REDUCTION IN WASTE LOAD FROM A MEAT PROCESSING PLANT-BEEF

SUBMITTED BY

Randolph Packing Co.
Asheboro, N.C.

IN COOPERATION WITH
FOOD SCIENCE EXTENSION
N.C. STATE UNIVERSITY

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N.C. Pollution Prevention Pays Program

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EXECUTIVE SUMMARY

Randolph Packing Company is a beef slaughterhouse and boning operation located in Asheboro, N.C. The plant discharges its wastewater to the Asheboro publically owned treatment works. This study is a review of the plant's water use and waste load. It examines the technical and economic feasibility of incorporating training programs and process modifications to reduce the waste load.

The plant was surveyed to identify sources of waste and water use. Methods are suggested to reduce water use and waste load by increasing the efficiency of byproduct recovery. Pretreatment options were also examined.

A benchmark period was established for study comparison. Water use was found to be 256 gal/1000 lb LWK. Waste loads were BOD, (5.43), COD (7.74), TSS (1.79), TkN (0.74) and FOG (0.27) lbs/l000 lb LWK, respectively. The plant used approximately 15,000 gallons of water per day.

Predicted reduction in BOD_5 with all recommendations incorporated could be as much as 80 percent or 60,000 lb/year. BOD_5 contained in the final effluent could drop to 610 mg/l from its benchmark figure of 2,543 mg/l. Water use reduction could total l,000,000 gal/year or a 25 percent drop from current use. As a result of management interest and employee training, a 41 percent reduction in BOD_5 was realized over the project duration. The average BOD_5 load dropped from 2,543 mg/l to 1,433 mg/l.

Randolph Packing was recovering 77 percent of its potential BOD_5 load with more than a 10 percent additional recovery predicted when this project was initiated, so the research team could not recommend expensive pretreatment systems such as dissolved air flotation. Thus, blood collection system and improved paunch handling procedures were the major recommendations to reduce waste load. Management attitude and employee training are also effective measures for further reduction.

The initial investment for the recommended process changes throughout this report would amount to less than $10,000. Annual increased costs to sustain these recommended changes are estimated to be $10,500. Net savings would be approximately $1,500 per year. Although this may not seem like a large monetary return, it does equate to pollution prevented... and "pollution prevention pays."

Project funding provided by a Challenge Grant from the NC Pollution Prevention Pays Program

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The foresight of Mr. Roger Schecter and Mr. Gary Hunt of the N.C. "Pollution Prevention Pays" Program allows for such projects to be instituted. Their help, concern and patience throughout this study is especially appreciated. They should be commended for their unique approach to helping industry find ways to prevent pollution. Funds for this project were provided through Agreement C-1537 of the Pollution Prevention Pays Program of the North Carolina Department of Natural Resources and Community Development.

The authors extensively utilized some of the EPA reports noted in the reference. Many of the tables, ideas, suggestions and observations were abstracted or taken directly from these publications.

The authors extend their appreciation to Ms. Lisa Nance for her invaluable assistance in typing this report. The editorial assistance of Dr. Duane Larick and Ms. Susan Borowski is gratefully acknowledged.

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SCOPE OF WORK

Randolph Packing Co., under the direction of Hr. Craig Hamlet, submitted the project entitled "Reduction in the Waste Load from a Meat Processing Plant - Beef" to the XC "Pollution Prevention Pays" program on December 15, 1985. An agreement (No. C-1537) was signed on July 24, 1986 to authorize the project. Memorandum of Agreement was entered into by Randolph Packing Co. and NC State University, who would assist in the project. Drs. Carawan and Pilkington of the Food Science Department and the North Carolina Agricultural Extension Service cooperated in this study.

