minimizing the analytical effort is by compositing the samples. Basically, sufficient samples should be taken so that, when mixed together (before analysis), the results which are obtained will be similar to taking a sample from a completely-mixed tank which had collected all the flow from the stream in question. Greater accuracy is obtained if the amount of sample in the composite is taken in proportion to the flow. In general, the greater the frequency of samples taken for the composite, the more accurate the results.

Obtaining a representative sample should be of major concern in a monitoring program. A thorough analysis of the waste flows in the plant must be made and a responsible staff member should be assigned to insure that the samples taken are representative. As a general rule, closer attention must be given to waste sampling than in the sampling of a manufacturing process stream.

In many process operations, the wastes are pumped from sumps within the plant before the liquid goes into settling tanks. Where a liquid is being pumped through a pipe, flow monitoring and sampling are often simplified, for in most cases the variations in pumping rate are minor and can either be calculated from the pump curves, or by calibrating pumps. Sampling under these systems involves using time-operated solenoid valves which open for a brief interval every minute or so. The timers should be attached to the pump motors so that samples are taken only when the effluent is being pumped.

Once the samples have been obtained, analysis procedures should be initiated as soon as practical. Table 1 summarizes the recommended storage procedure for specific analysis.

Waste Loads and Their Characteristics

A definite analysis of the waste characteristics of the meat packing industry is not a simple matter. It is difficult to characterize a typical plant and its associated wastes, owing to the many procedures and facets of meat-processing operations. A given plant may perform many or only a few of these procedures.

Typical slaughterhouse and packinghouse wastes are generally high in 5-day biochemical oxygen demand (BOD5), total suspended solids, floatable material, and grease. Furthermore, the waste is generally at an elevated temperature and contains blood, bits of flesh, fat, manure, dirt, and viscera. Important processes such as blood recovery, grease recovery, separate paunch manure handling, and efficient rendering operations can reduce waste loads substantially and may also produce salable by-products.

Table 2 lists waste loads that have been found, through extensive study and research of records, to be typical of various types of meat-packing plants. The values listed for slaughterhouses apply only to medium-sized plants that slaughter from 95,000 to 750,000 pounds of meat per day. These plants process few edible by-products, or none at all, and do not process blood or dry it in such a manner as to produce no blood water. They do, however, perform dry inedible rendering. The values associated with packinghouses apply to most medium or large plants that carry out all processes associated with salughtering, cutting, rendering, and processing. Values listed for processing plants represent plants that cut and process meat, but do no slaughtering or rendering. Generally, the processes performed at a packing plant have a much greater affect on the waste load factors than the size of the plant.

Table 3 shows the characteristics of the waste flow from 16 cattle and hog packing plants, illustrating a typically wide variation from plant to plant.

Table 1. Recommended Storage Procedure.

Analysis	Sample Storage	
	Refrigeration @4°C	Frozen
Total Solids	OK	OK
Suspended Solids	Up to several days	NO
Volatile Suspended Solids	Up to several days	NO
COD	Up to several days	OK
BOD	Up to one day in composite sampling systems	OK Lag develops; must use fresh sewage seed.
Oil and Grease	Add 2 mg H_2S0_4/1 of sample Preservation good for 24 days	
Color	Preservation good for 24 hours	

Table 2. Standard Raw Waste Loads.

Type	Flow, gallons	BOD_5, pounds	SS, pounds	Grease, pounds
Slaughterhouse, per 1,000 pounds LWK[1]	696	5.8	4.7	2.5
Packinghouse, per 1,000 pounds LWK[1]	1,046	12.1	8.7	6.0
Processing plant, per 1,000 pounds product	1,265	5.7	2.7	2.1

[1]LWK indicates live weight kill.

Table 3. Unit Waste Loadings for Meat Packing Plants.

Type of animal slaughtered	BOD_5	Suspended solids	Nitrogen	Grease
	Pounds per 1,000 pounds of live weight			
Hogs	18.0	12.0	2.67	0.90
Hogs	15.0	9.1	1.29	2.30
Mixed	12.7	4.6	2.02	1.44
Hogs	13.1	9.8	1.25	2.83
Cattle	20.8	14.8	2.24	.68
Hogs	15.7	14.8	2.01	1.79
Hogs	10.5	10.0	1.02	1.00
Mixed	19.7	9.4	2.59	.60
Hogs	9.8	7.2	1.46	.27
Mixed	16.7	15.0	2.18	2.00
Cattle	10.0	11.0	1.08	.55
Mixed	14.7	13.2	1.70	1.5
Mixed	6.5	6.2	.79	.5
Mixed	19.2	11.2	2.10	2.1
Mixed	8.9	10.8	.89	([1])
Mixed	21.6	21.7	1.82	6.0
Average	14.6	12.0	1.70	1.63

[1]Data missing.

Wastewater Characteristics

Water is a raw material in the meat packing inidustry that is used to cleanse products and to remove and convey unwanted material. The principal operations and processes in meat packing plants where wastewater originates are :

- Animal holding pens
- Slaughtering
- Cutting
- Meat processing
- Secondary manufacturing (by-product operations) including
- Edible and inedible rendering
- Clean-up

Wastewaters from slaughterhouses and packinghouses contain organic matter (including grease), suspended solids, and inorganic material such as phosphates, nitrates, nitrites, and salt. These materials enter the waste stream as:

- blood
- meat and fatty tissue
- meat extracts
- paunch contents
- bedding
- manure
- hair
- dirt
- contaminated cooling water losses from rendering
- curing and pickling solutions
- preservatives
- caustic or alkaline detergents.

Raw Waste Characteristics

The raw waste load from the industry's four categories excludes the by-products gleaned from in-plant recoveries. These recoveries "kill two birds with one stone" by reclaiming by-products which would otherwise be sent to the waste streams and subsequently require treatment as pollutants.

One EPA study of the industry analyzed 85 plants. Much of the following discussion is based on the data gathered during that study. The parameters used to characterize the raw effluent were the flow, BOD, suspended solids (SS), grease, chlorides, phosphorus, and Kjeldahl nitrogen. BOD was considered to be, in general, the best available measure of the waste load. Parameters used to characterize the size of the operations were the kill (live weight) and volume of processed meat products produced. All values of waste parameters are expressed as kg/1000 kg/LWK, which has the same numerical value when expressed in lb/1000 lb LWK. In some cases the effluents were so dilute that the concentration became limiting. In these cases , concentration was expressed as mg/l . Kill and amount of processed meat products are expressed in thousands of kg. Tables 4 through 7 include a data summary showing averages, standard deviations, ranges, and number of observations (plants) for each of the four industry categories.

Slaughterhouses

A typical flow diagram illustrating the sources of wastewaters in both simple and complex slaughterhouses is shown in Figure 4. Note that a simple slaughterhouse normally conducts very few of the by-product operations (secondary processes) listed in Figure 4, whereas a complex slaughterhouse conducts most or all of them. Occasionally slaughterhouses may not have wastewaters from some of the operations shown, depending upon individual plant circumstances. For example, some slaughterhouses have dry animal pen clean-up with no discharge of wastewater, some have little or no cutting, and others may have a separate sewer for sanitary waste.

The flow diagrams include both beef and hog operations. No distinction was made in the categories for the type of animal being slaughtered. It is recognized, however, that in some small plants there will be more significant differences in pollution waste loads depending on the animal type. These cases, however, are still within the waste loads cited for the subcategory.

Simple Slaughterhouses. Table 4 summarizes the plant and raw waste characteristics for a simple slaughterhouse. The table shows that 24 of the 85 plants analyzed were simple slaughterhouses (about one-half were beef and the others divided between hogs and mixed kill) and that the

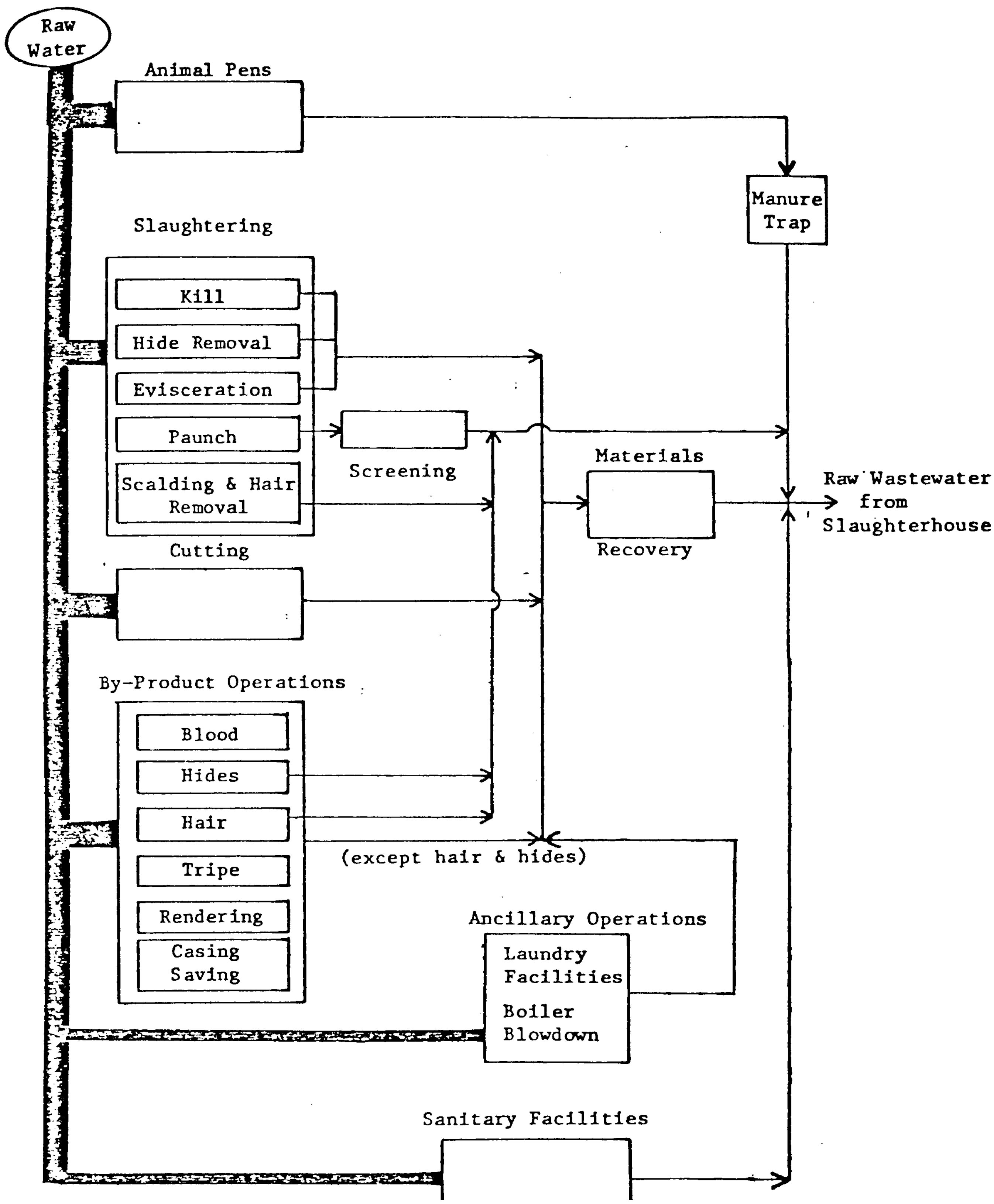

Figure 4. Operating and Wastewater Flow Chart for Simple and Complex Slaughterhouses.

Table 4. Summary of Plant and Raw Waste Characteristics for Simple Slaughterhouses.

Base	Flow 1/1000 kg LWK	Kill 1000 kg/day	BOD_5 kg/1000 kg LWK	Suspended Solids kg/1000 kg LWK	Grease kg/1000 kg LWK	Kjeldahl Nitrogen as *N* kg/1000 kg LWK	Chlorides as *Cl* kg/1000 kg LWK	Total Phosphorus as *P* kg/1000 kg LWK
(Number of Plants)	(24)	(24)	(24)	(22)	(12)	(5)	(3)	(5)
Average	5,328	220	6.0	5.6	2.1	0.68	2.6	0.05
Standard Deviation	3,644	135	3.0	3.1	2.2	0.46	2.7	0.03
Range, low-high	1,334-14,641	18.5-552.	1.5-14.3	0.6-12.9	0.24-7.0	0.23-1.36	0.01-5.4	0.014-0.086

Table 5. Summary of Plant and Raw Waste Characteristics for Complex Slaughterhouses.

Base	Flow 1/1000 kg LWK	Kill 1000 kg/day	BOD_5 kg/1000 kg LWK	Suspended Solids kg/1000 kg LWK	Grease kg/1000 kg LWK	Kjeldahl Nitrogen as *N* kg/1000 kg LWK	Chlorides as *Cl* kg/1000 kg LWK	Total Phosphorus as *P* kg/1000 kg LWK
(Number of Plants)	(19)	(19)	(19)	(16)	(11)	(12)	(6)	(5)
Average	7,379	595	10.9	9.6	5.9	0.84	2.8	0.33
Standard Deviation	2,718	356	4.5	4.1	5.7	0.66	2.7	0.49
Range, low-high	3,627-12,507	154-1498	5.4 18.8	2.8-20.5	0.7-16.8	0.13-2.1	0.81-7.9	0.05-1.2

Table 6. Summary of Plant and Raw Waste Characteristics for Low-Processing Packinghouses.

Base	Flow 1/1000 kg LWK	Kill 1000 kg/day	BOD_5 kg/1000 kg LWK	Suspended Solids kg/1000 kg LWK	Grease kg/1000 kg LWK	Kjeldahl Nitrogen as N kg/1000 kg LWK	Chlorides as Cl kg/1000 kg LWK	Total Phosphorus as P kg/1000 kg LWK	Processed Products 1000 kg/day	Ratio of Processed Products to Kill
(Number of Plants)	(23)	(23)	(20)	(22)	(15)	(6)	(5)	(4)	(23)	(23)
Average	7,842	435	8.1	5.9	3.0	0.53	3.6	0.13	54	0.14
Standard Deviation	4,019	309	4.6	4.0	2.1	0.44	2.7	0.16	52	0.09
Range, low-high	2,018-17,000	89-1,394	2.3-18.4	0.6-13.9	0.8-7.7	0.04-1.3	0.5-4.9	0.03-0.43	3.0-244.	0.016-0.362

Table 7. Summary of Plant and Raw Waste Characteristics for High-Processing Packinghouses.

Base	Flow 1/1000 kg LWK	Kill 1000 kg/day	BOD_5 kg/1000 kg LWK	Suspended Solids kg/1000 kg LWK	Grease kg/1000 kg LWK	Kjeldahl Nitrogen as N kg/1000 kg LWK	Chlorides as Cl kg/1000 kg LWK	Total Phosphorus as P kg/1000 kg LWK	Processed Products 1000 kg/day	Ratio of Processed Products to Kill
(Number of Plants)	(19)	(19)	(19)	(14)	(10)	(3)	(7)	(3)	(19)	(19)
Average	12,514	350	16.1	10.5	9.0	1.3	15.6	0.38	191	0.65
Standard Deviation	4,894	356	6.1	6.3	8.3	0.92	11.3	0.22	166	0.39
Range of low-high	5,444-20,261	8.8-1,233.	6.2-30.5	1.7-22.5	2.8-27.0	0.65-2.7	0.8-36.7	0.2-0.63	4.5-631.	0.40-2.14

BOD waste load covered a range from 1.5 to 14.3 kg/1000 kg LWK (same value in lb/1000 lb LWK). Small plants were determined as those with a LWK of less than 43,130 kg (95,000 lbs), and medium plants as those with a LWK between 43,130 kg and 344,132 kg (758,000 lb).

Two of the 24 plants were small. and the remainder were medium-sized.

Complex Slaughterhouses. Table 5 summarizes the plant and raw waste characteristics for complex slaughterhouses. Nineteen of the 85 plants analyzed were complex slaughterhouses (11 were beef; 6 hogs; and 2, mixed). Defining a large plant as one with a LWK of greater than 344,132 kg (758,000 lb), and a medium plant as in the paragraph above, Table 5 kill data show all complex slaughterhouses included were either medium or large. Actually about one-third were large.

Packinghouses

A typical flow diagram illustrating the sources of wastewaters in both low- and high-processing packinghouses is shown in Figure 5. Remember that the main difference between a low- and high-processing packinghouse is the amount of processed products relative to kill; i.e., a ratio of less than 0.4 for a low- and greater than 0.4 for a high-processing plant. As a result, the waste load contribution from processing is less for a low-processing packinghouse. A packinghouse has the same basic processes and operations contributing to the waste load as a slaughterhouse, plus the meat processing steps for the packinghouse. Another difference is that the degree and amount of cutting is much greater for a packinghouse. In some cases, unfinished products may be shipped from one plant to another for processing, resulting in more products produced at a plant than live weight killed there.

Low-Processing Packinghouses. Table 6 summarizes the plant and raw waste characteristics for low-processing packinghouses. Twenty-three of the 85 plants analyzed were low-processing packinghouses. The average ratio of processed products to kill in these 23 plants was 0.14, with a standard deviation of 0.09. The low-processing packinghouses included in the analyses have a ratio of processed products to LWK well below the value of 0.4 used to distinguish between low- and high-processing plants. Using the above definitions of plant size, the kill data show that all the packing houses in the sample were medium or large in size.