The project included a feasibility study of the potential for reduction and recovery/reuse of process waste. The project scope is as follows:

1. Review the use of water by unit processes to identify water-reduction options.

2. Review the waste load by unit processes to identify waste-reduction options.

3. Use planning sessions to get management and employee suggestions for reduction in water use and waste load.

4. Examine the technical and economic feasibility of incorporating process changes to reduce waste generation.

5. Present findings of this study in a final report to include technical and economic evaluations of the waste-reduction options:

   - Introduction to the problem

   - Technical evaluation of technology(ies)

   - Economic assessment of costs, pay back period and annual cost savings

   - Summary

INTRODUCTION

Wastewater will always be generated whenever food in any form is handled, processed, packaged and stored. The quantity of this processing wastewater and its general quality (i.e.. pollutant strength, nature of constituents), are both economic and environmental factors in the treatability and disposal of wastewater.

The waste load from a meat processing plant is a result of blood, flesh particles, soluble protein losses and waste materials which are intentionally or inadvertently lost to the sewer **system.** There are three proven ways to reduce waste load as well as water use and wastewater discharge. First, operate the plant more efficiently. Second, make process modifications to reduce water use and waste. Third, consider pretreatment steps to reduce the waste load.

Water, sewer and surcharge costs are significant to any meat plant. EPA documents contend that plants with effective waste management programs can reduce surcharges by 80 per cent. Well-trained employees, the **most** modern technology and management support are necessary to achieve the least costly reduction of water use and waste.

External restraints on a **meat** plant's wastewater **may** convince management to consider water and waste reduction programs. These restraints can include effluent restrictions on selected wastewater parameters such as BOD, COD, FOG, TKN, P and flow. The city of Asheboro, NC has imposed such limits on industries through a Sewer Use and Pretreatment Ordinance (1986).

Water is an essential tool for the **meat** industry. In processing and quality control, it helps to cleanse the product and to convey and remove unwanted materials. But in wastewater handling, water flushes organic and inorganic matter to the sewer. Wastewater treatment is basically a processing system to separate the organic and inorganic matter from the water that collected it. Thus, keeping organic and inorganic matter out of the water eliminates the necessity for treatment.

In food processing plants, most wastes are losses from food products and are primarily organic in nature. The goal of every wastewater engineer is to remove these organic solids "dry," without discharging them to the sewer, and to use an absolute minimum of water for the essentials of sanitation. This goal provides the pattern for waste and water conservation in the plant:

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

- Keep waste solids contained for disposal as a solid or concentrated sludge, not for discharge 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 USDA regulations.

- Use minimum pressure and water volume for washing product, adhering to quality control standards.

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

- Use valves that automatically shut off water supply when water is not needed.

Randolph Packing Company

Randolph Packing Company is a small beef processing plant located in Asheboro, NC. The wastewater from the plant is discharged to the Asheboro publically owned treatment works (POTW). Randolph Packing is a modern plant that slaughters beef cattle and totally processes the carcasses and hides. By-products are recovered and trucked to a rendering plant.

Meat Plant Wastewaters

A basic understanding of the nature of **meat** plant wastewaters and factors that influence these wastewaters is essential for the control of wastewater volume and waste loads. Analyzing waste characteristics of the meatpacking 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. However, **some** similarities have emerged during extensive study and research.

Typical slaughterhouse and packing house wastes are generally high in 5-day biochemical oxygen demand (BOD_5). total suspended solids (TSS), floatable material and grease (FOG). The waste is usually at an elevated temperature and often contains blood, bits of flesh, fat, manure, dirt and viscera. Blood recovery, grease recovery, separate paunch manure handling and efficient rendering operations can reduce **waste** loads substantially and **may** also produce salable by-products. Chlorides, phosphorus and nitrogen compounds are also found in the wasteload.

Parameters used to define the size of operations were the kill (live weight) and volume of processed meat products, which are expressed in thousands of kg. 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.

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

- Animal holding pens
- Slaughtering
- Cutting
- Meat processing
- Secondary manufacturing (by-product operations)
- Cleanup operations

Wastewaters from slaughterhouses and packing houses 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

A survey of the meat industry was sponsored by EPA. From this work the authors of an EPA publication (1973) prepared Table 1 which lists waste loads 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, if any, edible by-products and process blood in such a manner that it will not be released into the wastewater. They also perform dry, inedible rendering.

The flow and waste load values associated with packing houses apply to **most** medium or large plants that carry out all processes associated with slaughtering, cutting, rendering and processing. Values listed for processing plants represent plants that **cut** and process **meat,** but do not slaughter or render. Generally, the processes performed at a packing plant have a much greater effect on the waste load than the size of the plant.

The authors of an EPA publication (1973[b]) also prepared Table 2 which shows the characteristics of the waste flow from two cattle packing plants, illustrating a typically wide variation from plant to plant. Average data are shown for 16 hog, cattle or mixed hog and cattle packing plants with a BOD_5 SS, TkN and FOG loads of 14.6., 12.0., 1.70 and 1.63 pounds (respectively) per 1000 lb of live weight killed.

Slaughterhouses

A typical flow diagram illustrating the sources of wastewaters in both simple and complex slaughterhouses is shown in Figure 1. Note that a simple slaughterhouse normally conducts very few of the by-product operations (secondary processes) listed in Figure 1 as compared to a complex slaughterhouse, which performs 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 cleanup with no discharge of wastewater; some have little or no cutting: and others may have a separate sewer for sanitary waste.

Table 1. Standard Raw Waste Loads

Type	Flow	BOD_5	TSS	FOG
	(gal)	(lb)	(lb)	(lb)
Slaughterhouse, per 1000 lb LWK[1]	696	5.8	4.7	2.5
Packinghouse, per 1000 lb LWK[1]	1,046	12.1	8.7	6.0
Processing plant, per 1000 lb product	1,265	5.7	2.7	2.1

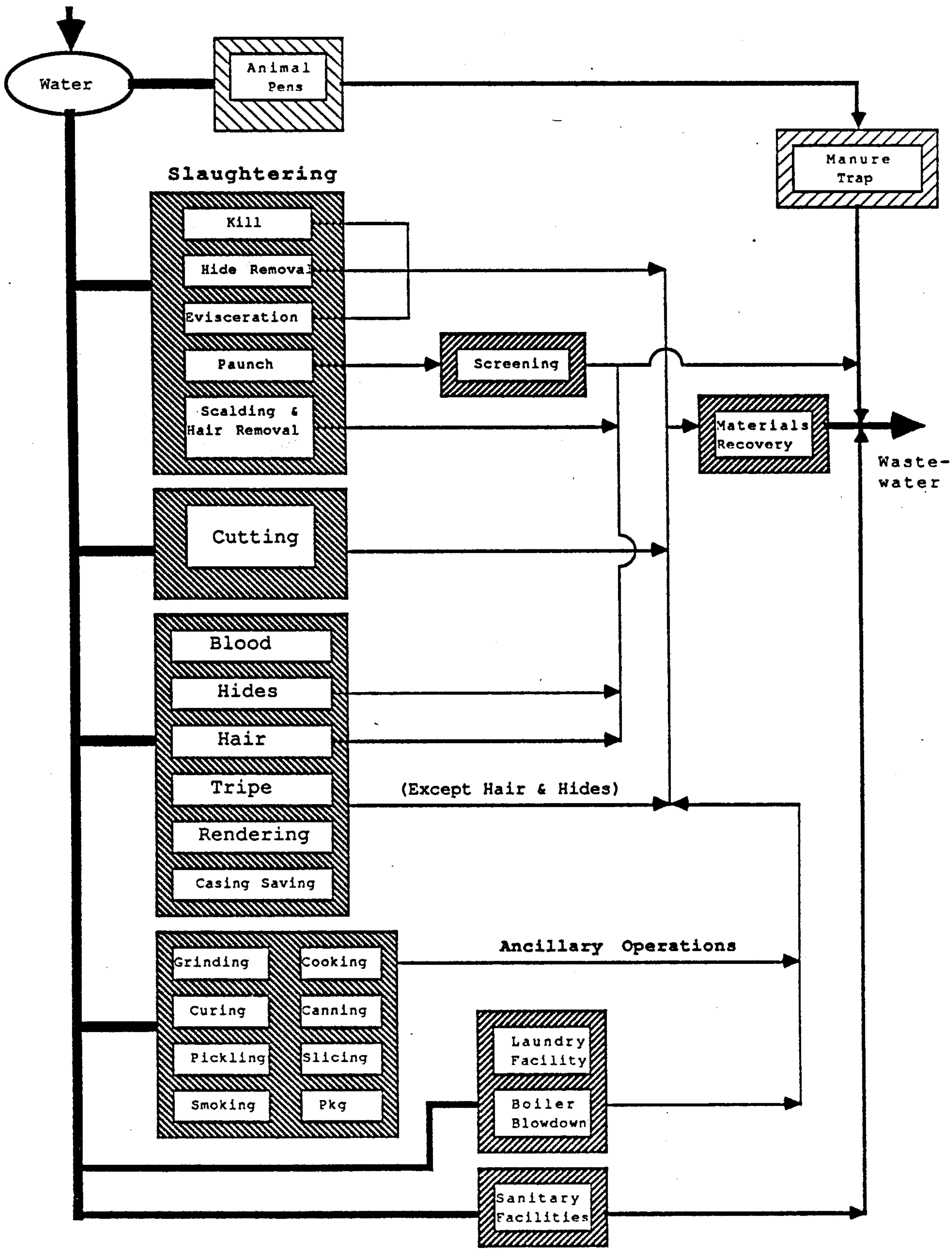
[1]LWK indicates live weight killed.