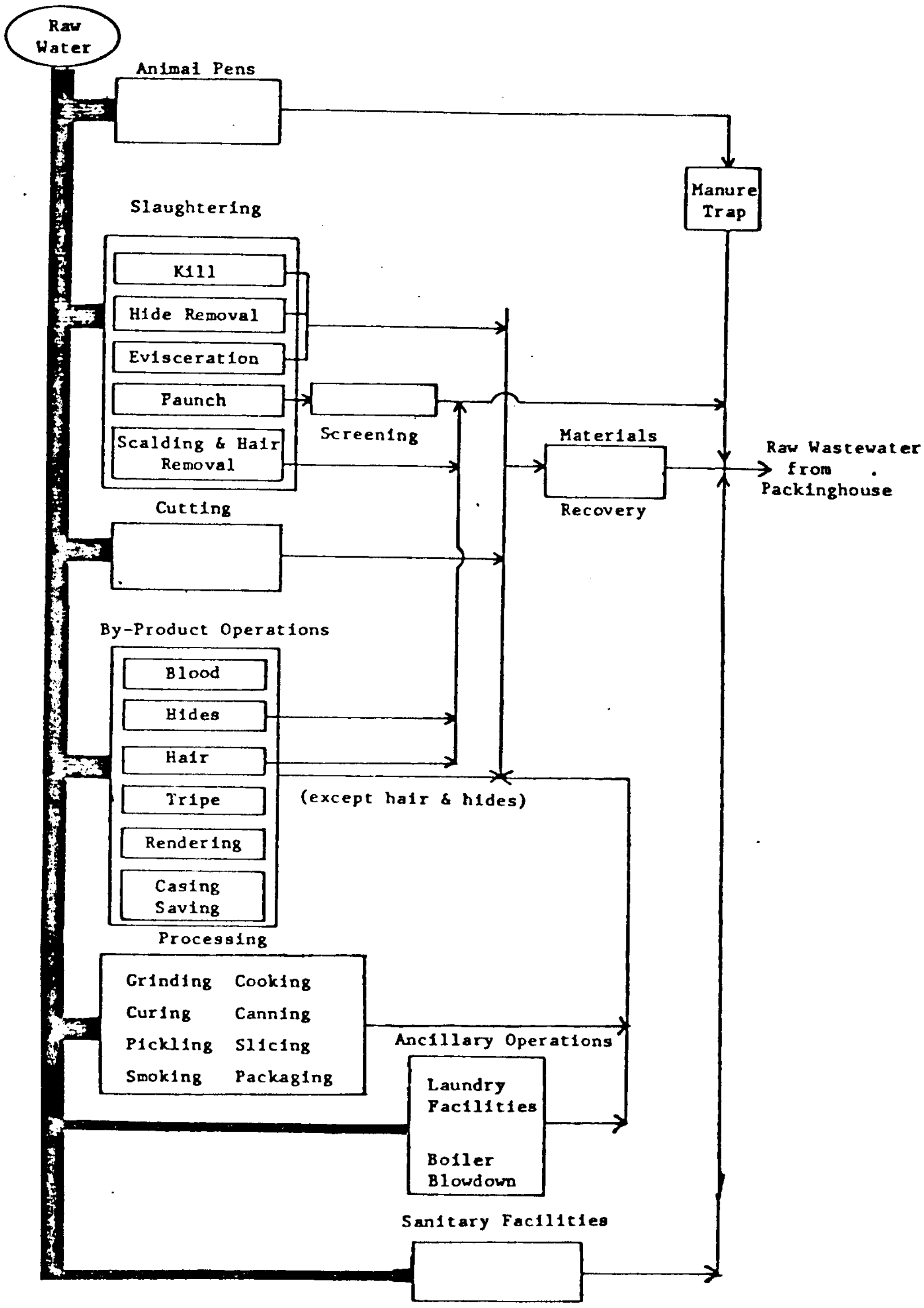

Figure 5. Operating and Wastewater Flow Chart for Low- and High-Processing Packinghouses.

High-Processing Packinghouses. Table 7 summarizes the plant and raw waste characteristics of high-processing packinghouses. Nineteen of the 85 plants analyzed were high-processing packinghouses. The range of data for the 19 plants is large for all waste load parameters. The range of 0.4 to 2.14 for the ratio of processed products to LWK suggests that many of the waste load variations were caused by the wide variation in processing relative to kill. Plant size as measured by kill ranged from small to large; Two plants were small, 11 medium, and 6 large.

Discussion of the Raw Wastes

The data in Tables 4 through 7 cover:

- A wastewater flow range of 1334 to 20,261 1/1000 kb LWK (or 160 to 2427 ga1/1000 1b LWK);
- A waste load range of 1.5 to 30.5 kg/BOD/1000 kg LWK (or 1.5 to 30.5 lb BOD/1000 lb LWK);
- A kill range of 18.5 to 1498 kkg LWK/day (or 40 to 3300 thousand lb/day).

In comparing data from Tables 4 and 5, you will see that the averages of all waste parameters are higher for a complex slaughterhouse. This could be expected because complex slaughterhouses conduct more secondary (or by-product) processes than do simple slaughterhouses.

A look at Tables 6 and 7 reveals that high-processing packinghouses exhibit much higher average values for all waste parameters on a LWK basis.

Some variations in wastewater flow and strength within any one of the four categories can be attributed to differences in the amount and kind of operations carried out beyond slaughtering, such as by-product and prepared meat processing. The effectiveness of materials recovery in primary in-plant treatment can also be partly responsible for those variations. However, the major causes of flow and waste load variations are differences in water use and housekeeping practices.

In all four categories, statistical correlation analysis of the data revealed that the raw waste load BOD values correlated very well with values measuring the presence of suspended sol ids (SS), grease and Kjeldahl nitrogen on a LWK basis. This means that a change in one parameter will account for a certain predictable change in another parameter.

The effect of plant size (kill) on waste load as measured by BOD for each category was assessed by a regression analysis. The results showed that larger plants tend to have slightly higher waste loads. This trend is not caused by differences in processing. Rather, it results from some plants operating with ever increasing loads, often beyond the LWK for which the plant was designed. Under these circumstances, housekeeping and water management tend to become careless. As a result, line speed-up overloads fixed operations such as inedible rendering and blood handling with consequent increases in raw waste loads.

As shown in Tables 4 through 7, chloride and phosphorus are two parameters that relatively few plants measure. From the data reported however, the chloride and phosphorus waste load components are dependent on in-plant operations and housekeeping. For example, large amounts of chlorides contained in pickling solutions and used in processing ham, bacon, and other cured products ultimately end up in the wastewater. This explains the unusually high chloride Values for high-processing packing-houses where relatively large amounts of products are cured. Very little useful information on other waste parameters such as Kjeldahl nitrogen, nitrites, nitrates, ammonia, and total dissolved solids were reported by 85 plants surveyed. However, some information on these parameters was obtained from other sources during this study. Typical ranges are listed below for these waste parameters. Note that values for dissolved sol ids in the wastewater are also affected by the dissolved sol ids occurring in the plant's water supply.

Nitrates and Nitrites, as N, mg/l	0.01 - 0.85
Kjeldahl nitrogen, mg/l	50 - 300
Ammonia as N, mg/l	7 - 50
Total dissolved solids, mg/l	500 - 25,000

Bacteria are also present in raw waste from meat packing plants. The usual measure is in terms of coliforms, and for these the MPN (most probable number) typically is in the range of 2 to 4 million per 100 ml.

The process wastewater is normally warm; it averages about 32°C (90°F) and reaches a high of about 38°C (100°F) during the kill period and a low of about 27°C (80°F) during clean-up.

The pH of the process wastewater is typically in the 6.5 to 8.5 range, although occasionally it may be outside this range.

Water Use and Its Relationship to Waste Loads

In the meat packing industry, increased water use causes increased pollutional waste load. This cause and effect relationship has been verified by analyzing individual plant data over long time periods (up to two years), and by analysis of the data from each of the four categories. This portion of the EPA study related BOD waste load data to kill and flow data and found that a variation of one standard deviation would change the predicted BOD from a simple slaughterhouse by 1.0 kg/1000 kg LWK (1.0 lb/1000 lb LWK); it would change the predicted load for a complex slaughterhouse by 2.8 kg/1000 kg LWK (2.8 lb/1000 lb LWK). Another analysis of BOD and flow data showed that one standard deviation in flow changed the predicted BOD by 5.6 kg/1000 kg LWK for low-processing packinghouses, and by 5.3 kg/1000 kg LWK for high-processing packinghouses.

Figure 6 graphs the average and range of the results of separate regression analyses on the flow waste load data from each of eleven plants. You can see from the figure that water use strongly affects the pollutional waste load from a plant in any given category. For example, the figures show that reducing water use by 20% would on the average result in a BOD reduction of 3.5 kg/1000 kg/LWK.

Further evidence for the dependence of pollutional waste load on water flow is that in three of the four categories, <u>the plant with the lowest waste load also had the lowest water use.</u> In the fourth category, the plant with the lowest waste load had the second lowest water use. Moreover, substantially improved effluent quantity was found for those plants which conserved water as part of general housekeeping practices.

Lowering water use, which consequently lowers absolute waste load, requires efficient water management. For example, available data showed that two simple slaughterhouses employed very good water use practices. Both plants produced waste loads of about 2 kg/1000 kg/ LWK; their wastewater flows ranged from 1333 to 2415 1/1000 kg LWK. One plant was an old beef slaughterhouse; the other a new hog slaughterhouse. This outstanding performance was achieved in a category whose flows rose to 21,000 1/1000 kg LWK, and whose BOD loading rose to over 14 kg/1000 kg LWK.

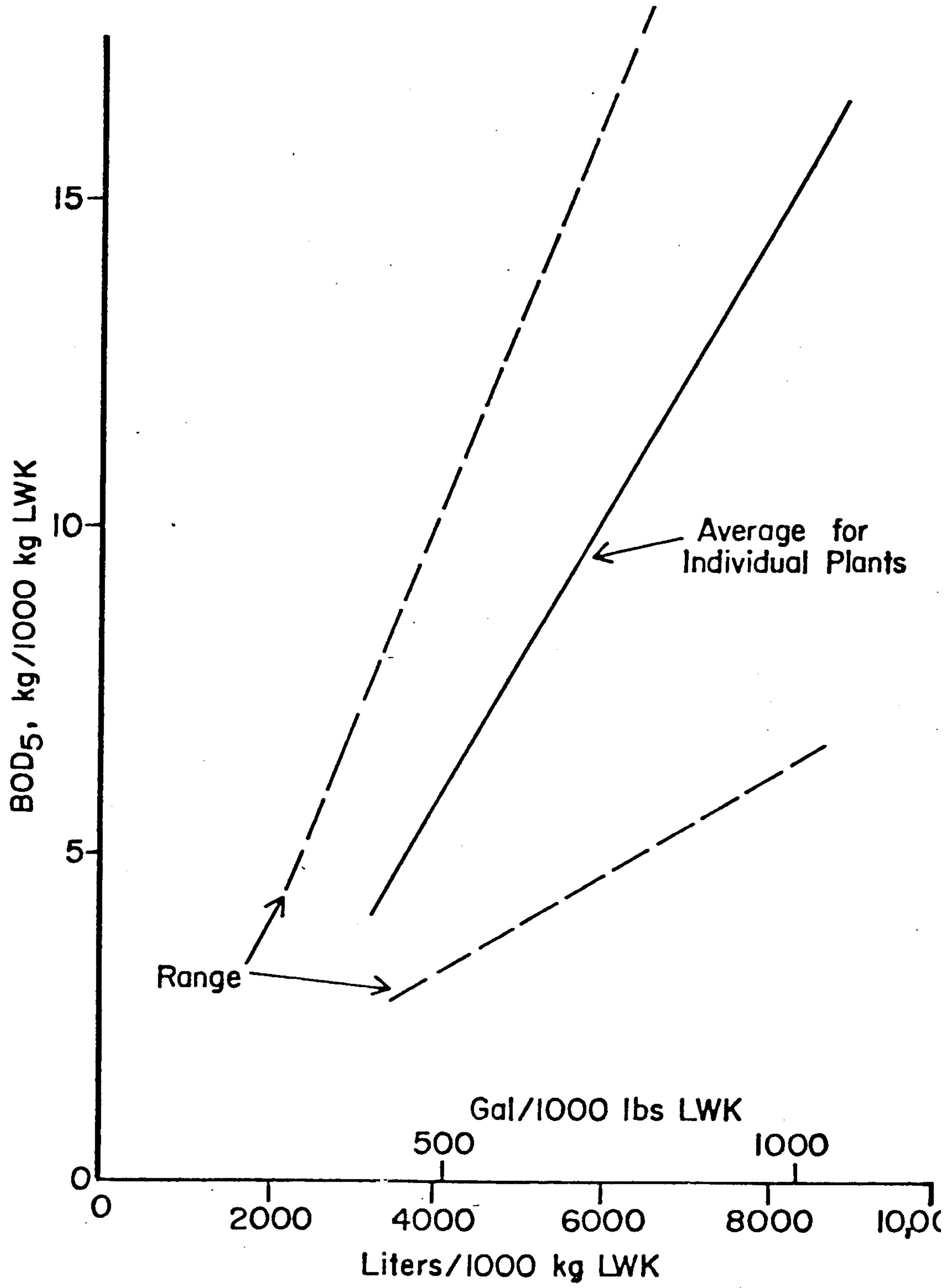

Figure 6. Effect of Water Use on Wasteload for Individual Plants.

Sources of Wastewater

Animal Pens. Although pen wastes only contain about 0.25 kg of BOD/1000 kg LWK, these wastes are high in nutrients. Frequently, the sol id wastes are removed by dry cleaning, followed by little or no washdown. If washdown is practiced, a manure trap is frequently used to recover solids rather than allowing them to enter a treatment system. Any rainfall or snowmelt run-off is normally contained and routed for treatment with other raw waste flows. Watering troughs are another source of pen wastewater. Each trough may discharge 8 1/min (2.1 gal/min) or more. With 50 or more pens used at a large plant, the water source becomes significant. However, considering the total waste load from the plant, pen waste is but a minor contributor.

Slaughtering. The slaughtering operation is the largest single source of waste load in a meat packing plant, and blood is the major contributor. Blood is rich in BOD, chlorides, and nitrogen. It has an ultimate BOD of 405,00 mg/l and a BOD5 between 150,000 and 200,000 mg/l. Cattle contain up to 50 pounds of blood per animal, and typically only 35 pounds of the blood are recovered in the sticking and bleeding area. The remaining 15 pounds of blood are lost as wastes which represents a waste load of 2.25 to 3.0 kg BOD/1000 kg LWK (2.25 to 3.0 lb/1000 lb LWK). Total loss of the blood represents a potential BOD waste load of 7.4 to 15 kg/1000 kg LWK (7.5 to 15 lb/1000 lb LWK). Because very few meat plants practice blood control outside of the bleeding area, the typical BOD load from blood losses in the slaughtering operation is estimated to be 3 kg/1000 kg LWK. In beef plants, much of this loss occurs during hide removal. Beef paunch or rumen contents is another major source of waste. Paunch manure, which contains partially digested feed material, has a BOD of 50,000 mg/l . At an average paunch weight of 50 pounds per head, dumping of the entire contents can contribute 2.5 kg/1000 kg LWK. However, the common practices are to either screen the paunch contents, washing the sol ids on the screen (wet dumping), or to dump on a screen to recover the solids, allowing only the "juice" to run to the sewer (dry dumping). Because 60 to 80 percent of the BOD5 in the paunch is water soluble, wet dumping of the paunch represents a BOD5 loss of about 1.5 kg/1000 kg LWK. If dry dumping is practiced, the pollutional waste load is much less than this. When none of the paunch is sewered but is processed or hauled Out of the plant for land disposal , paunch handling does not contribute to the waste load. Nevertheless, cooking of the rumen or paunch is a hot alkaline solution (tripe processing) will add to the waste load, particularly to the grease load. The strong alkalinity of these waste-waters may also make grease recovery more difficult.

The hog scald tank and dehairing machine are other sources of pollution. The overflow from a hog scald tank is usually about 84 1/1000 kg LWK (10 ga1/1000 1b LWK) at a BOD loss of about 3000 mg/l . This could represent a BOD loss of about 0.25 kg/1000 kg LWK. Continuous overlow of water from the dehairing machine is estimated to contribute a maximum BOD5 load of 0.4 kg/1000 kg LWK.

Other wastes from slaughtering and carcass dressing are from carcass washing, viscera and offal processing, and stomach and neck flushing. The offal operations such as chitterling washing and cleaning intestinal casings can also contribute to the waste load. The waste contribution from these operations could be greatly reduced if the slime waste from the casings was not sewered.

The highest source of water use in slaughtering is from the washing of carcasses; an extreme example for which data are available shows rates of 2915 l/min (350 gal/min). Flushing the manure from chitterling and viscera, conveyor sterilizing, and the tripe "umbrella" washer are other high water use operations.

Meat Processing. The major pollutants from meat processing are meat extracts, meat and fatty tissue, and curing and pickling solutions. Loss of these solutions can be the major contributor to the waste load from processing. The results of a recent study showed that only 25 percent of the curing brine remained in the product. The rest of the brine was lost to the sewer. This source of chlorides, plus others such as from hide curing and salting floors to reduce slipperiness, explains why some packinghouse wastes are high in chlorides. Another constituent of the cure is dextrose; it has a BOD equivalent of 0.66 kg/kg (lb/lb). Consequently, packinghouses with a sizeable curing facility will have a high BOD waste unless the wastes from curing are segregated or recycled. In one plant over 2000 pounds of dextrose was lost daily. The pollution load from meat and fatty tissue can be substantially reduced by dry clean-up prior to washdown. The water use in meat processing should be primarily limited to cleanup operations and to product washing, cooling, and cooking.

Secondary Manufacturing Processes

Secondary manufacturing processes are those by-product operations within the industry for the handling, recovery, and processing of blood, trimmings, and inedible offal. They include paunch and viscera handling, hide processing, hair recovery and processing, and edible and inedible rendering. Those viscera and offal operations that occur on the slaughtering floor, such as paunch handling and tripe processing, were considered under slaughtering .

The hashing and washing of viscera, often performed prior to rendering, produces a strong waste load with a BOD value of about 70,000 mg/l. The waste conservation trend in the past few years has been toward not hashing and washing prior to rendering, but sending the uncleaned viscera directly to rendering. In one plant, removal of the hasher and washer reduced the BOD by 910 kg (2000 pounds) per day, with an attendant increase in the rendered animal feed production.

Efficient recovery of hog hair is now practiced widely within the industry, although the market for this by-product has been reduced in recent years. Very few plants hydrolyze hog hair, but rather wash and bail it for sale or disposal directly to land fill.

Hide curing operations are becoming increasingly involved at meat packing plants. Today many beef slaughter operations include hide curing in tanks, vats, or raceways. The hides, prior to being soaked in brine, are washed and defleshed. These washings, which are sewered, contain blood, dirt, manure, and flesh. In most defleshing operations the bulk of the tissue is recovered. In addition to these wastes, soaking the hide in the brine results in a net overflow of approximately 7.7 liters (2 gallons) of brine solution per hide. In a few plants the brine in the raceway is dumped weekly. In others it is dumped yearly or whenever the solids build up to a point where they interfere with the hide curing operation. The life of the brine can be extended by pumping the recycled brine over a vibrating or static screen. The waste load from the overflow and washings, in a typical hide curing. operation, where the hide curing wastes are not frequently dumped, is about 1.5 kg/1000 kg LWK for BOD and about 4 kg salt/1000 kg LWK.

Blood processing may be done either wet or dry. Continuous dryers, which are quite common, use a jacketed vessel with rotating blades to prevent burn-on; this process results in low losses to the sewer (estimated to contribute about 0.3 kg BOD/1000 kg LWK). Continuous ring dryers are sometimes used; they produce a relatively small amount of blood water that, in some small plants, is discharged to the sewer. The hold technique of steam sparging the blood to coagulate it is still frequently used. The coagulated blood is separated from the blood water by screening. The blood water has a BOD of about 30,000 mg/l. It is often sewered, contributing a waste load of about 1.3 kg/100kg LWK. This loss can be eliminated by evaporating the blood water, either by itself or by combining it with other materials in conventional inedible dry rendering operations.

Wet rendering and low temperature rendering are potentially large sources of pollution. Tank water from wet rendering can have a BOD value of 25,000 to 45,000 mg/l, and the water centrifuged from low temperature rendeirng can have a BOD of 30,000 to 40,000 mg/l. It is estimated that sewering of either of the waste streams produces a waste load of 2 kg BOD/1000 kg LWK. These waste loads can be eliminated by evaporation or combining with other materials used in dry inedible rendering. Triple-effect vacuum evaporators are often used to concentrate the "tankwater" from the wet rendering operation. The waste load from wet rendering is primarily caused by overflow or foaming into the barometric leg of these evaporators and discharge to the sewer or, sometimes directly to a stream. From dry rendering the pollution comes from the condensing vapors, from spillage, and from clean-up operations. A recent study revealed that a typical dryer used 454 to 492 l/min (120 to 130 gal/min) of water for condensing vapors, and that the effluent contained 118 mg/l of BOD and 27 mg/l grease. The estimated waste load from dry rendering is 0.5 kg/1000 kg LWK.

Cutting. The main pollutants from cutting operations are meat and fat scraps from trimming, and bone dust from sawing. Most of these pollutants enter the waste stream during clean-up operations. These wastes can be reduced by removing the majority of them by dry clean-up prior to washdown, and also, by some form of grease trap in cutting area.

The collected material can be used directly in rendering. Bone dust is a large source of phosphorus and when mixed with water, does not settle out readily; thus it is difficult to recover, and should be captured in a box under the saw.

Clean-up. Clean-up contributes between 0.3 and 3 kg BOD/1000 kg LWK in small packinghouses. Data collected by the Iowa Department of Environmental Quality showed that anywhere from 27 to 56 percent of the total BOD waste load is contained in the clean-up wastewaters. The clean-up operation is a major contributor to the waste load. It also leads to a significant loss of recoverable by-products. Detergents used in clean-up can adversely affect the efficiency of grease recovery in the plant catch basin.

The techniques and procedures used during clean-up can greatly influence the water use in a plant and the total pollutional waste load. For example, dry cleaning of floors prior to wash down to remove scraps, and dry scraping of the blood from the bleed area into the blood sewer are first steps. A light washdown, draining to the blood sewer before the normal washdown, definitely decreases the pollution load from clean-up.

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CONTROL OF WATER AND WASTEWATER

In-Plant Modifications Resulting in Water and Wastewater Reduction

The waste load discharged from the meat packing industry to receiving streams can be reduced by conscientious wastewater management, in-plant water and waste control, and process revisions.

The waste load from a meat packing plant is composed of a wastewater stream containing the various pollutants already described. In-plant control techniques will reduce both water use and pollutional waste load. Waste loads will be reduced directly by minimizing the entry of solids into the watewater stream and indirectly by reducing water use. Waste treatment - - that is, the removal of soluble, colloidal and suspended materials - - is expensive. It is far simpler and less expensive to keep the solids out of the sewer entirely. This section describes some in-plant control techniques that are available or are being developed to achieve various levels of waste reduction.

Pen Wastes

Livestock holding pens should be covered and dry cleaned with only periodic washdown as required by the USDA regulations. Bedding material and manure can be disposed of on farm land. A separate sewer and manure pit can be provided for handling liquid wastes from the pens for disposal of on land or to a secondary treatment system. Drinking water in the pens should be minimized and based on need using automatic water level controls on the watering troughs.

Blood Handling

One of the major sources of in-plant pollution is the blood from the kill floor. Whole blood has a BOD5 of 156,500 to 198,000 mg/l, an ultimate biochemical oxygen demand (BODL) of 405,000 mg/l and a potential BOD load of 7 to 15 lbs/1000 lbs LWK (live weight killed). If the blood is coagulated prior to drying, the serum (blood water) has a BOD_5 of 30,000 mg/l and contributes a waste load of 1.3/1000 lbs LWK.

This can be eliminated by evaporation of the blood water or by drying of the whole blood into a profitable byproduct.

In a well-mangaged plant, blood should not be sent to the sewer. It should be almost totally contained and collected in a blood collection system. By enlarging the curbed area used for blood collection, by installing separate sewers for blood drainage and for clean–up, and by use of dry cleaning and/or high pressure–low volume clean–up hoses, this potential waste load can be substantially reduced.

Paunches

Contents of the paunch, or rumen, alsoso represents a primary pollution hazard. This partially digested material exerts a BOD5 of 50,200 mg/l and a BODL of 104,000 mg/l, or 3 to 6 lbs/1000 lbs of LWK. Sixty to eighty percent of the BOD in paunches is water soluble and is thus not removed by the common solids separation screens used in the industry.

The use of water in the initial dumping of paunch material or in pumping it should be discontinued and two other alternatives should be considered:

1) A solids handling pump could be installed, thus eliminating the need for water to form a slurry.
2) The entire unopened paunch could be transported directly to rendering, as mentioned earlier.

Collecting the entire paunch contents (including the liquid) for disposal or treatment without sewering, then following with a small volume but high pressure water rinse or vacuum of the paunch will minimize the waste created by this operation.

Viscera Handling

Good quality grease may be obtained from the wash water used in cleaning edible viscera (i.e. chitterlings). The grease and solids re–covered from this washing operation can substantially reduce the waste load and the recovered grease becomes a salable byproduct that could bring in revenue.

Viscera that is designated for inedible rendering does not require a washing step prior to rendering.

Caustic washings from any viscera processing operating should be segregated before being sewered. Segregation will minimize grease saponification and avoid creating a wastewater with a high pH.

Troughs

Troughs can be instal led under the carcass conveying line in the killing area to keep as much blood, trimmings, bone dust and other material off the floor with substantial waste load reductions. A squeegee or scraper shaped to fit the troughs should be used during clean-up to transfer all collected materials to the inedible rendering operation before wash-up.

Rendering

Both wet and dry rendering are used for edible and inedible rendering processes, although the trend is toward dry rendering. In processing lard, low-temperature to medium-temperature continuous rendering systems are common. The water centrifuged from this process can be sold as 50% to 60% edible "stickwater" and should be evaporated and not discharged to the sewer.

In dry rendering, sprays are commonly used to condense the vapors. In inedible dry rendering, catch-basin effluent can be reused as condenser water. In edible dry rendering, the vapors are commonly condensed with fresh water. A direct heat exchanger can be used to condense the vapors without increasing wastewater volumes.

In wet rendering, the greases are drawn off the top of the tank, then the water phase (tankwater) is removed. This tankwater has a BOD5 ranging from 22,000 mg/l to as high as 45,000 mg/l. Suspended solids content can be as high as 2%. <u>Under no circumstances should this type of waste be discharged to the sewer!</u> It should be evaporated, and the end product called ''stick'' or "stickwater" should be used in animal feeds. The tankwater may also be dried directly with inedible solids in a dry rendering tank. The bottom sludge from wet rendering should be pressed for recovery of residual grease, and the remaining solids should be used as edible product from edible rendering, and as an animal feed ingredient from inedible rendering .

Hide Processing

An overflow of water from the hide curing vat or raceway occurs because water is added to the curing solution. This overflow could be contained, collected, and treated separately to achieve a "cleaner" effluent, especially in terms of salt concentrations. It is particularly important to dump the vat's contents infrequently - - perhaps only annually. When dumped, the vat should be drained slowly, over a 24-hour period or longer, to avoid an extreme shock load on the treatment system. The life of the solution can be extended by pumping it over a static or vibrating screen.

Scald Tank

The hog scald tank contains settled solids and wastewater with a high waste load. Collection, treatment, and reuse of this water should be considered. Slow drainage of the tank will reduce any shock load on the waste treatment system and should be a standard practice. Provisions should be made for removing the solids through the bottom of the tank to a truck for land disposal.

Pickle and Curing Solutions

These solutions are high in salt content and, in many curing solutions, high in sugar content. Salt is a difficult pollutant to remove and sugar has a very high BOD. In present production techniques, only 25% of the pickling brine remains in the product; through loss of the remainder and other additions of salt to wastewater streams, a packinghouse typically adds over 1000 mg/l of chlorine to its effluent. The operations involving injection or soaking meat in these solution should be equipped to collect any of the solution presently being wasted. The collection pans and equipment should be designed to permit reuse of these solutions.

Segregation of Waste Streams

In meat packing operations, it has been common practice to provide separate sewer systems for:

- grease wastes
- nongrease wastes
- clear waters from chilling, condensing, and cooling operations

- surface and roof water (surface drainage)
- stockpen wastes
- sanitary wastes

In new plants, however, further segregation is often desirable in order to permit removal of pollutional ingredients before the wastewaters mingle with other plant waters. Screening equipment can then be smaller in size and designed to remove specific solids rather than required to remove the plant's whole gamut of solids. In some cases, such segregated waters may be sufficiently dilute to use for recycling.

In-Plant Attempts to Reduce Wastewater From Hog Slaughtering Operations

A study conducted by Berthovex et al. (1977) attempted to characterize and quantify wastes generated in a typical hog slaughtering operation both before and after modifications were made to reduce wastewater volume and strength and to increase byproduct recovery. One goal of this project was to discover what could be reasonably accomplished in a typical, large hog slaughtering operation without making major alterations in the plant, and without hindering productive output. This need to reduce in-plant waste while maintaining the usual production rate and quality required the cooperation of the operating personnel and the backing of management

Process Changes and Recharacterization

The initial characterization of wastewaters, and visual plant inspection indicated the areas in the plant which produced the greatest amounts of pollutants and those which used the largest volumes of water. This information was used to guide redesign and process changes. In a few cases one of the three plants studied was using water in a particular process more efficiently than the other two plants, so this plant could be pointed to as a good example of water use in that particular unit process.

Implementation of desirable changes was not always simple or possible. Fearing that delays could cost dearly in terms of lost labor and lowered production, mangement was reluctant to test some ideas. Even when changes were made, many delays were experienced in installation of equipment and process redesign features due to a shortage of trained mechanical personnel available for this project. Because it was not possible to test all changes that were thought to be desirable, in this section not only are the actual changes that were tested presented and discussed, but also tests which should have been made and changes which are clearly worthwhile are presented. Tables 8 and 9 provide a summary.

Changes in the Stick and Bleed Area

Problem. Most of the blood which is washed down the bleed area floor drain during clean-up originates as a production shift problem. The two sources of blood entering this drain were drippings from the chain or bleed conveyor and blood overflowing the bleeding trough. The overflows were intermittant, and rather infrequent. Overflows occur when heavy blood clots collect along the bleeding trough.

Solution. A change in technique solved this problem. The person who sticks the hogs now positions every 30th or 40th hog so that one front leg drags along the trough as the hog is conveyed into the scald tank. This prevented collection of large clots, eliminated the overflow problem, and reduced by about 80% the amount of blood reaching the bleed area floor drain. The residual 20% of the blood that use to enter the bleed area floor drain originates as drippage from the chain, washing of knives and hands, etc., and is not considered recoverable. The results of this change in technique is that 25 lb (11.3 kg) of blood equivalent to about 5 lb (2.3 kg) of BOD, now enters the blood recovery system instead of entering the wastewatersystem.

Problem. After the last hog was killed for the day, six sprays along and above the bleed trough were started to wash some of the blood from the troughs to the blood recovery system. The first sluice of water with about 50% of the blood went to the blood recovery system; after this short initial sluice, drainage was diverted from the blood recovery system to the bleed conveyor floor drain.

Solution. A squeegee with an offset handle was made to remove blood from the blood trough into the blood recovery system without using the initial sluice of water. This dry cleaning procedure increased the amount of blood recovered from 50% of that on the trough as clean-up began to 80 to 90% of the blood that was on the trough at the start of clean-up. Not

Table 8. Summary of Changes in Pollution Load and Flow.

Item	Production shift			Cleanup shift			Production & Cleanup		
	Flow gal/shift	BOD lbs/shift	SS lbs/shift	Flow gal/shift	BOD lb/shift	SS lb/shift	Flow gal/day	BOD lbs/day	SS lbs/day
Original condition	350,700	5,820	5,500	170,800	310	625	521,500	6,130	6,125
Reduction	116,802	3,757	3,600	95,660	124	243	212,462	3,881	3,843
Percent reduction	33%	65%	65%	56%	40%	39%	41%	63%	63%
Net after change	233,898	2,063	1,900	75,140	196	382	309,038	2,249	2,282

Table 9. Identification of Reduction by Sample Point.

Sampling point	Production Shift			Cleanup shift			Production & cleanup		
	Flow gal/shift	BOD lb/shift	SS lb/shift	Flow gal/shift	BOD lb/shift	SS lb/shift	Flow gal/shift	BOD lb/shift	SS lb/shift
Bleed area floor drain	0	0	0	0	5	0	0	5	0
Bleed conveyor bl drain	0	0	0	0	5	0	0	5	0
Bleed conveyor washer drain	2,668	0	0	0	0	0	2,668	0	0
Dehair floor drain	50,000	382	461	60,000	124	243	110,000	506	704
Scald tank	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Rosin stripper	0	0	0	0	0	0	0	0	0
Rail polisher drain	6,400	-	-	-	-	-	6,400	0	0
660 grease drain	8,753	0	0	0	0	0	8,753	0	0
Carcass shower	(8,753)[a]	(0)	(0)	(0)	(0)	(0)	(8,753)	(0)	(0)
Center grease drain	6,520	0	0	0	0	0	6,520	0	0
Head washer	(6,520)	(0)	(0)	(0)	(0)	(0)	(6,520)	(0)	(0)
Stomach washer drain	0	0	0	0	0	0	0	0	0
Hasher washer drain	42,461	3,375	3,139	35,660	0	0	78,121	3,375	3,287
a. Blades out	(0)	(2,948)	(2,906)	(0)	(0)	(0)	(0)	(2,948)	(2,906)
b. a + curb + vacuum	(39,427)	(170)	(-148)	(0)	(0)	(0)	(39,427)	(170)	(0)
c. a + b + new nozzle for cleanup	(0)	(0)	(0)	(35,660)	(0)	(0)	(35,660)	(0)	(0)
Neck washer	(3,034)	(257)	(381)	(0)	(0)	(0)	(3,034)	(257)	(381)
Net reduction	116,802	3,757	3,600	95,660	124	243	212,462	3,881	3,991

[a]Values in parenthesis are a subset of the above value and are not included in the total.

Only is more blood recovered by this method, but the cost of recovering the blood is reduced because the water added to clean-up does not have to be handled and heated in the blood recovery process.

Problem. During production the bleed conveyor was sprayed with cold water to wash blood off the slotted side of the conveyor. This was to prevent the conveyor from becoming coated with dried blood that would be difficult to clean off. The water used in these sprays was 2,668 gal (10,100 lb) per production shift.

Solution. Tests showed that eliminating these water sprays did not make clean-up of the chain more difficult. The sprays are now used only one or two hr/day and this is during the clean-up shift. These sprays are not operated during the production shift. This saves 2,668 gal of water/day, and $260/yr.

Process Changes in the Dehairing Operation

Problem. In Madison during production, 50,000 gal (190,000 1) of potable water are used solely to transport removed hair and toenails from the dehairing machine to the sewage treatment plant, and 60,000 gal (227,000 1) of water are used during clean-up to dislodge hair from the machine and sluice it away. The reason for increased water use during clean-up is that hair drops out of the machine in large matted bunches and, unless large amounts of water are used for sluicing, these bunches plug the dehair floor drain.

The cost of this large volume of water is approximately $10,725/yr in Madison*. An additional cost of $8,681 is due to pollution load. Over 5 years at 10% interest, this capitalizes to $73,564 which could be invested in process modification.

*This cost is estimated using the current cost of 15¢/1000 gal for cold potable water, a sewer charge based on the volume of wastewater entering the Madison Sewage System of 24#/1000 gal and 250 working days/yr. All cost for water and sewage disposal reported in this chapter will use this basis for calculation unless a specific notation is made otherwise.

Solution. Other slaughtering plants visited during the course of this study provided optional methods to reduce the water use. In Davenport, hair and toenails are scraped out of the dehairing machine onto a chute which directs the hair into a dump truck. At Beardstown, hair is transported from the dehairing machine to the sewage treatment plant by reclaimed sewage. Other plants which were visited used conveyors to transport the hair from the dehairing machine to a truck for hauling to land-fill disposal. If dry conveyance of hair is not possible, recycled water should be used in minimal amounts for sluicing. See Tables 10 and 11 for estimated savings from using dry conveyance in Madison. Another way to eliminate this source of pollution is to change the carcass handling and skin the hogs rather than remove the hair.

Changes in Rail Polisher Operations

Problem. Water use in the rail polisher in all plants was too high, principally because clean-up personnel leave the sprays on during clean-up shift. This water serves no useful purpose.

Solution. One solution is better training and supervision of clean-up personnel. This is not always easy to accomplish, so a mechanical solution was developed and tested. An automatic switch was installed which turns off the water when the last hog has gone through the rail polisher. A steel push bar is depressed by the hog trolley to activate a solenoid valve on the water supply to the rail polisher. The savings during the clean-up shift were 1,640 gal (6,208 1) for every hour these sprays are left on, and this unnecessary water had been running several hr/day. The cost of the automated shut off was $255.00. The estimated annual savings in water use is 1,600,000 gal (6,400 gal/day x 250 day/yr) or $624.00.

Process Changes in the Carcass Shower

Problem. The problem was excessive water use. The final carcass shower contributed 60 gpm (3.78 l/s) into the grease drain. This was the primary source of wastewater entering that drain.

Solution. Different kinds and configurations of nozzles were experimented with to reduce the volume of water required for cleaning the hog carcasses. In Madison a series of 6 Veejet nozzles (Spraying Systems

Table 10. Dehairing Machine Reductions in Flow and Pollution Load. (gal/1000 lbLWK or lb/1000 lbLWK)

Item	Before change[a]			After change			Net Reduction
	Prod.	Cleanup	Total	Prod.	Cleanup	Total	
Flow	70.29	65.96	136.75	35.52	24.25	59.77	76.48[b]
Total solids	1.225	0.504	1.729	0.619	0.159	0.779	0.950[b]
Susp. solids	0.649	0.247	0.896	0.328	0.078	0.406	0.490
Grease	0.180	0.022	0.202	0.091	0.007	0.098	0.104
TKN	0.131	0.016	0.147	0.066	0.005	0.071	0.075
BOD	0.536	0.125	0.661	0.270	0.039	0.309	0.352
COD	1.308	0.377	1.685	0.660	0.119	0.779	0.906

[a]The change is to replace sluicing of hair from the dehairing machine with dry conveyance.
[b]Multiply by 1437.5 to get gal./day or lb/day.