Table 2. Unit Waste Loads for Selected Meatpacking Plants

Type of animal slaughtered	Biochemical Oxygen Demand (BOD_5)	Suspended Solids (TSS)	Nitrogen (TkN)	Grease (FOG)
		(lb/1000 of LWK)		
Cattle (Plant A)	20.8	14.8	2.24	.68
Cattle (Plant B)	10.0	11.0	1.08	.55
Average	14.6	12.0	1.70	1.63

[1]Average for 16 hog, cattle, and hog and cattle plants

Figure 1. Operating and Wastewater Flow Chart for Low- and High-Processing Packinghouses



Simple Slaughterhouses. Carawan et al. (1979) presented Table 3 which summarizes the plant and raw waste characteristics for simple slaughterhouse. The table represents simple slaughterhouses with about one-half beef and the others divided between hogs and mixed kill. The BOD waste load covered a range from 1.5 to 14.3 lb/1000 lb LWK. Plants with a LWK of less than 95,000 lbs were considered **small**, and medium plants were classified by a LWK between 95,000 and 758,000 lb. This small category of the simple slaughterhouse best fits the operation of Randolph Packing Company.

Packing Houses

A packing house has the **same** basic processes and operations contributing to the waste load as a slaughterhouse, plus the packing house has added waste load from meat processing. The degree and amount of cutting is also much greater. 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.

In EPA studies of the meat industry, packing houses are classified as low or high-processing. The main difference between a low- and high-processing packing house 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, waste load from processing is less for a low-processing packing house.

Low-Processing Packing Houses. Carawan et al. (1979) presented Table 4 which summarizes the plant and raw waste characteristics for low-processing packing houses. The average ratio of processed products to kill was 0.14. The low-processing packing houses included in the analyses have a ratio of processed products to LWK well below the value of 0.4 which distinguishes between low- and high-processing plants. Using the aforementioned definitions of plant size, the kill data show that all the packing houses in the sample were medium to large in size. High-processing plants were studied and reviewed but are not pertinent to this study.

In an EPA survey on meat plants in the United States the researchers found:

- A wastewater flow range of 160 to 2427 gal/1000 lb LWK

- A waste load range of 1.5 to 30.5 lb BOD/lOOO lb LWK

- A kill range of 40 to 3300 thousand lb/day

The major causes of variations observed in wastewater strength and flow were water use and housekeeping practices. Some variations in wastewater flow and strength were attributed to differences in the operations carried out beyond slaughtering, such as by-product and prepared **meat** processing Effectiveness of materials recovery in primary in-plant treatment was also believed to be partly responsible for the variations.