Table II. Annual Savings Due to Possible Dehairing Machine Change[a].
(based on 250 work days/year)

Item	Amount
Flow savings:	
110,000 gal/day = 27,500,000 gal/yr @ $0.39/1000 gal	$10,825/yr
BOD surcharge savings:	
506 lb/day = 126,500 lb/yr @ $0.319/lb	$4,035/yr
SS surcharge savings:	
704 lb/day = 176,000 lb/yr @ $0.0264/1b	$4,646/yr
Total Annual Savings	$19,406/yr
Presentvalueofsavings:	
10%..@years..5	$73,564
Estimated cost of installing dry conveyance system	$22,000
Estimated net present value of savings	$51,564

[a]The cost of water is $0.15/1000 gal for cold potable water plus $0.24/1000 gal for wastewater surcharge. The BOD and SS surcharge are the 1975 Madison rates.

Co.) were installed to spray the top of the carcass to sluice off loosened soil. These nozzles did a good job of removing dirt from the carcass and reduced the water use from 60 to 43 gpm (3.78 to 2.7 l/s). Unfortunately, these nozzles created a fine spray mist that carried out of the shower enclosure, so the nozzle arrangement has to be modified. The reduction technique saved 8,753 gal/day with an annual savings of $853 with a cost of $184.

Changes in Carcass Work-up Area

The carcass work-up area is defined as that part of the kill floor after the final carcass shower where the carcass is trimmed, cut and split. In this section the focus is on water, meat and fat scraps, and blood that falls onto the floor under and around the kill chain. Pollution can be eliminated by properly handling these scraps and drippings.

Problem. Eyelids, which are removed from the carcass right after the carcass shower, were dropped onto the floor. Despite periodic dry pick-up many of these meat scraps were washed into the grease drain by water originating in the carcass shower

Solution. A combination bridge and screen was built to fit across the drain and gutter to keep eyelids out of the drain. About 12 lb of this scrap formerly entered the drain. The amount of grease, BOD, etc., is not known, but there is no doubt that this simple change has reduced the pollution load.

Problem. Trimmings, blood clots, and meat and bone dust from carcass splitting littered the carcass work-up area. Mid-shift and final clean-up personnel often found it more convenient to flush this material into a drain rather than use dry clean-up methods. This caused a large periodic pollution load and lost material for inedible rendering. Dry clean-up with a broom and shovel, the normal procedure, is an effective procedure. A "Tornado" industrial vacuum cleaner was tried for dry clean-up. This cleaner readily picked up blood, floor scraps, sawdust, and even whole kidneys, and left the floor dry, but it was cumbersome and slow. Some congested areas were not accessible. A man with a broom and shovel could do almost as well in less time and with less interference to kill-line operations. The vacuum system could be used to good advantage in some places, particularly if installed as a central system, thereby eliminating the cart, electrical cords, and movable tank.

Problem. When the hog brisket is split open and viscera is removed, large clots of blood fall into the gutter beneath the kill rail. During rnidshift clean-up and final clean-up these are often pushed down the chute leading to the hasher-washer rather than being salvaged for rendering. Sluicing to the hasher-washer breaks up the clots and leaches substantial amounts of soluble material from the clots.

Solution. The solution is dry clean-up. Training and supervision of personnel is vital. Vacuum cleaning would be effective in some places.

Problem. Blood clots near the viscera removal treadmill fall onto the floor and are washed with water from lavatories, drinking fountains, and the viscera removal treadmill sprays. This leaches soluble material and generates a pollution load.

Solution. More frequent dry pick-up of clots would reduce the problem, but not eliminate it. This was not a practical solution because of labor costs. Elimination of the water sources was not a practical solution either. Segregation of the water and the blood clots was practical. A curb was built around the eviscerating treadmill to divert water and prevent it from contacting the clots. Mid-shift dry pick-up of these "protected clots'' became part of the pollution reduction solution at this location.

The kill method of electrical stunning and hung bleeding used at Beardstown produced more complete carcass bleed-outthan the CO2 immobilization prone bleeding method used in Madison. This reduced the amount of blood clots reaching the floor.

Problem. Bits of fatty tissue, abdominal aorta and skin from around the stick wound are trimmed off and dropped into the gutter. Periodically these were swept into the hasher-washer chute where the sluice water would leach soluble material. Because of labor standards and work efficiency, it was not practical to have the trimmer deposit the scraps into a barrel or other container. The vacuum cleaner was too cumbersome to be efficient in this work area.

Solution. Blood clots and trimmed tissue could be kept off the floor and out of the drains by installing a stainless steel trough under the kill-line. Material could then easily be collected dry for rendering. The kill rail is so low in the Madison plant that such a trough could not be installed without having the heads or ears of sows come into contact with it. This would not be allowble. Such a trough would be useful in many plants where only butcher hogs are slaughtered or where the kill rail is higher.

Changes in Viscera Handling

Problem. There was a continual loading of blood and other material which is washed off the eviscerating treadmill by water spray. These sprays used a total of 15 gal/min, part of which is 180°F water which is used to sanitize the treadmill, part of which is cold water spray to loosen blood and other matter. The problem was to reduce the amount of water used for washing.

Solution. Experiments showed that cleaning with only 5 gal/min of water was sufficient. The reduction in water use was accomplished by installing new nozzles. in the spray system. The nozzles from the Spraying Systems Company are as follows: 1/8 K 4.0 nozzles on 6 in. centers located 3 in. from the treadmill for the cold water washer; 1/8 K 2.5 nozzles on 6 in. centers located 3 in. from the treadmill for the hot water sanitizing sprays. The change saved 4,670 gal (17,676 1) of water/day on the treadmill alone which is $455.00 annually. The cost of making the change was $63.00.

Problem. The greatest contributor of water to the hasher-washer drain in the Madison plant was the viscera pan washer on two kill-lines. The problem was to reduce the water required to wash and sanitize the viscera pan. The washing procedure consisted of a cold water wash followed by a hot water (18O°F) sanitizing water spray, followed by a cold water rinse to cool viscera pans. The cold water wash consisted of two 1 1/2 in. water pipes which were perforated with 1/8 in. holes drilled 1 1/2 in. apart. One of these spray pipes was located above the viscera pans and one was located below the pans.

Solution. The old spray system was replaced with new nozzles. The nozzles were placed on 8 in. centers at a 6 in. distance from the viscera pan conveyor to spray the backs of the pans, and 6 nozzles were spaced on 6 in. centers at a distance, of 6 in. from the pan to wash the insides of the pan. This nozzle change reduced the water use to clean and sanitize the viscera pans from 115 to 40 gal/min. Tables 12 and 13 give an accounting of the pollution and monetary savings for all the changes implemented in the evisceration area; these implementations include the curb around the treadmill which segregates water and blood clots so blood clots can be cleaned up dry, changes in the treadmill washing, and changes in the viscera pan washing.

Problem. Excessive amounts of water were being used on the viscera pans and the evisceration treadmill during clean-up. The clean-up personnel would leave the viscera pan and treadmil1 sprays turned on during most of the clean-up. After the first thirty minutes, these sprays accomplished no useful purpose.

Solution. Solenoid valves were installed on the 3 water lines which supply the viscera pan sprays and treadmil1 sprays. These valves are controlled by a locked timer box. During production the timer is set on manual operation and the solenoid valves remain open. At the end of production the timer is set on automatic and the control cabinet is locked. To use the sprays, the clean-up man must push a button on the control cabinet to activate the timer and open the water supply valve. The timer automatically closes the solenoid valve after 15 min. The sprays can be restarted by pushing the button again if more water is needed, but they cannot be left running by inaction or carelessness. This automated lockout would not be required if clean-up workers were properly motivated toward good conservation practices and were well supervised. In many plants automation will be the practice which is certain and effective. The savings accomplished by using this automated valve during clean-up shift were found to be $2,907/yr with an installed cost of $1,285.

Changes in the Hasher-Washer

Several of the changes mentioned previously to collect scraps from the floor and prevent leching of soluble materials were designed to keep scraps out of the hasher-washer drain. In this section a major improvement made in the hasher-washer itself is considered.

Problem. The hasher-washer drain is the largest contributor of pollution load from the kill floor. Intestines and great quantities of other sol id materials are sluiced into the hasher-washer from various parts of the kill floor. Knives in the hasher-washer slash the intestines and

Table 12. Reductions in Flow and Pollution Load Due to Evisceration Treadmill and viscera Spray Changes: Segregation, Vacuum Cleanup, and New Nozzles. (gal/1000 lb LWK or lb/1000 1 b LWK)

Item	Before change	After change	Net reduction
Flow	53.14	25.70	27.1[a]
TS	1.433	0.883	0.550[a]
ss	0.324	0.320	0.004
Grease	0.255	0.213	0.042
TKN	0.134	0.062	0.072
BOD_5	0.650	0.529	0.121
COD	1.581	0.953	0.628

[a]Multiply by 1437.5 to get gal/day or 1 lb/day.

Table 13. Annual Savings Due to Evisceration Treadmill and Viscera Spray Reductions of Table 12. (Based on 250 work days/yr and costs of $0.39/1000 gal, $0.0319/lb BOD5, and $0.0264/lb SS)

Item	Amount
Flow savings :	
39,427 gal/day = 9,856,750 gal/yr	$3,844/yr
BOD savings:	
170 lb/day = 4,250 lb/yr	$136/yr
Loss due to increased SS	Negligible
Net annual savings	$3,980
Present value of savings:	
5 years @ 10%	$15,087
Installation cost	$2,377
Net present value of savings	$12,710

this enables the sluice water to flush out the intestinal contents. The objective is to allow fat and meat solids to go to inedible rendering, and permit wastewater to go to the wastewater treatment plant. The separation of solids from the liquid is very inefficient. Large quantities of solids escape with the water through the large slots in the hasher-washer drum. The problem is to send less of the solid material, which represents an extremely high load in terms of BOD solids, grease, and other pollutants, to the wastewater treatment plant and to capture these materials for rendering.

Solution. One solution would be to design a hasher-washer with smaller slots that could recover a greater portion of the solid material. A similar solution would be to follow the existing hasher-washer with a second screening operation that would capture smaller particles. Neither of these alternatives was tested because a better solution existed. The chopping blades were removed from the hasher-washer so the unit functioned only as a dewatering device. The large and small intestines and their contents were allowed to remain intact and were sent to inedible rendering. This increased the quantity of meat scrap and material for rendering by an average of 8,500 1lb/day. The present value for rendered meat scrap is $5.75/100 lb; this 8,500 lbs/day is worth $488.75. This additional income is not the total savings associated with the change because allowance must be made for savings in wastewater treatment. Analysis of the meat scraps produced during the test period did not indicate reduction in the quality, although the crude fiber content of the meat scraps did increase from 1.5% to 1.7%.

The solids from the hasher-washer are rendered to produce grease and meat scraps. During the test with the hasher-washer blades removed, there were several customer complaints about the quality of the choice white grease. Some of this grease had to be downgraded to A-white with the resultant loss in the selling price of .50/100 weight. (Choice white grease sold for $14.75/100 weight.) During the years 1971 through 1975 the Madison plant produced an average of 5,188,000 lbs of choice white grease/yr. If this total production were downgraded to A-white, there would be a loss in income of $25,940/yr. This is offset by the increase in meat scraps going to rendering which was estimated as $488.75/day which over 250 working days/yr approximates $122,000. This accounting is not exact. The extra cost of drying the additional meat scraps, the savings in power and maintenance in not running the hasher, and savings in wastewater treatment have not been included.

Removing the hasher-washer blades gave a substantial reduction in BOD, suspended solids, and other pollutants going to the wastewater treatment facility. See Tables 14 and 15 for detailed pollution and cost data.

Changes in Head and Neck Washer

Problem. The scouring action of the neck washer removes fatty tissue from the neck and jowl area of the carcass and removes blood from the stick wounds. Excessive amounts of water are used and there is a large pollution load generated.

Solutions. A Chad neckwasher was installed in the Madison plant to replace the two or three men who previously washed the necks with manually operated scrubbers. The Chad neck washer uses 20 gal/min of water at 800 psi pressure to scourblood and soil from the neck. The method previously used consumed 26 gal/min. The pollution and dollar savings from installing the new Chad neck washer were: flow savings = 758,500 gal/yr, BOD reduction = 64,250 lb/yr, TSS reduction = 95,250 lb/yr and an annual savings of $4858/yr.

Problem. The head washing equipment contributed a major portion of the flow and pollution load into one of the Madison plant's drains. The USDA requires nothing specific of head washing equipment. The equipment is supposed to remove blood and stomach contents which have dripped onto the heads, and make the heads easier to handle in the trimming operation.

Solution. The flow was reduced from 16,520 gal/shift to 3,260 gal/shift in the head washer by removing three of the six spray nozzles and by decreasing the flow from the three nozzles which remained.

Changes in Chitterling Washing

Beardstown is the only Oscar Mayer Plant that saves chitterlings.

Problem. Excessive amounts of water were used to flush manure from the chitterlings. Additional large amounts of water were being used to wash workers' hands. Most of the water was being discharged through eight shower-type spray nozzles located along the chitterling machine.

Table 14. Reduction in Production Shift Pollution Load Due to Removal of Hasher Washer Blades.

Item	Before change	After change	Net reduction lb/1000lbLWK	lb/day
Flow	No	change	--	--
BOD lb/1000 lbLWK	2.70	.6498	2.050	2948
SS lb/1000 1bLWK	2.35	.324	2.020	2906
TS lb/1000 lbLWK	4.34	1.433	2.907	4180
Grease lb/1000 lbLWK	2.83	.255.	2.625	3775
TKN lb/1000 lbLWK	.23	.134	0.096	138
COD lb/1000 lbLWK	6.80	1.581	5.219	7505

Table 15. Annual Savings Due to Removing the Hasher Blades. (Based on 250 work days/yr and costs of $0.39/1000 gal, $0.0319/lb BOD, and $0.0264/lb SS)

Item	Amount
Flow savings	**None**
BOD savings:	
2948 lb/shift = 737,250 lb/yr	**$23,518/yr**
SS savings:	
2906 lb/shift = 726,500 lb/yr	**$19,179/yr**
Total annual savings	**$42,697**
Annual added value due to increased meat scrap:	
8500 lb/day = 2,125,000 lb/yr @ $5.75 per CWT	**$122,187/yr**
Annual loss due to downgrading grease quality	**$25,940**
Annual net savings	**$128,944**
Present value of savings	
5 years @ 10%	**$526,681**
Cost of modification	**$ 275**
Net present value of savings	**$526,406**

Solution. The shower type nozzles were replaced with Spraying Systems Company 3/8 in. GG "full jet" nozzles. Meter readings indicated that the average water use for the three chitterling washers dropped from 112,500 gal/day to 60,685 gal/day. The savings based on the water flow alone was $5,061/yr.

Summary

The list of solutions reviewed in this section represent a net present value over five years (at 10% interest) of more than one-half million dollars. It is remarkable how small process changes, made with little or no expense, add up to savings of thousands of dollars annually. Reductions in water use alone is a great savings, and there is the added benefit that decreasing the water use almost always brought a reduction in BOD, suspended solids, and other pollutants. Often there was increased byproduct recovery, as well.

Reviewing the Hog Slaughtering Study

The quantity of wastewater issued from the hog slaughtering floor and the quantities of pollutants (BOD, COD, Kjeldahl nitrogen, suspended solids, etc.) carried by this wastewater were measured for both the production shift and the clean-up shift. Several process modifications were made to reduce flow and the pollution load. The cost to make the changes ranged from zero to $12,000; most cost only a few hundred dollars. Savings ran from $280 annually for turning off a valve to $128,944 annually for modifying the hasher-washer to recover more scrap for rendering while simultaneously reducing the pollution load discharged. Even small and simple modifications resulted in annual savings of several thousand dollars/yr. Often the savings in water alone more than paid for the modification with savings due to pollution load reduction being a tidy bonus. No installed change failed to more than pay for itself. In-plant modifications are cost-effective, sometimes astonishingly so.

Two-thirds of the flow was discharged during the production shift. The three largest water users in Madison for production were the dehairing machine, 70.3 gal/1000 lb LWK; the stomach washer, 48.5 gal/1000 lb LWK; and the process areas that contributed sluice material to the hasher-washer, 53.2 gal/1000 lb LWK.

BOD load comes primarily from the hasher-washer, 2.707 lb/1000 lb LWK out of a total for production and clean-up of 4.266 lb/1000 lb LWK. The stomach washer discharges 0.542 lb/1000 lb LWK and the next largest contributors are the dehairing machine (0.661 lb/1000 lb LWK) and the 330 hog/hr kill-line grease drain (0.215 lb/1000 lb LWK). Eighty percent of the BOD was discharged during the production shift.

These summaries clearly identify the sources of gross pollution and lead one to the process areas that must be modified. Table 16 lists the modifications made and the savings won. The flow was reduced by 41%; the BOD load was reduced 63%; and other pollutants were reduced in proportion to BOD. Many modifications required such a small investment that the first year savings paid for the installation. The net savings over a five-year period were impressive. The present value of the sequence of savings less the initial investment to make the change is listed as the net present value of savings. The total net present value of savings, over 5 yr at 10% interest, exceeds half a million dollars. This impressed management with the enormous benefit/cost ratio of in-plant changes and wastewater reduction steps will be continued with enthusiasm.

Conclusions

Many older slaughtering operations were designed without consideration of wastewater treatment costs and problems. Water was used extravagantly; it was drained indiscriminantly across floors where it contacted blood clots and meat scraps, clean-up, and the cost of pollution control was unknown or well hidden in overhead and utility costs. These older plants can be modified, often rather easily and without great expense, to reduce water use and lessen the amount of materials entering the drains as organic pollution.

Many specific problems and solutions have just been discussed in a previous section. The magnitude of the wastewater flow and pollution load reductions achieved and the net savings are reported there as well. Broader conclusions are given here.

1) In the Madison plant the production shift discharged about two-thirds of the flow and 80% of the BOD. Even after making production shift modifications, while leaving the clean-up shift unchanged, the production shift would yield more wastewater (about

Table 16. Costs of Changes and Savings Resulting from Changes.
(All changes were made in Madison except where noted)

Problem Area	Cost of Change	Annual savings	Notes
Bleed trough	$ 0	$ 40	-----
Bleed trough clean-up	$ 3	$ 40	-----
Bleed conveyor sprays	$ 0	$ 260	-----
Hair chute - Davenport	$22,000	$19,406	-----
Rail polisher shut off - Beardstown	$ 255	$ 624	-----
Final carcass shower - Madison	$ 184	$ 853	-----
Beardstown	$ 88	$ 2,080	-----
Eyelids on Floor	$ 86	-------	Increased by product recovery value unknown
Brisket splitting Bone dust - carcass splitting Viscera pan wash sprays	$ 2,377	$ 4,078	-----
Viscera pan wash solenoid valves	$ 1,285	$ 2,907	-----
Hasher-washer blade removal	$ 275	$42,697 $96,244	Pollution reduction Increased byproduct recovery
Head washer	$ 0	$ 831	-----
Neck washer	$17,000	$30,000 $ 4,858	Reduced labor Reduced pollution & water consumption
Chitterling washer - Beardstown	$ 78	$ 5,070	-----

60% of the total) and more BOD (about 90% of the total). Making changes in both shifts gave the following result:

Flow . . . . 41% reduction to about 310,000 gal/day
BOD . . . . 63% reduction to about 2,250 lb/day
SS . . . . 63% reduction to about 2,300 lb/day.

After all changes, the clean-up shift represents about 25% of the flow, 9% of the BOD, and 17% of the suspended solids.

The opinion is often stated that the greatest target for reductions is the clean-up shift. The use of water for clean-up in the Madison plant was not terribly wasteful when the project began; nevertheless, the amount of water saved by making simple process modifications was 75,000 gal/day, a 56% reduction. This savings was due to process changes and not due to retraining clean-up personnel. or enforcing stricter procedures for using hoses and the like. Impressive as this value is, shifting to dry conveyance of hair during the production shift represented greater savings.

2) Dry conveyance of hair from the dehairing machine saves thousands of dollars on water purchase and disposal. It also reduces the load of suspended solids, BOD and other pollutants on the waste disposal facility.

3) Sluicing intestings, other viscera, and other scrap to rendering is a water use that should be minimized. Usually it cannot be eliminated and, therefore, some solid-liquid separation device may be needed prior to rendering. The separated liquid will be very high in all pollutants and was the largest single source of pollution in the Madison-plant. Modifications of this solid liquid separation will be rewarded handsomely by reduced treatment problems and increased income from rendering.

4) Dumping the contents of the hog stomach creates a very heavy load of suspended solids and other pollutants. Many of the contents

are soluble and any contact with water gives an immediate rise in the soluble pollution load that must later be removed by expensive secondary treatment processes. Dry dumping of stomachs would save greatly on water consumed and it would represent a major savings in pollution, but a solution has not been developed.

5) Other than the three processes previously mentioned, the main sources of pollution during the production shift are blood drippings and clots, and meat scraps dropped on the floor. Some easily installed and cheap remedies are screens around drains to hold back scrap until it can be shoveled into a container, catch troughs under the kill-line to keep blood clots and scrap out of gutters and prevent leaching of organic pollutants, and curbs to divert water flow from floor areas which are covered with potential pollutants.

6) There is good correlation between BOD and COD; either measure could be used. also, total Kjeldahl nitrogen is proportional to BOD, COD, SS, and could be used as a surrogate measure for screening studies.

7) USDA regulations severly restrict the possibilities for reusing water except for sluicing hair and material that goes to inedible rendering. If sluicing must be used for transport of material , use recycled water and then reduce the volume of water to the minimum. Better yet, eliminate sluicing whenever possible and use dry conveyance methods. This eliminates leaching of organics from meat scraps and break-up of blood clots.

8) The most difficult part of an in-plant wastewater reduction program may be winning the cooperation of the management who must approve the use of mechanics and other personnel to install the changes. Obviously, production cannot be interrupted by slacking on maintenance and process repairs, and mechanics are usually not overabundant. The best hope of winning this cooperation is to show estimated savings due to a particular change.

The In-Plant Survey

The Spinoff on Management Control outlines a strategy for making a plant survey to identify Valuable process modifications. The goal here is to provide advice that can help a plant accomplish in-plant water and wastewater reductions without investing great amounts of time and money in data collection. Small plants need not necessarily carry out extensive research programs to save money, and water.

The Cost Benefit Factor

Sometimes the pollution control problem requires that rather massive modifications be considered. Plant managers should then insist upon an orderly and detailed evaluation. The cost of the modifications can be estimated easily, but the total benefits can be elusive. A special problem exists when several alternate modifications, each expensive yet beneficial, are to be studied.

The cost of organizing a study and implementing a proposed change must be weighed against the benefits of lower water bills, reduced sewer charges, reduced treatment costs, and increased by-prouct recovery. The cost/ benefit analysis must be considered for several years into the future. The uncertainty of future labor, energy, raw water, and wastewater treatment costs, makes the analysis very difficult and requires careful judgement by the plant.

The first step is for the plant to realize that a pollution problem exists or that a savings can be made by reducing its total effluent load. This realization may come about through violation of an effluent constraint, excessive user charges, or industrial cost sharing studies.

Once the plant decides to act, step two is a survey of "in-house" operations to pinpoint major problem areas and sources for potential improvement. The most difficult decision facing the plant will be selecting the most cost-effective changes.

The third step requires the plant to make a detailed analysis of the present or expected treatment and disposal costs. This analysis will become the basis of comparison with the costs of revision. One plant may operate a primary and secondary treatment facility and discharge the treated effluent into a municipal sewage district interceptor. Other plants may have complete on-site treatment. In all cases, the present disposal cost, the method used for calculating that cost, and an estimate of future changes in those costs should be understood. It is often, difficult to estimate accurately the "real" present treatment cost. This is due to the poor segregation of all costs associated with wastewater treatment, from general corporate costs. Estimates of treatment costs often do not include "hidden" administrative costs for secretaries, engineers, processing plant managers, vice presidents, and other personnel who spend a portion of their time with different aspects of the pollution problem. The vice president of finance may spend a great deal of time arranging financing for a treatment facility, while a public relations manger may devote time and resources to keeping the public informed concerning the company's pollution abatement efforts. These and other costs are definitely associated with pollution control and should be included when making a valid cost/benefit analysis.

The fourth step in this approach involves studying each proposed modification and estimating the pollution reduction and water conservation that each can achieve. The reduced effluent load is used for calculating the revised treatment cost, and the cost for installing and operating the modification. Also, any benefits due to reduced raw water volumes and byproduct recovery can be calculated.

If the net result is a savings, the modification should be installed. If the new cost is greater than the original cost, the modification should be rejected or re-examined. If an initial segregation modification is rejected, a more complete segregation can be examined.

The viable modifications can be compared and the ones with the best cost/benefit analysis should be chosen if they also satisfy the plant's requirements for space, base of operation, reliability, and other factors. The best judgement of the plant must be used to select the modifications which will achieve a least-cost, long-run solution to its pollution problem.

It must be noted that the treatment costs and by-product recovery values are on an annual basis, while the cost for the modification is a one-time cost. Current value analysis should be applied to account for the time value of money. At times when plants are faced with tighter capital markets, in-plant reduction can be a method for reducing treatment costs with minor capital expenditures.

In-plant wastewater reduction studies offer significant savings to meat processing plants. Studies should progress from a "first-cut'' to a complete plant survey unless the desired reductions are achieved. The plant must decide if it should invest additional money in a wastewater treatment plant, or invest that money in more efficient process equipment.

Review

The following list offers a summary of practices and equipment that will be helpful in reducing water use and waste production in red meat processing plants.

- Replace all drilled spray pipe systems with spray nozzles designed and located to .provide a desired water spray pattern.

- Replace all washwater valves with squeeze- or press-to-open valves wherever possible. Foot- or knee-operated valve control are useful where operator fatigue is a problem or where the operation requires the operator to work with both hands.

- Install foot-pedal operated handwashing and drinking fountain water valves to eliminate water running constantly.

- Install automatic control for sprays which need to operate only about 50 percent of the time.

- Product chillers using cold water may be replaced by chillers using a cryogenic liquid such as nitrogen, thus reducing water consumption and perhaps improving product quality.

- Plant clean-up as an operating procedure consumes a substantial quantity of water in most plants. Reduced water use can be achieved with equipment such as high pressure water spray systems, steam and water mix spray systems, or automated clean-in-plant

(CIP) systems. Management control is particularly vital in clean-up operations if water is to be conserved and cleanliness standards are to be maintained.

- Whenever possible, reusable water should be made the water source for operations that may use other than potable or "fresh" water. For example, carcass washwater may be used in the dehairing operation, and lagoon water could be reused in the cooling operation. The general axiom is: use the lowest quality of water that will satisfy the needs of the process.

- Use water wisely - only enough to get the job done.

- Keep waste solids in bulk whenever possible, for disposal as a solid or as a concentrated sludge, without discharging to the sewer.

- Clean with high pressure and minimum water volume (small hoses). Use the right detergents in the right proportions to clean well with minimum rinsing.

- Recycle water as much as possible, within the limits of U.S. Department of Agriculture regulations. Some reconditions, such as cooling or screening, may be necessary for recycling in some instances.

- Use the minimum pressure and volume for washing product, consistent with quality control. High pressure in washing product may drive soil into the product and also wash away valuable edible protein and fat.

- Control volume, temperature, and pressure automatically. Dependence upon manual regulation can lead to waste.

- Use valves that shut off automatically when the water is not needed. For example, photoelectric cells are used in Japan to turn water on when product is in a washing position.

- Study each process independently. General rules alone will not do the job.

- Make an in-plant waste and water survey as discussed earlier. Develop annual cost information for each possible change to include:

  - amortized cost of installed improvements.
  - power costs, such as heating, cooling, and pumping for recycling and water reuse.
  - chemical costs if some in-house treatment is required in recycling a waste stream.
  - labor cost (maintenance and operation).

- Design selected improvements to achieve the required results, considering elements such as:

  - flexibility for alteration and expansion.
  - operating skills required.
  - quantity of residual solids and grease and feasible means of disposal or sale as byproduct.

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BY-PRODUCT RECOVERY AND USE

Introduction

Food Processing plants inherently tend to generate significant quantities of waste material. Frequently, the waste is believed to have potential nutritional or industrial value, thereby representing a possible basis for a new business opportunity. But turning these beliefs into new business, is often a complex technical and economic problem. Extracting the critical business and engineering parameters for decision-making requires an analysis of the economic, technological, and marketing factors involved, as well as an ability to resolve problems arising from these factors.

This section presents some recovery attempts by Red Meat processors to transform hitherto waste products into useful by-products. This idea of recovering by–products from waste has been "catching on" throughout the food processing industry, but many of these recovery schemes have not been published. The examples that follow are not meant to represent a full-scale review of the state-of-the-art.

PAUNCH MANURE AS CATFISH FOOD

One of the most serious pollution problems facing the meat-packing industry is finding an acceptable means to dispose of the paunch manure from slaughered cattle. Paunch manure is the partially-digested feed contained in the rumen, or first stomach of a cow. Fresh paunch manure is yellowish-brown in color, containing recognizable fiber and grain and possessing an obnoxious odor.

Yin (1974) investigated the possibility of using dehydrated paunch manure as a constituent in formulated feeds which are fed to pond-reared channel catfish. It was found that levels of 10 to 20% paunch manure could be used without producing a significant reduction in catfish growth, as compared with fish reared on a typical commercial feed. Economically, levels of paunch manure up to 20% could be used without increasing the feed costs per kg of fish flesh produced. Thus, paunch manure was found economical for use as a feed constituent up to a 20% level in formulated feeds for pond-rearing channel catfish. For cage cultured catfish, however, paunch manure at a 10% substitution level would not produce a desirable economic return, so only smaller amounts could be used.

Under the experimental conditions of this study which endeavored to simulate typical catfish farming techniques, fish culture did not cause appreciable water quality deterioration in one growing season. Moreover, there was no significant difference in water quality between ponds using a typical commercial feed and a feed containing dehydrated paunch manure. At similar densities, there was no difference in water quality between ponds using cage- and pond-rearing techniques.

Ensilage of Paunch Manure

One researcher reported successful ensilage and refeeding of a mixture of paunch manure and ground cornstalks. A layer of cornstalks was put in a bunker silo and paunch manure spread over the top. This mixture was compacted in the silo. Several layers of cornstalks and paunch manure were used to fill the bunker. Paunch manure was added to bring the mixture up to between 65 and 75% moisture. The cornstalks reached a low of 8% moisture, and considerably more paunch manure than cornstalks was used on a wet weight basis. Tramp metal in the paunch manure can present a problem in refeeding, but metal suspension with a magnet has been accomplished. Refeeding of the silage required a four-to-one ratio of cattle on feed to cattle slaughtered per day.

Using the cornstalks in the silage restricted the operation to the annual harvest season. To overcome this limitation, ensilage of paunch manure with sugar beet pulp pellets and corn was tried at a 7.5:1.5:1.0 ratio in a bunker silo. The beet pulp expanded as it absorbed the paunch liquids and broke out of the bunker silos a time or two. However, a more serious problem was the limited acceptance by the cattle. The problem was diagnosed as acidosis and solved by the addition of sodium bicarbonate to the silage.

A packing company has proposed the ensilage process using paunch manure and grain (mainly corn) in closed vertical silos. Feeding high moisture corn to feeder cattle is practiced to improve feed conversion efficiencies. The vertical silo offers mixing and handling equipment and a controlled atmosphere.

Blood Processing

Handling and processing blood is usually a part of the slaughter-house operation. However, in some cases, the blood may be shipped out of a plant for processing elsewhere. The blood may be heated to coagulate the albumin; then the albumin and fibrin are separated (as with a screen or centrifuge) from the blood water and forwarded for further processing into such products as pharmaceutic1 preparations. The blood water, or serum remaining after coagulation, may be evaporated for use in animal feed. In most cases, the whole blood is sent directly to conventional blood dryers and used in animal feed.

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RECYCLING AND REUSE OF FOOD PROCESSING WASTEWATERS

Introduction

This section explores several aspects of recycling and reusing food processing wastewaters. It is meant to give you an overview of the factors affecting wastewater reuse and recycling.

Keep the following basic concept in mind with regard to reusing wastewater. Reusing wastewater basically involves collecting the effluent from one or more unit processes, and then using that effluent as the influent for other unit processes. The key to wastewater reuse lies in matching the effluent from one unit process with the influent requirements of another unit process. The "matchmaker" must be careful to take into account the effluent's quantity and quality when examining the source requirements of prospective processes.

Legal Aspects of Water Reuse

Water rights and related laws are under nationwide review. Scientists, economists and lawyers are evaluating current and future use of our water resources; constitutional rights as well as individual state laws may be involved before the present systems of water regulations can be applied to multiple-use water.

Reusing water is not a new concept. Published data estimate that 60 percent of the population presently reuses water. The intake water supply pipe of one city is often downstream from the discharge sewage pipe of another metropolis, and coastal municipalities have no choice but to commingle supply and wastewaters when tidal conditions return the sewage effluents into the water supply storage reservoir. The use of interstate streams is not only subjected to the laws of each user state but is also under regulations and control by federal authorities.

Pollution abatement programs have generally classified state waters according to use and thus have established standards of quality in accordance with these objectives. It seems only prudent that the processor should consult the stream classifications and standards that govern water purity in the state within which wastewater is to be reused.

Public Health Aspects of Wastewater Reclamation

Decision to reuse renovated wastewater for human consumption or in processes that normally require potable water (i.e., food processing), must be equated with potential health risk and hazards. The U.S. Public Health Service in a policy statement believes that renovated wastewater is not suitable for drinking water when other sources are available. Water to be reused in meat plants must be approved by the USDA.

Reclamation Methods

Water is absolutely necessary in food processing, and by practicing conservation, reuse and recycling, the amount of liquid waste and consequently the pollution load from food processing operations can be reduced. Reduction of water use through reuse of the same water can pay significant dividends in improving a waste disposal situation. Water reuse is beneficial because water is no longer a free commodity; it costs money to procure water; it costs money to pump water; and it costs money to dispose of water.

Food processing waters cannot be reused indiscriminately. Their recirculation in contact with food products must allow satisfactory product and plant sanitation. To offer more specific guidance in the use of reclaimed waters, NCA offered the following recommendations:

- The water should be free of microorganisms of public health significance.
- The water should contain no chemicals in concentrations toxic or otherwise harmful to man, and no chemical content of the water should impose the possibility of chemical adulteration of the final product.
- The water should be free of any materials or compounds which could impart discoloration, off-flavor, or off-odor to the product, or otherwise adversely affect its quality.
- The appearance and content of the water should be acceptable from an aesthetic viewpoint.

Water is best saved by reducing its rate of consumption. Industries that routinely monitor their water usage and their waste effluent flows have been able to reduce the in-house uses of water by as much as 50%. Unfortunately, some water managers consider renovated wastewater to be acceptable only as a last resort alternative. Such attitudes obscure the real importance of wastewater as being potentially the most economical choice available as a source of water.

Salvageabl e Food Fractions

Food wastes found in water can consist of particulate matter, dissolved solids and fats - either as an emulsion or in a free-floating state. Both the food and the water quality have an influence on deciding whether or not the salvaged fractions gathered from wastewater are suitable for human or animal consumption. If wastes are channeled into sewer lines, these materials become a treatment burden, at some cost to a waste treatment system. Obviously, processes that reclaim human food-grade materials must meet sanitary standards. By-products for animal foods are continuously being upgraded; thus, it may be prudent to furnish reasonable duplication in nonhuman food production of those techniques used in human food processing.

Food as particulate matter is often separated from liquids by settling, screening, skimming, or centrifuging. Automated continuous processes suitable for cleaning in place are most attractive (as contrasted with batch methods) for both short-term and long-term goals. Careful planning with well-defined objectives is required to create resources from wastes.

Recovery of Chemicals

While cleaning chemicals in waste matter often cause toxicity and poor performance of the biological treating processes, they also represent a BOD demand. For example, surfactants or common acid detergents produce 0.65 lb BOD_5/lb of substance. Table 17 shows the BOD demand of selected substances, cleaners and sanitizers.

Liquid detergents, sanitizers and other analogous products can be handled in bulk in a series of vessels. These materials may then be piped to reservoirs that can store and feed the cleaning solutions. Clean-in-place (C.I.P.) circuits can be designed to reuse fluids that are circulated by pumping through pipelines, bulk tanks, storage reservoirs and other media. Final uses of captured liquids include floor cleaning or use as the fluidizing liquid in sludge pumping.

Table 17. BOD5 of selected chemicals in detergents, sanitizers and lubricants used in food plants.

Material	*Pound of BOD per Pound of product Material*
Acetic acid	0.65
Duponol D, alkyl alcohol. sulfonated	0.45
70% hydroxycetic acid	0.07
Alkyl phenyl condensate of ethylene oxide	0.04
Phenoxypolyoxyethylene	0.005
Nacconol NR-Na alkylarylsulfonate	0.004
Neutrony, x 600, aromatic polyglycol ether	0.0
Nopco 1,1,1,1-sulfonated coconut oil	0.96
Nopco, 1665-soluble fatty acid ester	0.12
Pine oil	1.08
Tallow	1.52
Triethano1amine	0.01
Ultra-Wet DS-sodium alkylarylsulfonate	0.0
Linear alkylarylsulfonate	0.65
Ethylene glycol	0.70
Zalon-fatty, amide	0.20

Heat Recovery

Flow measurements are also necessary because the temperature alone is not adequate to reflect the magnitude of potential heat recovery. Wastewaters should be grouped according to purity and temperature, and the hot-test water should be without dilution to avoid heat dissipation. Steam condensate is returned to the boiler by deaerators because the water is soft as well as hot.