Table 3. Summary of Plant and Raw Waste Characteristics for Simple Slaughterhouses

Base	Flow	Kill	BOD_5	Suspended Solids	Grease	Kjeldahl Nitrogen (as N)	Chlorides (as Cl)	Total Phosphorus (as P)
	(gal/l000 lb) LWK	(1000 lb/day) LWK	(lb/l000 lb) LWK	(lb/1000 lb) LWK	(lb/l000 lb) LWK	(lb/l000 lb) LWK	(lb/1000 lb) LWK	(lb/l000 lb) LWK
Average	554	559	6.0	5.6	2.1	0.68	2.6	0.05
Standard Deviation	379	343	3.0	3.1	2.2	0.46	2.7	0.03
Range, low-high	139-1,523	47-1402	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 4. **Summary** of Plant and **Raw** Waste Characteristics for Low-Processing Packing Houses

Base	Flow	Kill	BOD_5	Suspended Solids	Grease	Kjeldahl Nitrogen (as N)	Chlorides (as Cl)	Total Phosphorus (as P)	Processed Products	Ratio of Processed Products to Kill
	(gal/1000 lb) LWK	(1000 lb/day) LWK	(lb/1000 lb) LWK	(lb/1000 lb) LWK	(lb/1000 lb) LWK	(lb/3000 lb) LWK	(lb/1000 lb) LWK	(lb/1000 lb) LWK	(1000 lb/day)	
Average	816	1105	8.1	5.9	3.0	0.53	3.6	0.13	54	0.14
Standard Deviation	418	785	4.6	4.0	2.1	0.44	2.7	0.16	52	0.09
Range, low-high	210-1768	226-3541	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	0.016-0.362

Statistical correlation analysis of the data revealed that the raw waste load BOD_5 values correlated with values measuring the presence of suspended solids (TSS), grease (FOG) and kjeldahl nitrogen (TkN) on a LWK basis. This means that a change in one parameter will account for a certain predictable change in another parameter.

Chloride and phosphorus are two parameters that relatively few plants seemed to measure. The chloride and phosphorus waste load components were found to be dependent on in-plant operations and housekeeping. For example, large amounts of chlorides contained in pickling solutions used in processing ham, bacon, and other cured products ultimately end up in the wastewater. The authors believe this explains the unusually high chloride values for high-processing packing houses which cure many of their products. 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 for EPA. Other sources provided the typical ranges listed below for these waste parameters:

- 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 were also found to be present in raw waste from meat packing plants. The usual measure is in terms of coliforms, for which the most probable number is typically in the range of 2 to 4 million per 100 ml.

The process wastewater was noted as normally being warm. It was found to average about 32°C (90°F) and reach a high of about 38°C (lOO°F) during the kill period and a low of about 27°C (80°F) during cleanup.

The pH of the process wastewater was found to vary from 6.5 to 8.5, although occasionally it may be outside this range.

Sources of Wastewater

Animal Pens. Pen wastes are high in nutrients, although they only contain about 0.25 lb of BOD/1000 lb LWK. Solid wastes can be removed by dry cleaning, followed by little or no washdown. If washdown is practiced, a manure trap can be used to recover solids rather than allowing them to enter a treatment system. Any rainfall or snowmelt runoff is normally contained and routed for treatment with other raw waste flows.

Watering troughs are another source of pen wastewater. Each trough may discharge 2.1 gal/min or more. With 50 or more pens used at a large plant, the water source becomes significant although pen waste is but a minor contributor in the plant's waste load.

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 405,000 mg/l and a BOD_5 between 150,000 and 200,000 mg/l.