Sometimes a water demand may be satisfied by preferential water make-up, where the idea is to use all the salvage water first with fresh water supplied only when the other sources are exhausted.

Water Reuse

Water reuse may be adopted with economical advantage when:

- there is insufficient water available locally to maintain an open circuit system all year 'round.
- valuable by-product materials can be economically recovered from the treatment processes.
- treatment cost of recycling water is less than the initial cost of water, plus the cost incurred in discharging the effluent into the sewer.
- cost of treating the effluent to a required standard is such that, for a little extra investment, the water quality can be made suitable for recycling.

The practice of water reuse can be divided into sequential reuse, recirculation without treatment and recirculation with treatment. Sequential reuse is the practice of using a given water stream for two or more processes or operations before final treatment and disposal, i.e., to use the effluent of one process as the input to another. Recirculation is the practice of recycling the water within a unit process or group of processes. A combination of these practices will probably be required for an optimum reuse scheme.

In an effort to optimize industrial water use and wastewater management, emphasis is now being given to decreasing the quantities of water used and the contaminants introduced during use. Alternatives available for volume and pollutant reduction include water conservation, good housekeeping, waste stream segregation, process modification and water reuse.

Historically, little consideration was given to water reuse because of its abundance in nature and because it was considered to be hazardous due to bacterial contamination. Contamination potential shows that, in washing fruit, unless 40% of the water is exchanged each hour, the growth rate of bacteriological organisms becomes extremely high. In order to overcome this, other means of control, such as chlorination, must be used. When chlorination is discontinued, the bacterial count more than doubles. As soon as chlorination is resumed, the bacterial counts are again brought under control.

Water Conservation

There may be several operations in a meat processing plant where water is wasted continuously, thus causing an overload to subsequent collection and treatment systems. Consideration should be given to steps that can be taken within a plant to conserve water, thus enabling the liquid waste disposal system to operate more efficiently and thereby reduce water pollution. As an example of water conservation methods the steps possible in a meat processing plant include 1) using automatic shutoff valves on all water hoses to prevent waste when hoses are not in use (a running hose can discharge up to 300 to 400 gallons of water/hour), 2) using low-volume, high-pressure nozzles rather than low-pressure sprays far cleanup, 3) avoiding unnecessary water overflow from equipment, especially when not in use, and providing automatic fresh water makeup valves, 4) avoiding using water to transport the product or solid waste when the material can be moved effectively by dry conveyors, and 5) reducing cooling water flow to the minimum to accomplish product cooling.

Another water conservation method is using the closed loop systems on certain processing units, such as a hydrostatic cooker-cooler for canned product. The water is reused continuously, fresh makeup water being added only to offset the minor losses from evaporation. Closed loop systems not only conserve water but also reclaim much heat and can result in significant economic savings.

A delicate balance exists between water conservation and sanitation. there is no straightforward or simple formula to obtain the least water use. Each case and each food process has to be evaluated with the equipment used in order to arrive at a satisfactory procedure involving water use, chlorination and other factors, such as detergents.

Elimination of Water Use

Eliminating water in certain unit operations in turn eliminates attendant problems of treating the wastewaters, which were generated by those operations. Wherever possible, food should be handled by either a mechanical belt or pneumatic dry conveying system. If possible, the food should be cooled by an air system rather than by a water cooling system.

Waste Stream Segregation

Waste segregation involves the separation of waste streams according to their wastewater load. Noncontaminated streams offer the possibility of being discharged directly to receiving bodies of water, whereas contaminated waste streams have to be treated.

As a general rule, all plants should be provided with three water discharge systems, namely 1) storm and cooling water, 2) sanitary waste, and 3) industrial waste.

The stormwater system should receive all surface and storm runoff. This system can also be used for discharging uncontaminated waters, such as cooling waters, that require no treatment prior to discharge. Although it is desirable to keep uncontaminated wastewater out of the treatment plant, the cost of installing separate collection systems for small, isolated streams may be so high that by-passing the treatment plant becomes uneconomical.

The sanitary system should collect the wastewaters from all washrooms and shower rooms. For most industrial plants it is desirable to send these wastes to a municipal plant for treatment, rather than to treat them individually.

A Summary

Reuse of wastewater is the utilization of a process waste stream one or more times before it leaves plant boundaries. This can be accomplished by piping the wastewater from one unit to another, by treating or diluting effluents before reuse in other units, or by combining a few or all effluents, treating them and reusing the water.

Incentives for water reuse involves the possibilities of reduction of wastewater treatment costs and raw water costs. Although lower waste treatment costs currently provide the major savings from reuse, in some areas the supply of acceptable raw water is decreasing, the price is rising, and reduced raw water usage may provide a significant incentive in the future. The typical plant considering reuse seldom plans to completely eliminate wastewater discharges since this would usually require very extensive modifications. The important standard for economic reuse is that an unused makeup process water can be replaced by a lower-quality water without harming the process. So, reuse schemes should always be considered in planning for pollution abatement.

Ultimate requirements for water pollution control may be completely closed systems from which no discharges are permitted, and use of fresh water is only required as makeup for evaporation losses. closed water systems as the final goal of pol1ution research has long been an ideal. Even though total reuse may not be legally required, it may be a viable alternative to meeting stringent discharge regulations.

Possible steps for proceeding toward an intermediate or total reuse system are:

- Determine the effluent qualities and quantities and makeup requirements for plant units. A waste stream survey is a must for such an analysis.

- Study the lowest-cost treatments needed for various effluents to reach the required qualities of secondary users. Trends have been toward treatment of combined waste streams. Segregation of waste streams may offer better reuse possibilities.

- Reduce wastewater volumes by increased maintenance and equipment modifications can reduce flows significantly.

- Study the effects of reuse on existing treatment equipment because water reuse generally results in a lower volume, more concentrated waste stream.

Commitment to total reuse requires an economic justification covering the expected future costs of fresh water and ultimate waste disposal. In some areas of the world, the cost of fresh water is rising and the cost for ultimate disposal may gradually decrease as technology improves. The key to inexpensive reuse is volume reduction. The total reuse will be able to economically treat only a small waste stream for total removal of contaminants.

The decision of whether to implement total reuse will be set by a comparison of costs of raw water and water treatments with and without discharges. These include: water supply; treatment required before use of fresh water; waste treatment required before discharge; treatment required for use of reused water; plant modification to accept lower quality or higher temperature reused water; extra piping and control valving; loss of *flexibility due to integrated water system.

A total reuse plan should begin at the individual process units, since it will affect their operation. In certain cases it may even be more economical to modify a process so that it requires little or no water. The economics of total reuse will vary from plant to plant.

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WASTEWATER TREATMENT

Pretreatment

The pretreatment of food processing wastewaters is commonly associated with discharges to a municipal waste treatment system. the degree of pretreatment required of the food processor is determined by the specified municipal discharge limitations defined in a Sewer Use Ordinance. These limitations focus on wastewater characteristics which have historic- ally, caused either a hazardous condition for the waste treatment plant operators or have been responsible for detrimental influences on the waste treatment system's operation and waste removal efficiences.

Another factor which has identified pretreatment as a necessity when discharging to a municipal waste treatment facility is the advent of the Federal Water Pollution Control Act of 1972 which requires that before any grant is approved to a municipality for facility expansion or improvement, EPA must be assured that provisions are made to prevent the municipal system from receiving pollutants that would inhibit the operation of the municipal treatment works, or that would pass through the system untreated. Therefore, if the municipality receives a federal grant, the food processor may be required to provide some form of pretreatment if the waste being discharged, ''as is", to the municipality is judged detrimental to the system and modifications are indicated.

Discharging of meat process wastewaters to a municipal sewer system and the possibility of requiring a pretreatment system are quite probable realities for the meatpacking industries. This is reflected in a 1967 survey of meat packing plants which was conducted by the federal environ- mental agency established at that time. Current assessment of those plants still discharging to a public sewer remains in the 60 to 70% range, thus reinforcing the probability of some form of pretreatment requirement for these type food processing operations. However, EPA has concluded that meat processing wastewaters are compatible and biodegradable.

Alternatives

It is an obvious economic fact that before any meat processor undertakes the task of building a pretreatment facility for discharge to a municipal sewer, pays a municipal charge for wastewater treatment, or builds a complete treatment plant for discharge to a receiving stream that he must initiate in-plant waste saving practices, along with water recycling and reuse measures. Another consideration is the restrictions that are placed on the meat processing wastewater discharge. Principal limitations focus on substances that may be toxic, cannot be adequately treated or stabilized, or materials which cause obstruction to flow in the sewers. While toxic substances are not commonly associated with meat type process waste streams, certain wastes are present that are not amenable to treatment and can cause obstruction and maintenance requirements. These troublesome wastes are grease (FOG), animal guts or tissues, paunch manure, bone, hair, hides, and fleshings. Thus, some form of isolation and pretreatment of the waste stream becomes necessary prior to discharge to a ‘municipal waste treatment facility.

The third consideration the meat processor must address is the strength and volume of his processing wastewater. These parameters are influenced by the fluctuation in production volumes and production facility expansion programs. As these activities take place, increasing wasteloads can occur which could, and frequently do, reduce the ability of the municipal waste treatment system to adequately treat the added waste. Should this happen with regularity, then the meat processor may be faced with a problem of pretreatment or supporting a municipal waste treatment plant modification or expansion program. In either case, careful economic considerations will need to be reviewed. Since the meat processor knows what his sewer costs are, he can calculate the cost of the added sewage treatment load and determine whether the projected cost could better be handled by pretreatment or financially supporting a municipal expansion program.

Cost Considerations

Inherent in modification or expansion of a municipal waste treatment facility is the federal requirement (if federal grant money is used) that should these activities include treatment capacity for industrial wastewaters, then some form of cost sharing must be established. Much of this cost recovery activity is accomplished through the use of a surcharge system keyed to specific wastewater parameters.

Comnon parameters used are BOD strengths, suspended solids and the fats, oils and grease category.

Surcharge systems vary, and no one can predict whether pretreatment can be justified economically until costs are evaluated. A surcharge system should be based upon an evaluation, by the city's consulting engineer, of the cost of the elements of the municipal treatment plant necessary to accommodate the flow, remove the suspended matter, and treat the other ingredients of the industrial wastewater to the required levels all on a unit basis (cost per pound of constituent).

Many surcharge systems start with a flow base rate and apply multipliers for concentrations of any or all such ingredients as BOD, suspended solids, and grease. As an example, the flow base rate charged to all sewer users may be 50 percent of the water bill, including flow from private water supplies. Then, taking BOD as an example, assume that 250 mg/l has been established as a bottom base for surcharges. Then a multiplier might be.applied for BOD between 250 and 500 mg/l, and a higher multiplier between 500 and 1,000 mg/l. Another set of multipliers might be applied for suspended solids, another for grease, others for other factors. These multipliers are then added together to establish a single multiplier to be applied to the flow base charge to arrive at the total bill.

An example of the cost formulation as developed by the Federal EPA and used as a general guideline is as follows:

$$Ci=voVi+boBi=soSi$$

where Ci = charge to industrial users, dollars per year

vo = average unit cost of transport and treatment chargeable to volume, per gallon

bo = average unit cost of treatment, chargeable to BOD, dollars perpound

So = average unit cost of treatment (including sludge treatment) chargeable to suspended solids, dollars per pound

Vi = volume of wastewater from industrial users, gallons per year

Bi = weight of BOD from industrial users, pounds per year

Si = weight of suspended solids from industrial users, pounds per year

Note: The principle applies equally well with additional terms (e.g., chlorine feed rates) or fewer terms (e.g., voVi only).

The terms b_0 and s_0 may include charges (surcharges) for concentrated wastes above an established minimum based on normal load criteria.

Inasmuch as it is an objective of the guidelines to encourage the initiation and use of user charges, this general method of allocation is both preferable and acceptable.

Weighing the Advantages and Disadvantages of Pretreatment

Although compliance with municipal regulations regarding the quality of a meat packer's wastewater for discharge to the city's sewer usually will determine the degree of pretreatment, there are some factors that may encourage pretreatment beyond the levels required by the ordinance.

1. A higher quality of pretreatment may be justified economically if the city's charges and surcharges are at a level where some additional pretreatment becomes economically advantageous.
2. The meat packer may prefer to assume treatment responsibilities to avoid complaints from the municipality.
3. There may be indications that the future will bring increases in the city's rate structure.
4. Grease and solids may have a good market in the area. Proximity of a soap plant or similar grease market may produce economic advantages for grease recovery, or may warrant some expense in improving quality of the finished inedible grease or tallow. Such improvements will also improve the wastewater effluent.

Following are some disadvantage in pretreatment.

1. The pretreatment will be placed on the property tax rolls, unless state regulations permit tax-free waste treatment for industry.
2. The maintenance, operation, and record keeping may be expensive or burdensome.
3. The burden of good operation increases as the treatment becomes more complex and extensive.

Evaluating Needs

After the plant has been surveyed completely, and all possible waste conservation and water reuse systems have been identified, the necessary pretreatment system must be designed and the cost estimated. Those parts of the treatment attributable to flow (such as grease basins and dissolved air flotation) should be totaled and reduced to a cost per 1,000 gallons. Similar breakouts in cost per pound can be carried out for grease, suspended solids, and BOD.

Then each major in-plant expense for waste conservation and water recycle and reuse can be evaluated, based on the estimated reduction in flow, BOD, suspended solids, and grease. From such data, priorities can be established for each in-plant waste-conservation measure suggested in the survey.

Pretreatment Processes

Pretreatment can cover a broad range of wastewater processing elements, including flow equalization, screening, gravity separation of solids and floatables, pressurized air flotation, chemical treatment as an adjunct to gravity separation or flotation, and biological treatment such as aerated lagoons or some other form of biological treatment.

Before any pretreatment is considered, an adequate survey should be made, including flow measurement, composite sampling, and chemical analysis, to determine the extent of the problem and the possibilities for pretreatment. Analyses may include BOD, suspended solids, suspended volatile solids, settleable solids, pH, temperature and FOG. A permanent flow-measuring and composite-sampling arrangement are warranted if sampling is done regularly to determine municipal surcharges.

Most common pretreament practices will include flow equalization, and the separation of floatables and settleable solids. In some instances lime and alum, ferric chloride, or a selected polymer may be added to enhance separation. Paddle flocculation may follow alum and lime or ferric chloride additions to assist in coagulation of the suspended solids. Separation may be accomplished by gravity or by air flotation. Screening, which could include vibrating, rotary or static type screens, may precede the separation process and may also be used to concentrate the separated floatables and settled solids. These various systems will be discussed under separate headings.

Flow equalization and neutralization are important in reducing hydraulic loading in the waste stream. Equalization facilities consist of a holding tank and pumping equipment designed to reduce the fluctuations of waste streams. These facilities can be economically advantageous whether the industry is treating its own wastes or discharging into a city sewer after some pretreatment. The equalizing tank will store wastewater for recycle or reuse, or to feed the flow uniformly to treatment facilities throughout the 24-hour day. The tank is characterized by a varying flow into the tank and a constant flow out. Lagoons may serve as equalizing tanks or the tank may be a simple steel or concrete tank, often without a cover.

Removal of floatables and suspended matter will provide a satisfactory means of reducing BOD concentrations. Frequently this degree of treatment will reduce the waste load sufficiently to comply with municipal sewer use ordinance limitations. If additional BOD removal is required, a study of biological treatment systems may be instituted, possibly in pilot scale. Several biological treatment systems have been successfully adapted to the treatment of meat processing wastes. These include the lagoon arrangement, activated sludge, and land application.

Treatment Alternatives to Meet Regulations

In the treatment of meat processing wastewaters, one should be cognizant of the important constituents in this waste stream. These wastewaters contain considerable insoluble suspended matter which can be removed from the waste stream by chemical and physical means. Some form of pretreatment is recommended for that purpose. Other wastewater characteristics important to the treatment of these influents are the high colloidal and soluble protein as well as fat (FOG) which can not be adequately removed from the water by chemical and physical means.

Treatment alternatives have been briefly mentioned in the pretreatment section of this chapter. Figure 7 presents an overview of meat industry waste reduction programs and identifies most of the variables involved in treating processing wastewaters. If additional information is required by

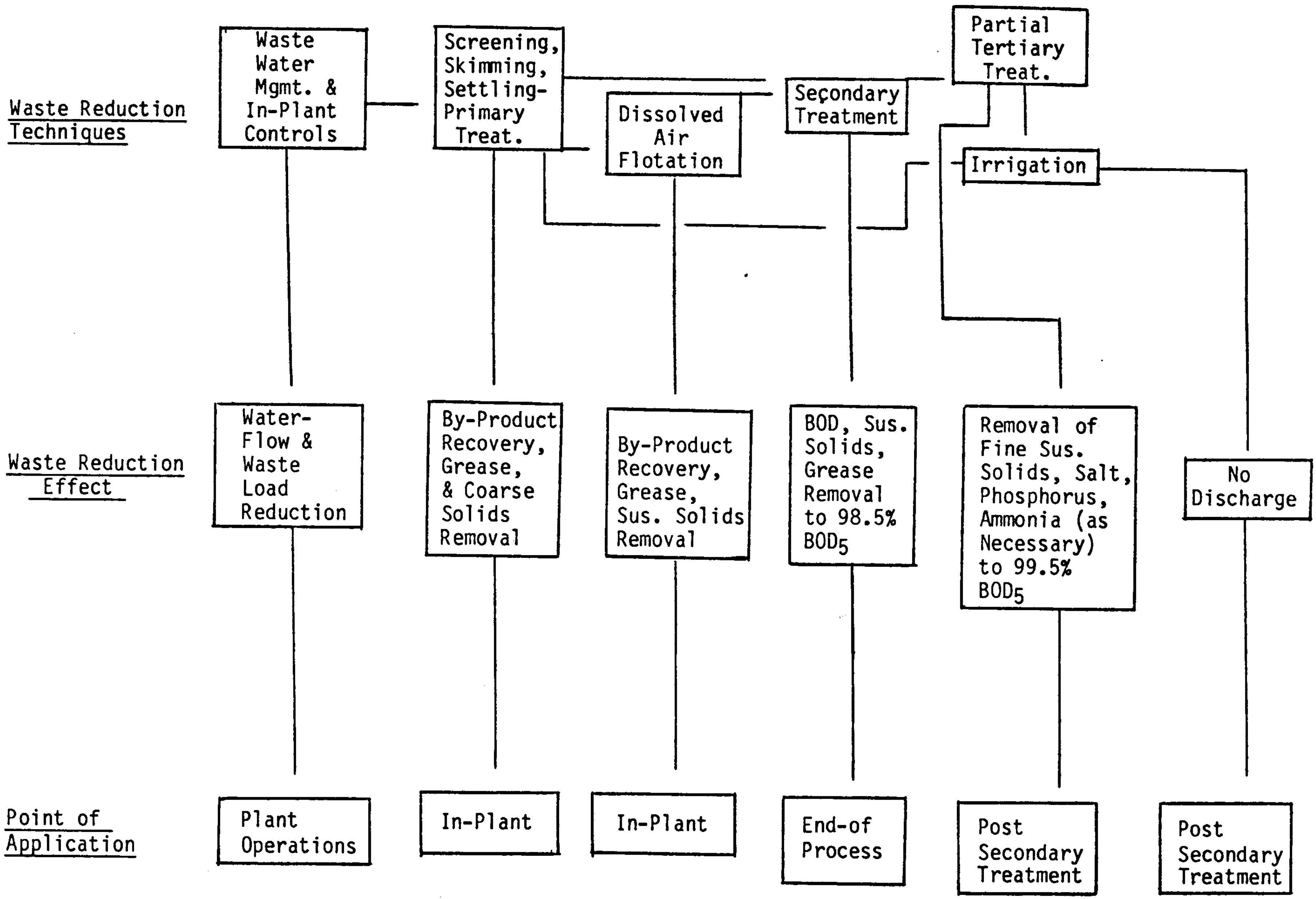

Figure 7. Meat Industry Waste Reduction Program.

the reader about specific unit processes mentioned, this desired in-put can be obtained by referring to the supplemental reference material provided in this manual series entitled "Wastewater Treatment of Food Processing Effluents". Basically, the treatment processes involve screening, sedimentation or dissolved air flotation.

Perhaps the most commonly used process is screening. Screening may employ vibrating screens, static screens or a rotary screen. In pretreating meat processing waste streams, the vibrating and rotary screens are the most frequently used. These screening systems are used in a flow away (water in forward flow and passes through with solids constantly removed from screen) mode of operation and can vary widely both in mechanical action and in mesh size. Mesh seizes can range from 0.5 inch in a static screen to 200 mesh in high-speed circular vibratory polishing screens. Screening systems may be used in combination (i.e., prescreen-polish screen) to achieve the desired solids removal efficiency.

Sedimentation is another process form used by the meat industry to remove solids from the wastewater influent. Sizing of the detention vessel and providing a quiescent state for the raw wastewater are important design considerations. Temperature variation of the wastewater is another important consideration because of the development of heat convection currents and the potential interference with marginal settling particles. Grease removal is also accomplished with this unit process through removal of the surface scum.

The other process receiving acceptability by the meat industry is the use of dissolved air flotation. Dissolved air flotation is a waste treatment process in which oil, grease, and other suspended matter are removed from a waste stream. This treatment process has been in use for over 15 years and has been most successful in removing oil from waste streams. Another natural area for application of this treatment system has been the removal of contaminants from the food processing plant waste streams.

Essentially, dissolved air flotation is a process for removing suspended matter from wastewater that uses minute air bubbles, which upon attachment to a discrete particle reduce the effective specific gravity of the aggregate particle to less than that of water. Reduction of the specific gravity for the aggregate particle causes separation from the carrying liquid in an upward direction. Attachment of the air bubble to the particle induces a vertical rate of rise. The mechanism of operation involves a clarification vessel where the particles are floated to the . surface and removed by a skimming device to a collection trough for removal from the system. The raw wastewater is brought in contact with a recycled, clarified effluent which has been pressurized (40 psig) through air injection in a pressure tank. The combined flow stream enters the clarification vessel and the release of pressure causes tiny air bubbles to form which bring their ascentency to the surface of the water, carrying the suspended particles with their vertical rise.

A more complete treatment of the meat processing wastewater can be achieved through biological assimilation or physiochemical means. Most secondary treatment processes used for meat associated waste influents are biological. The frequently used systems are, after adequate screening: treatment in an anaerobic lagoon followed by an aeration lagoon and stabilization–polishing pond; extended aeration type activated sludge system; and land application.

Treatment of Meat Industry Wastewaters

A number of waste treatment systems are available for treating meat processing waste streams. These systems are summarized in Table 18 which defines the unit process, its order of use in the waste treatment sequence and the expected waste reduction performances by these unit processes.

As previously mentioned, a frequently used system for the waste treatment of meat processing wastewaters is the anaerobic lagoon followed by an aeration lagoon and stabilization–polishing pond. Since some meat processing plants are located in rural areas, land availability is good and this type system can be installed with a minimum cost. Energy costs are limited to the operation of the aerators and maintenance of the lagoon is also minimal. The anaerobic lagoon segment can handle up to 20 lb BOD/1000 cu ft/day but requires from 4 to 20 days detention and an operating temperature of at least 22°C or above. Expected BOD reduction efficiencies are between 65 to 75%. Because of this low BOD efficiency range, a subsequent treatment is required. This secondary treatment step takes place in an aerated lagoon. Aerated lagoons use mechanical agitators to maintain a dissolved oxygen environment of from 1 to 3 mg/l and can handle between 1

Table 18. Meat Industry Wastewater Treatment Practices.

Treatment System	Use	Effluent Reduction
Dissolved air flotation (DAF)	Primary treatment or by-product recovery	Grease, 60% removal, to 100 to 200 mg/l BOD_5, 30% removal SS, 30% removal
DAF with pH control and flocculants added	Primary treatment or by-product recovery	Grease, 95-99% removal, BOD_5, 90% removal SS, 98% removal
Anaerobic + aerobic lagoons	Secondary treatment	BOD_5, 95% removal
Anaerobic + aerated + aerobic lagoons	Secondary treatment	BOD_5, to 99% removal
Anaerobic contact process	Secondary treatment	BOD_5, 90-95% removal
Activated sludge	Secondary treatment	BOD_5, 90-95% removal
Extended aeration	Secondary treatment	BOD_5, 95% removal
Anaerobic lagoons + rotating biological contactor	Secondary treatment	BOD_5, 90-95% removal
Chlorination	Finish and disinfection	--
Sand filter,	Tertiary treatment & Secondary treatment	BOD_5, to 5-10 mg/l SS, to 3-8 mg/l
Microstrainer	Tertiary treatment	BOD_5, to 10-20 mg/l SS, to 10-15 mg/l
Electrodialysis	Tertiary treatment	TDS, 90% removal
Ion exchange	Tertiary treatment	Salt, 90% removal
Ammonia stripping	Tertiary treatment	90-95% removal
Carbon adsorption	Tertiary treatment	BOD_5, to 98% removal as colloidal & dissolved organic
Chemical precipitation	Tertiary treatment	Phosphorus, 85-95% removal to 0.5 mg/l or less
Reverse osmosis	Tertiary treatment	Salt, to 5 mg/l TDS, to 20 mg/l
Spray irrigation	No discharge	Total
Flood irrigation	No discharge	Total
Ponding and evaporation	No discharge	Total

to 15 lbs of BOD/1000 cu ft/day. For each pound of BOD applied, approximately 0.2 pounds of sludge solids is produced and an expected BOD reduction of 80 to 85% is achieved. Due to the sludge solids produced, a polishing pond usually follows the aerated lagoon. The polishing pond can stablize 20 lbs of BOD per acre in northern regions and 50 lbs of BOD per acre in the southern regions, providing a reduction of 80 to 85%. Overall BOD and suspended solids reduction for this system are 85 to 90%, respectively. However, this system is temperature dependent and its waste removal efficiency is greatly influenced by this operating parameter.

Another system frequently used by the meat industry is the extended aeration activated sludge system. The design which appears best for treating meat processing waste streams is the oxidation ditch concept. This process maintains the waste materials in contact with the sludge biomass for extended periods of 20 to 30 hours, under constant aeration. After the aeration step, the stabilized suspended solids enter a clarification step which removes the solids from the water by settling. The oxidation ditch can handle a BOD loading of between 10 to 30 lbs/day applied for each 1000 cu ft of available aeration space. Food (pounds of BOD applied daily) to microorganisms (pounds of MLSS in the aeration basin) ratios should be maintained between 0.05 and 0.2 to assure the best sludge assimilation and settling properties. Sludge solids should have a 16 to 20 day turnover. For each pound of BOD applied, approximately 0.2 to 0.3 pounds of new sludge solids can be produced with an expected BOD reduction of 90 to 95%. Temperature (winter operations in the northern regions of the U.S.) can have a significant influence on the waste removal performance of the oxidation ditch since reported cases of developed pin-point floc loss of biological activity will decrease the performance efficiency of this system under cold weather operating conditions.

The third effective means for treating meat industry process wastewaters is land application. Two types of land application techniques seem most efficient, namely - infiltration and overland flow. As these land application techniques are used, the processor must be cognizant of potential harmful effects of the pollutants on the vegetation, soil and surface and ground waters. He must also be aware of such factors as the wastewater quality, climate, soil, geology, topography, land availability, and return flow quality requirements as a land application technique is selected. Details about infiltration-percolation and overland flow can be found in the technical support manual included in this manual series entitled "Wastewater Treatment of Food Processing Effluents.''

The treatability of high strength meat packing plant wastewater by land application has been shown to be excel lent for both infiltration and overland flow type systems. With respect to organic carbon removal, both systems have been shown to achieve pollutant removal efficiencies of approximately 98% and 84% for the infiltration and overland flow systems, respectively. The advantage of higher efficiency obtained with the infiltration system is offset somewhat by the more expensive and complicated distribution system involved. The overland flow system also is less likely to pollute the potable water supplies.

Nitrogen removal is found to be slightly more effective with the infiltration type land application system when compared to the overland flow application. However, the infiltration type of application has been shown to be quite effective for phosphorus and grease removal and thus offers a definite advantage over the overland flow if phosphorus and grease removal are of prime importance. One factor that may negate this advantage is if the soil conditions are not favorable for phosphorus removal and chemical treatment is required.

Two potential problems may be encountered with land application of meat processing wastewaters. These problems may be in the presence of disease producing bacteria and unfavorable sodium absorption ratios of the soil. A key to minimizing the health hazard of spreading disease producing bacteria can be accomplished by using low pressure wastewater distribution systems which will reduce the aerosol drift of the water spray. With respect to unfavorable sodium absorption ratios as associated with the soil type, the meat processor should be aware that clay-containing soils will cause the most serious sodium absorption problem. Sandy type soils appear to not be generally affected by unfavorable sodium absorption ratios and seem to be the best suited for accepting the high sodium chloride content found in most meat packing plant wastewaters.

As meat packing plant wastewaters are applied to the land, certain types of grasses have been found to be compatable with these type wastewaters. These grasses are Bermuda NK-37, Kentucky -31 Tall Fescue, Jose Wheatgrass, and Blue Panicum. In addition, the southwestern areas of the

United States, with their arid climate, mild winters, and vast available land areas, present ideal conditions for land application treatment systems.

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DIRECT DISCHARGE

Introduction

Meat processing plants that discharge wastewaters directly to streams, bays, sounds, rivers, creeks and/or estuaries must have a permit for this discharge. In most cases, even plants that have septic tanks for process wastewaters or that use non-discharge systems such as land disposal will also need a permit. Permits for discharge are usually obtained from the state environmental control agency.

Effluent Guidelines and Limitations

Introduction

In response to widespread public concern about the condition of the Nation's waterways, Congress enacted the Federal Water Pollution Control Act Amendments of 1972. The 1972 act built upon the experiences of earlier water pollution control laws. The 1972 act brought dramatic changes.

What the 1972 law says, in essence, is that nobody - no city or town, no industry, no government agency, no individual - has a right to pollute our water. What was acceptable in the past - the free use of waterways as a dumping ground for our wastes - is no longer permitted. From now on, under the 1972 law, we must safeguard our waterways even if it means fundamental changes in the way we manufacture products, produce farm crops, and carry on the economic life of our communities.

Congress declared that the objective of the 1972 law is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

- The law requires EPA to establish national "effluent limitations" for industrial plants - including meat products plants. An "effluent limitation" is simply the maximum amount of a pollutant that anyone may discharge into a water body.

- By July 1, 1977, the law required existing industries to reduce their pollutant discharges to the level attainable by using the "best practicable" water pollution control technology (BPT). BPT was determined by averaging the pollution control effectiveness achieved by the best plants in the industry.

- By July 1, 1983, the law requires existing industries to reduce their pollutant discharges still more - to the level attainable by using the "best available" pollution control technology (BAT). BAT is based on utilizing the best pollution control procedures economically achievable. If it is technologically and economically feasible to do so, industries must completely eliminate pollutant discharges by July 1, 1983.

- The law requires new meat plants to limit pollutant discharges to the level attainable by meeting national "standards of performance'' established by EPA for new plants. A new plant must meet these standards immediately, without waiting for 1977 or 1983. These new plant standards may require greater reduction of pollutant discharges than the 1977 and 1983 'standards for existing plants. Where practicable, zero discharge of pollutants can be required. However, for the meat industry, the standards are equal to the 1977 or 1983 standards, with an additional standard imposedonammoniadischarge.

- The law requires seafood facilities that send their wastes to municipal treatment plants - as some meat plants do - to make sure the wastes can be adequately treated by the municipal plant and will not damage the municipal plant. In some industries, discharges to municipal plants may thus have to be "pre-treated." That is, the portion of the industrial waste that would not be adequately treated or would damage the municipal plant must be removed from the waste before it enters the municipal system. To date, the meat industry has not been required by law to pretreat their wastewaters.

- The law does not tell any industry what technology it must use. The law only requires industries to limit pollutant discharges to levels prescribed by law.

- The law also says that if meeting the 1977 and 1983 requirements is not good enough to achieve water quality standards, even tougher controls may be imposed on dischargers.

- And while the law requires industries to meet the national discharge standards set for 1977, 1983 and for new plants, the law also allows a state or community to impose stricter requirements if it wishes. The national standards are thus minimum requirements that all industries must meet.

The key to applying the effluent limits to industries - including the meat industry - is the national permit system created by the 1972 law. (The technical name is the "national pollutant discharge elimination system," or NPDES.)

Under the 1972 law it is illegal for any industry to discharge any pollutant into the Nation's waters without a permit from EPA or from a State that has an EPA-approved permit program. Every industrial plant that discharges pollutants to a waterway must therefore apply for a permit.

When issued, the permit regulates what may be discharged and the amount of each identified pollutant. It sets specific limits on the effluent from each plant. It commits the discharger to comply with all applicable national effluent limits and with any State or local requirements that may be imposed. If the industrial plant cannot comply immediately, the permit contains a compliance schedule - firm target dates by which pollutant discharges will be reduced or eliminated as required. The permit also requires dischargers to monitor their wastes and to report the amount and nature of wastes put into waterways. The permit, in essence, is a contract between a company and the government.

This combination of national effluent standards and limits, applied to specific sources of water pollution by individual permits with substantial penalties for failure to comply, constitutes the first effective nationwide system of water pollution control. Now what does all this mean to the meat industry? How does one determine the NPDES permit limitations for a plant discharge into a receiving stream?

The U. S. Environmental Protection Agency prepared standards for meat plants under the 1972 law. EPA did so, after considering many factors: the nature of plant raw materials and wastes; manufacturing processes; the availability and cost of pollution control systems; energy requirements and costs; the age of size of plants in the industry; and the environmental implications of controlling water pollution. (For instance, we would gain nothing if, in controlling water pollution, we created a new air or land pollution problem.) The industry was categorized as shown in Table 19.

Table 19. Subcategories of the Meat Products and Rendering Point Source Category.

Simple Slaughterhouse -- A plant that slaughters animals and has as its main product fresh meat as whole, half or quarter carcasses or smaller meat cuts, and which accomplishes very limited by-product processing, if any, usually no more than two (2) of such operations as rendering, paunch and viscera handling, blood processing, hide processing, or hair processing.

Complex Slaughterhouse -- A plant that slaughters animals and has as its main product fresh meat as whole, half or quarter carcasses or smaller meat cuts, and which accomplishes extensive by-product processing, usually at least three (3) of such operations as rendering, paunch and viscera handling, blood processing, hide processing, or hair processing.

Low-Processing Packinghouse -- A plant that both slaughters animals and subsequently processes carcasses into cured, smoked, canned or other prepared meat products, and that processes no more than the total animals killed at that plant, normally processing less than the total kill.

High-Processing Packinghouse -- A plant that both slaughters animals and subsequently processes carcasses into cured, smoked, canned or other prepared meat products, and which processes both animals slaughtered at the site and additional carcasses from outside sources.

Small Processor -- An operation that produces up to 2730 kg (6000 lbs) per day of any type or combination of finished products (fresh meat cuts, hams, bacon or other smoked meats, sausage, luncheon meats, stew, canned meats or related products).

Meat cutter -- An operation which fabricates, cuts, or otherwise produces fresh meat cuts and related finished products from livestock carcasses, at rates greater than 2730 kg (6000 lbs) per day, wherein finished products means fresh meat cuts such as steaks, roasts, chops or boneless meats.

Sausage and Luncheon Meats Processor -- An operation which cuts fresh meats, grinds, mixes, seasons, smokes or otherwise produces finished products such as sausage, bologna and luncheon meats at rates greater than 2730 kg (6000 lbs) per day.

Ham Processor -- An operation which manufactures hams alone or in combination with other finished products at rates greater than 2730 kg (6000 lbs) per day.

Canned Meat Processor -- An operation which prepares and cans meats (such as stew, sandwich spreads, or similar products) alone or in combination with other finished products at rates greater than 2730 kg (6000 lbs) per day.

Renderer -- An independent or off-site rendering operation, conducted separate from a slaughterhouse, packinghouse or poultry dressing or processing plant, which manufactures at rates greater than 75,000 pounds of raw material per day of meat meal, tankage, animal fats or oils, grease, and tallow, and may cure cattle hides, but excluding marine oils, fish meal, and fish oils.

The proposed regulations were issued by EPA. Then, they were sent to the industry and other interested organizations for review and comments. They were made public by publication in the Federal Register. Comments were submitted by meat companies and industry organizations, by State agencies, and by Federal agencies. EPA then carefully analyzed the comments and made appropriate changes in the standards. On February 28, 1974, EPA issued the final standards for meat plants to follow in order to meet the requirements of the 1972 law.

The standards are contained in an official government regulation published in the Code of Federal Regulations. This regulation is supported by three detailed technical documents called the "Development Document for Effluent Limitations, Guidelines and New Source Performance Standards for the ... Red Meat Processing ... Renderer ... Processor Segment of the Meat Products Point Source Category." Subsequent regulations and amendments have been made over the last several years.