Cattle contain up to 50 pounds of blood per animal, and typically only 35 pounds of blood are recovered in the sticking and bleeding area. The remaining 15 pounds are lost, which represents a waste load of 2.25 to 3.0 lb/1000 lb LWK. Total loss of the blood poses a potential BOD waste load of 7.5 to 15 lb/l000 lb LWK. The typical BOD load from blood losses in the slaughtering operation is estimated to be 3 lb/1000 lb LWK because very few meat plants practice blood control outside of the bleeding area. In beef plants, much of this loss occurs in the process steps following bleeding.

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 lb/1000 lb LWK. The common practices are to either screen the paunch contents, washing the solids 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).

Wet dumping of the paunch represents a BOD_5 loss of about 1.5 lb/1000 lb LWK because 60 to 80 per cent of the BOD_5 in the paunch is water soluble. If dry dumping is practiced, the pollution 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.

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 study showed that only 25 per cent 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 packing house wastes are high in chlorides. Modern brine pumping techniques may help to selectively bind more of the P, Na and CI ions. Therefore, less of these will be released to the sewer.

The pollution load from meat and fatty tissue can be substantially reduced by dry cleanup 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 by-product operations 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, are considered under slaughtering.

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 2 gallons of brine solution per hide.

In some 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 lb/1000 lb LWK for BOD and about 4 lb salt/1000 lb 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 cleanup operations. These wastes can be reduced by removing the majority of them by dry cleanup prior to washdown and by some form of grease trap in the 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.

Cleanup. Cleanup contributes between 0.3 and 3 lb BOD/l000 lb LWK in small packing houses. Data collected by the Iowa Department of Environmental Quality showed that anywhere from 27 to 56 per cent of the total BOD waste load is contained in the cleanup wastewaters. The cleanup operation is a major contributor to the waste load. It also leads to a significant loss of recoverable by-products. Detergents used in cleanup can adversely affect the efficiency of grease recovery in the plant catch basin.

The techniques and procedures used during cleanup can greatly influence the water use in a plant and the total waste load. For example, dry cleaning of floors to remove scraps prior to wash down and dry scraping of the blood from the bleed area into the blood sewer before the normal washdown decreases cleanup pollution load.

An Example of Water Conservation and Waste Control

In an EPA publication Lively (1976) reported how a meat packer decreased unduly high wastewater costs. He noted that the most logical alternative to high costs was to reduce the strength and volume of the slaughterhouse discharge. Water use was 1,060 gallons/l,000 lb LWK with a BOD of 11.8 lb/l,000 lb LWK, compared to the national average of 5.8 lb/l,000 lb LWK when the program began. An in-plant waste control program was devised to reduce the strength and volume of the wastewater to an acceptable level.

Lively reported that an equipment manufacturer guaranteed performance of 90 percent non-emulsified FOG and SS reduction for a DAF system. Attendant BOD removal ranging from 35-45 percent was also expected with SS removal. Additional estimated BOD reduction of 50 percent from a biological process was then considered adequate pretreatment for discharge to the city. Estimated cost of the system installed was $350,000 in the early 1970's.

Table 5 shows the assigned waste load reduction from in-plant control and pretreatment. Effluent from the trickling filter was not settled, thus suspended solids through the process were noted by Lively to be increased.

Water Conservation Program

Water Conservation. The water conservation program developed by Lively emphasized a conservation attitude. A training program was developed to re-train personnel to use only the amount of water needed for a job. He noted that the attitude that water was cheap and abundant had to be dispelled. Personnel was made aware of the plant's total cost, i.e., initial charges, product loss through excess washing and the cost for waste treatment. Hoses were not to be left unattended, taps and sprays were to be turned off during breaks and other non-use periods, and press-to-open valves not to be blocked open. Water use was reduced 3-5 percent following these practices. To sustain any significant savings, waste conservation was continually emphasized,

Plant Cleanup and Equipment. Lively found that cleanup operations generally use as much water as that required for processing. Standard equipment was a low-pressure high-volume hose discharging water at a rate of l0-20 gpm at temperatures of 140-180°F. High-pressure (500 psig) low-volume (3-5gpm) cleaning systems were installed with predicted water savings of 5-7 percent as part of the program.