In brief, here is what the regulation does:

- Sets limits on identified pollutants that can be legally discharged by plants in the sub-categories of the meat products industry that are identified in Table 19.

- Zeroes in on the major meat industry pollutants, it establishes maximum limitations for BOD and TSS that plants can discharge during any one day, and on an average over a thirty-day period based on terms of lbs pollutant that can be discharged per 1000 lbs of live weight processed. Additional limits were established for pH, oil and grease, fecal coliforms ammonia.

- Sets limits that can be met by using the "best practicable control technology currently available" - the 1977 requirement (Table 20).

- Sets more stringent limits that can be met by using the "best available technology economically achievable" - the 1983 requirment (Table 21). [For an example of the difference between the 1977 and 1983 standards, consider this: By July 1, 1977, a simple slaughterhouse should have limited its daily maximum discharge of organic waste (BOD) to 0.24 lb per 1000 lb of animals taken into the plant. By July 1, 1983, the BOD discharge must be lowered to 0.06 lb per 1000 lb of live weight killed.]

- Requires that the pH (acidity or alkalinity) of meat plant discharges be within the range of 6.0 to 9.0.

Table 20. Proposed 1977 Effluent Guidelines (BPT) for Slaughterhouses and Packinghouses.

	Contaminant levels (per 1000 lb LWK)								
	Biochemical Oxygen Demand (BOD_5)		Total Suspended Solids (TSS)		Oil and Grease		Ammonia (as N) mg/l		Fecal coliforms
Industrial category	maximum daily	average 30 days	maximum daily	average 30 days	maximum daily	average 30 days	maximum daily	average 30 days	MPN/100 ml (Peak)
Simple slaughterhouses	0.24	0.12	0.40	0.20	0.12	0.06	-	-	-
Complex slaughterhouses	0.42	0.21	0.50	0.25	0.16	0.08	-	-	-
Low-processing packinghouses	0.34	0.17	0.48	0.24	0.16	0.08	-	-	-
High-processing packinghouses	0.48	0.24	0.62	0.31	0.26	0.13	-	-	-
Small processor	2.0	1.0	2.4	1.2	1.0	0.5	-	-	-
Meat Cutter	0.036	0.018	0.044	0.022	0.012	0.006	-	-	400
Sausage and luncheon meats processor	0.56	0.28	0.68	0.34	0.20	0.10	-	-	400
Ham Processor	0.62	0.31	0.74	0.37	0.22	0.11	-	-	400
Canned meats processor	0.74	0.37	0.90	0.45	0.26	0.13	-	-	400
Renderer	0.34	0.17	0.42	0.21	0.20	0.10	-	-	400

LWK = Live weight

pH = 6.0-9.0

Table 21. Proposed 1983 Effluent Guidelines (BAT) for Slaughterhouses and Packinghouses.

Industrial category	Contaminant levels (per 1000 lb LWK)								
	Biochemical Oxygen Demand (BOD_5)		Total Suspended Solids (TSS)		Oil and Grease		Ammonia (as N)		Fecal coliforms
	maximum daily	average 30 days	maximum daily	average 30 days	maximum daily	average 30 days	maximum daily	average 30 days	MPN/100 ml (Peak)
							(mg/l)		
Simple slaughterhouses	0.06	0.03	0.10	0.05	10	-	8.0	4.0	-
Complex slaughterhouses	0.08	0.04	0.14	0.07	10	-	8.0	4.0	-
Low-processing packinghouses	0.08	0.04	0.12	0.06	10	-	8.0	4.0	-
High-processing packinghouses	0.16	0.08	0.20	0.10	10	-	8.0	4.0	-
Small processor	1.0	0.5	1.2	0.6	0.5	0.25	-	-	-
Meat Cutter	0.018	0.009	0.024	0.012	0.012	0.006	8.0	4.0	400
Sausage and luncheon meats processor	0.28	0.14	0.38	0.19	0.20	0.10	8.0	4.0	400
Ham Processor	0.32	0.16	0.42	0.21	0.22	0.11	8.0	4.0	400
Canned meats processor	0.34	0.17	0.44	0.22	0.26	0.13	8.0	4.0	400
Renderer	0.18	0.09	0.22	0.11	0.10	0.05	0.14*	0.07*	400

LWK = Live weight killed

pH = 6.0-9.0

- Establishes performance standards that new meat plants must meet without waiting for 1977 or 1983 (Table 22). For the meat industry, the new plant standard is the same as the 1977 or 1983 standard for existing plants in most cases with an additional limitation on ammonia discharges. However, regulatory officials shall be consulted for up-to-date information.

- Does not require zero discharge of any pollutant by a meat plant. Zero discharge may be technically possible in the industry, but the cost would be prohibitive for most if not all plants in the industry. Does not tell companies what technology to use to meet regulations.

In 1978, EPA reviewed the BAT standards in light of Section 304 (b)(4) of the Clean Water Act which established "best conventional pollutant control technology" (BCT). BCT was intended to replace BAT. Congress directed EPA to consider the:

> ... reasonableness of the relationship between the costs of attaining a reduction in effluents and the effluent reduction benefits derived, and the comparison of the cost and level of reduction of such pollutants from the discharge of publically owned treatment works to the cost and level of reduction of such pollutants from a class or category of industrial sources

The meat processing industry will be studied and regulations proposed. The results of these studies may find that some of the BAT regulations were found to be established from insufficient data and they will be recommended to be suspended if the completed studies of the food industry establish any trend.

Despite the voluminous amount of material available in regard to the regulations, many meat processors will find they are facing state regulations more stringent than the BPT, BAT or BCT standards. When facing a permit situation, prompt contact with the proper regulatory officials is recommended.

Table 22. Summary of New Source Performance Standards for Slaughterhouses and Packinghouses.

Industrial category	Contaminant levels (per 1000 lb LWK)								Fecal coliforms
	Biochemical Oxygen Demand (BOD_5)		Total Suspended Solids (TSS)		Oil and Grease		Ammonia (as N)		
	maximum daily	average 30 days	maximum daily	average 30 days	maximum daily	average 30 days	maximum daily	average 30 days	MPN/100 ml (Peak)
Simple slaughterhouses	0.24	0.12	0.40	0.20	0.12	0.06	0.34	0.17	-
Complex slaughterhouses	0.42	0.21	0.50	0.25	0.16	0.08	0.48	0.24	-
Low-processing packinghouses	0.34	0.17	0.48	0.24	0.16	0.08	0.48	0.24	-
High-processing packinghouses	0.48	0.24	0.62	0.31	0.26	0.13	0.06	0.03	-
Small processor	1.0	0.5	1.2	0.6	0.5	0.25	-	-	-
Meat Cutter	0.036	0.018	0.044	0.022	0.012	0.006	-	-	400
Sausage and luncheon meats processor	0.56	0.28	0.68	0.34	0.20	0.10	-	-	400
Ham Processor	0.62	0.31	0.74	0.37	0.22	0.11	-	-	400
Canned meats processor	0.74	0.37	0.90	0.45	0.26	0.13	-	-	400
Renderer	0.30	0.17	0.40	0.21	0.20	0.10	0.34	0.17	400

LWK = Live weight killed

pH = 6.0-9.0

MUNICIPAL DISCHARGE

Introduction

PL 92-500 and PL 95-217 will increase costs for meat plants discharging to municipal systems. The requirements for industrial cost recovery, user charges and sewer use ordinances will affect meat plants. Probably no more than 80% of the meat plants now discharge to municipal systems. However, with developing regulations and technologies, the future may find over 90% of the meat plants discharging to municipal systems.

The sewer use ordinance as used is to refer to the "sewer ordinance" defined as an instrument setting forth rules and regulations governing the use of the public sewer system. In most cases, the industrial cost recovery and surcharges (user charges) may be a part of this instrument. Little can be reported about industrial cost recovery as few municipalities have imposed the same and an 18 month moratorium has been imposed in PL 95-217. Surcharges will be treated as a section of the sewer use ordinance although in reality some municipalities pass separate ordinances for user charges.

Meat processors must ask themselves what is happening now and what will happen in the near future. Although charges for industrial wastes began as early as 1907, as late as 1969 only about 10% of United States municipalities collected these charges. Most municipalities did not have a stringent sewer use ordinance until after 1960. Most municipalities do not have one in 1978 although state and federal pressure and encouragement will surely force most municipalities to draft such an ordinance. Key questions that must be asked by industrial dischargers is how they can get a reasonable ordinance that gives both them and the city system protection -- them in having sewage treatment, at a reasonable cost and the city in preventing illegal or toxic discharges.

PL 92-500 and EPA require that municipalities institute industrial cost recovery, a system of user charges and have a sewer use ordinance if they obtain federal funds for water or wastewater facilities. However, one must look carefully at exactly what is required. The initial requirements were modified substantially by PL 95-217.

Industry must assist in the development of a "practical and sound regulatory ordinance fitted to local conditions". Industry should want the minimum number of restrictions that will protect the municipal system. These restrictions should be technically sound and rigidly enforced.

Sewer use ordinances are largely a matter of local and state jurisdiction. However, many individuals have been to a town council meeting and been told that "EPA insists and requires a 28 page document". EPA documents contain the following mention of specific requirements for a sewer use ordinance if Federal monies are received.

(1) 35.927-4	Prohibit new conections from inflow sources into sanitary sewers.
(2) 35.927-4	Insure that new sewers and connections are properly designed and constructed.
35.925-11	System of user charges paying proportionate share of O + M.
(3) 35.935-13	User charge system must be incorporated.
X. (1976 a.)	Equitable system of cost recovery. Note - all users pay user charge -- <u>not just industrial users.</u>
(4) 4.2.2 (1976 a.)	Users shall be required to immediately notify waste treatment plant of any unusual discharge (flow or waste parameters).
(5) x. (1976 a.)	Pretreatment of wastes that would otherwise be detrimental.
(6) Appendix B. (f)(3) (1976 a.)	User charges shall be reviewed annually to assure 0 + M recovery.
(7) 35.905-6	Recovery from industrial users of the grant amount allocable to the treatment of their wastes.

The preceeding was a summary of what has been found to be required. Now where do we get restrictions such as: Temperature less than 100°F, FOG less than 100 mg/l, BOD5 less than 2000 mg/l, and pH less than 9.0.

The key to industrial input appears to be contact with the body which passes the ordinance. Most ordinances are passed relying on their technical and legal consultants. They must understand the serious consequences of their actions.

Review of Proposed Sewer Use Ordinance

The best and perhaps the only time that industry can get input into a sewer use ordinance is during the passage by the city council or the sewer district board; i.e., the governing body. Normally public hearings are held but everyone must be most observant for the hearing notice.

The study of a proposed sewer use ordinance requires time and expertise. However, anyone can read and understand such an ordinance with a little extra effort. The key parts of a sewer use ordinance include the following:

- Preamble - Whereas
- Definitions
- Use of public sewers required
- Use of sewers - Prohibitions
  - Limitations
- Power and authority of inspectors
- Surcharge - Samling, analysis and formula
- Enforcement and penalties
- Conflict clauses
- Reviewprocess
- Effective date

A description of some of these and other key parts can be found in Table 23. Each word and sentence can have a real meaning. Management should not only ask the engineer or utilities director to explain what they meant to say but insist that the ordinance have language that clearly states the same. For example, does "sample manhole'' refer to the manhole in the street or does it refer to a specially constructed box with a wier, flow recorder, sampler and sample refrigerator that might cost as much as $25,000. Specific problems seen in ordinances for meat plants have included:

- Holding tanks or flow equilization being required - where are you going to put the tank?
- Control manhole or sampling facility being required.
- Limitations or prohibitions on BOD, FOG, etc. preventing discharge.
- Surcharge for industrial users only with other contributing commercial customers, not charged equally.
- Requirements for expensive pretreatment facilities.

Table 23. Some Key Parts to A Sewer Use Ordinance

Definitions	All key words should be included in the definitions. For instance: Does <u>representative sample</u> mean a grab sample, an average of 4 grab samples at 15 minute intervals or a 24 hour, proportional composit sample?
Resampling	Does the ordinance contain the specifics of resampling if industry objects to a particular sample? What are the costs of the resampling?
Mock Bill	A clause in a new ordinance can require the city to sample for a period of 6-12 months to perfect their techniques while billing you on a "mock bill" which does not have to be paid. If there are high charges, you have time to institute in-plant changes or pretreatment.
Appeal Procedure	State law probably requires an appeal if an action is considered unreasonable or injust. However, if a procedure and time schedule for appeal is not specified, an industry may find themselves without water and sewer for an extended period while court action is followed.
Responsible Person	The individual (s) responsible for interpretation and enforcement should be specified. Everyone should be aware of any interpretable decisions that might be made.
Representative Samples (wastewater characteristics)	What method(s) is specified for sampling? Is the sample proportional to flow? What is the frequency of the samples? Does each sample period give a set of characteristics or are sample periods averaged to determine wastewater characteristics?
Waiver (Special Agreement)	Does the ordinance have a special clause allowing a contract or agreement between industry and the municipality to allow otherwise prohibited flows or concentrations? Who okays such a pact? Will you be able to get one approved?
When in the event that metered water does not equal wastewater	There should be a clause alllowing plant records or metering or engineering studies to establish a percentage of metered water which actually leaves in the sanitary sewer which is sampled. Thus a "fair" wastewater load can be established.
Pretreatment	When, who and how is pretreatment or flow equilization required?

Specific review points when considering a sewer use ordinance should include the following:

- Whatis it going to cost as proposed - after enactment?
- Are there defacto or real limitations prohibiting your discharge?
- Who is the boss?
- Who handles complaints and reviews decisions?
- Will samples be representative and who pays for sampling and analysis?
- Are there unrealistic limitations - pH, FOG, BOD5?
- Did you review the ordinance before enactment?
- Can you obtain split samples?
- Can you object to unreasonable results? If so, how?

NOW, the most important point to remember is that you food plant management not always expect local officials to consider their plant's interests. In other words, when specifics get in an ordinance that can cause the plant problems, they will! It might be 5 years, but it is worth the effort to try to change the ordinance before it is passed. For example, management must remember that the current city engineer might leave tomorrow. Where is his promise written that he does not plan to enforce the maximum FOG restriction? If it is not written, it is not the law!

Also, normally the ordinance is passed by a public body. This is managements best chance of getting a receptive audience. Changes can be more easily obtained now than later. The procedures for obtaining changes are presented in the "Municipal Discharge Spinoff".

MunicipalCharges

Municipal charges for industrial plants include water, sewer, surcharge (user charge) and industrial cost recovery. Most municipalities compute water and sewage charges as follows:

Water ...	Based on water consumption metered into the plant. Often on a declining block scale so that the cost/unit decreases as you use more water. Note that the bill is usually in hundreds of cubic feet (1 cu. ft. = 7.48 gal.). Cost usually ranges from \$0.10 to \$1.00 per 1000 gallons.

Sewer Charge ...	Based on computed water charge and usually represents 10 to 200 % of the water bill. Normally 100% is the most common figure seen in the Southeast.
Surcharge ...	Based most often on metered water consumption and a parameter(s) measured in the wastewater. The most common factor is BOD5 and usually charged at a rate of $0.10 to $2.00 per pound for those pounds in excess of normal sewage. Similarly, the suspended solids (TSS) load is also used. A hydraulic load charge is sometimes included and is often used as a ''demand charge'' especially for seasonal operations.
Industrial Cost Recovery ... (Rules & Reg. 35.905-6)	Recovery by the grantee from the industrial users of a treatment works of the grant amount allocable to the treatment of wastes from such users pursuant to section 204 (b) of the Act and this subpart. (Note that ICR is under review and there may be somechanges.)

Surcharges

Surcharges are often included in a sewer use ordinance. However, they may be included in a separate ordinance.

Surcharges are usually passed because of local government's problems such as: (1) Waste treatment costs are rising, (2) More treatment is being required, (3) Loads are often increasing, (4) Property tax is already overburdened, or (5) because the municipality has received federal funds and is required to institute user charges.

Any food plant should keep careful records about their surcharge bill. A plant should keep up with the following in respect to their surcharge bills:

- For which characteristics are you paying
- Do these vary widely
- Does your flow vary widely
- How does your bill compare with similar plants

Careful attention should be paid to the method the city uses for calculating the surcharge. Careful attention should be directed toward the sampling method, sample analysis procedures, flow measurement method and the validity of the results. A surcharge calculation involves flow measurement, sampling, sample preservation, sample analysis, laboratory calculation, and surcharge calculation. An error in any of these will cause an error in the surcharge bill. However, remember that errors can be in your favor.

Conclusions

The lack of details is explained by the procedure a sewer use ordinance follows. As a normal rule, the person in charge of the waste treatment works and planning presents an ordinance drafted by an engineering firm for approval of the board or council. As the council members feel incompetent to review and discuss the same, rapid passage is the rule. Mr. Rankine', an attorney, noted that it is <u>the most important matter that a sewer regulating authority can pass.</u>

The meat industry is affected because for health and sanitation, much cleaning and washing results in large amounts of organic wastes which equate to BOD5. Also, many wastewaters contain fat which is forbidden above certain levels in most ordinances. Further, some of the raw material is wasted in meat processing as blood, bits of flesh, grease, etc., are lost to the sewer.

The most obvious legal fault generally observed in sewer use considerations is giving any or adequate <u>legal notice</u> and a <u>chance for a hearing</u>. A sewer use ordinance requires vast amounts of technological expertise. If the city is trying to reduce loads and not generate revenue, time is required by industry to institute changes. Another problem presented in many ordinances is that industry is singled out to pay for waste because many users are too small to easily sample.

The legal field of sewer use ordinance making is complex and ill reported. Challenges are usually settled out of court and legal records and precedents have not been established. The best defense to a badly drafted sewer use ordinance is a good lawyer and a friend(s) on the body responsible for voting on the same. Industries faced with bad ordinances must rally their forces and present a united front. City managers should consult industry when they draft sewer ordinances.

A serious and detailed legal study should be made of sewer use ordinances for the meat industry. Technical input is required if this study is to be a success. The 1975 revision of MOP No. 3, (WPCF) appears to have much technical input, but legal questions may remain unanswered. Also, recommendations concerning industrial input and assistance are largely ignored.

A pact with the city fathers allowing specific exemption for your wastes is a realistic alternative if an ordinance is in existence with a clause for such a pact. But, a processor should get the best technical and legal advice before doing this.

In conclusion, meat plants will probably face the issues discussed herein within the next several years. It would be to your benefit to be ready to assist them in these most serious negotiations. You must tell them to be alert to any indication that a sewer use ordinance is being developed or revised for such a development can drastically affect their wastewater discharge and municipal charges for their effluent.

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