Use of Sprays and Valves. At various points during processing the product is washed by sprays. Automated solenoid valves were installed to open only when the product was in the wash area.. Hand washing of product requiring less than 50 percent of the time was to be equipped with press-to-open valves. Animal drinking water troughs were to be equipped with float-operated valves. Projected water savings was 5 percent.

A heat exchanger condensing system which saved 96,000 gpd of water was designed to replace all the barometric condensers. Ammonia condenser water at 325 gpm was used as a feed to the heat exchanger. The heat exchanger effluent was tied to the plant hot water system. During processing hours with the rendering units operating, water temperature ranged from 50-60 C (120-140°F). The upper limit was controlled automatically with hot water being dumped when temperature exceeded the set point. During cleanup the set point was increased to 77°C (170°F) to produce the required warmer water. Six months of operation saw water savings of 156,000 gpd.

Water use throughout the plant was reduced by 29 percent. Goals and accomplishments of the conservation program are shown in Table 6.

Table 5. Waste Load Reduction

Process	BOD		SS		FOG	
	(lb)	(%)	(lb)	(%)	(lb)	(%)
Raw Waste	13,400	100	10,500	100	5,800	100
Housekeeping	1,400	10	4,200	40	1,450	25
Air Flotation	4,800	36	5,700	54	3,900	67
Trickling Filter	4,200	31	4,400	+41	375	6
Effluent	3,000	23	5,000	48	175	2

Table 6. Water Conservation Program

Change	Goal		Achieved
	Percent Reduction		
	(%)		(%)
Obvious Waste	5		NR[a]
Equipment Modification	10		17
Cleanup Practices	5		NR[a]
Process Change	18		12
Total (Projected)	38	(Metered)	29

[a]NR = No Results

Water savings through correction of obvious waste practices, equipment modification and altered cleanup practices could not be measured separately. A gross improvement for the entire plant was reported (Table 6). When all facets of the program have been completed, Lively predicts that anticipated water use will be 50 percent of the starting volume.

Waste Strength Reduction. The reduction in waste strength for each segment of the waste control program could not be determined. Process flows were not isolated and various phases of the program were conducted simultaneously. A gross effect was compiled and is presented in Table 7 which shows the reduction in waste during the two years Lively reported on his program. The reduction observed was 16 percent for $B0D_5$, 27 percent for TSS and 28 percent for FOG.

Summary. Lively (1976) reported how an integrated approach to water use control and waste reduction is possible in meat processing plants. He showed that a 29 percent reduction in water use and a 16 percent reduction in BOD_5 are possible.

Table 7. In-Plant Waste Strength Reduction

Date	BOD	SS	FOG
	(lb)	(lb)	(lb)
1972	13,400	10,500	5,800
1974	11,300	7,700	4.150
	% Reduction		
	16	27	28

PLANT REVIEW AND SURVEY

Introduction

Randolph Packing Company is located in the city of Asheboro, NC. The company is a small beef slaughtering facility that kills in excess of 250,000 lb per week. All carcasses are boned and the majority of the boneless meat sold to further processors. Randolph performs a limited amount of further processing, as in steaks, roasts and ground beef. All the wastewater from this modern plant is discharged to the sewers of the Asheboro publically owned treatment works (POTW).

Randolph Packing is a typical beef slaughter plant. A flow diagram of operations is shown in Figure 2. A beef slaughter plant is a water-intensive business that can contribute considerable pollution. It consists of a disassembly process that requires water at each step from the time the live animal enters the plant until its disassembled parts leave the plant. The water used becomes wastewater which can contain excess pollutants unless material deposition into the wastewater stream is avoided.

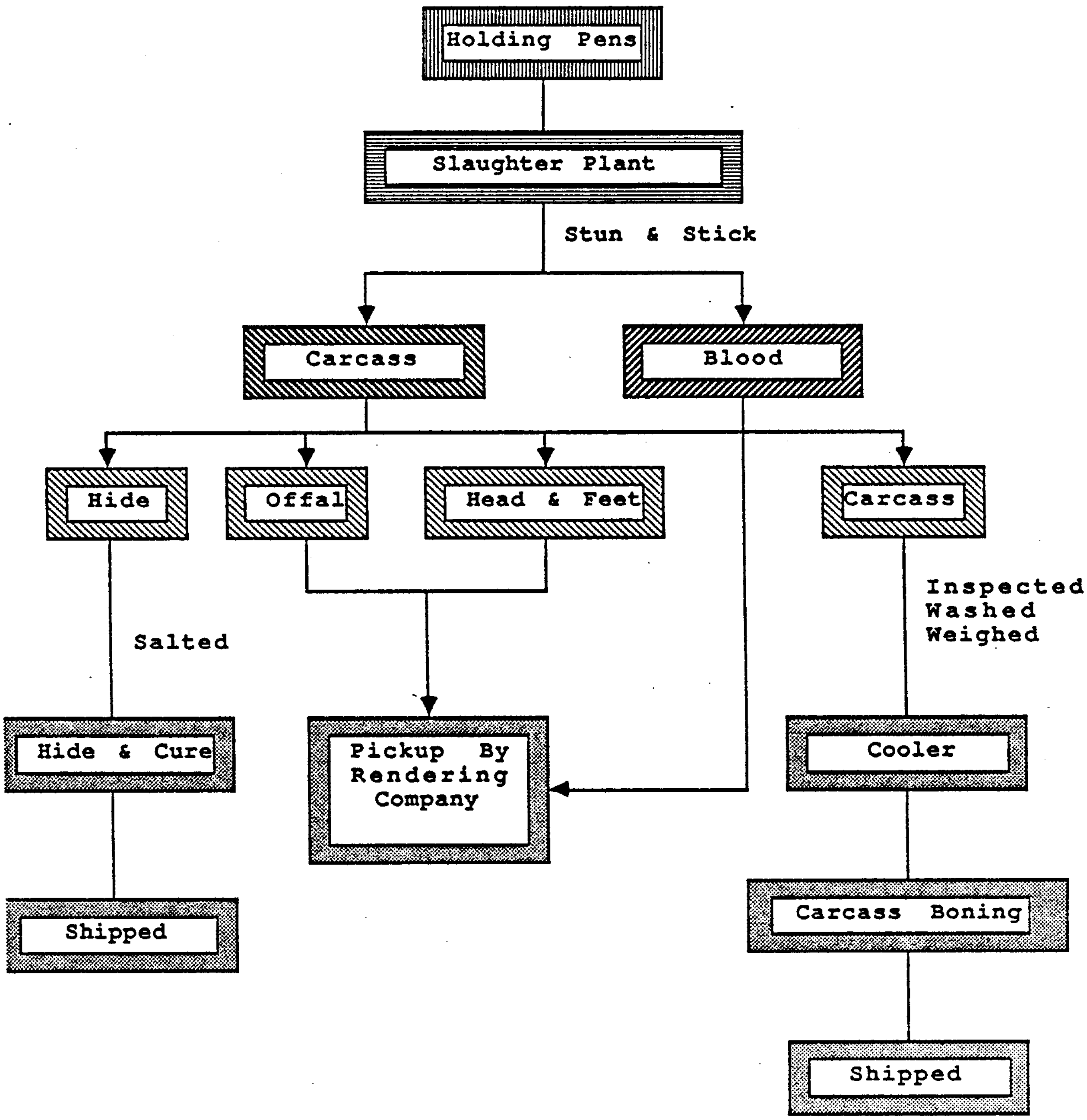
The beef cattle are placed in holding pens when they enter the plant. They remain in this area until they are ready for slaughter. The animals are given water and feed if the holding time is more than one day. The animals will excrete the non-utilized feed and water. To maintain a clean area for the cattle, the area should be dry cleaned to remove the excrement and the water should be flushed. A thorough dry clean will minimize excess pollutants to the wastewater system.

The slaughter process begins with rendering the animals insensitive using humane methods. They are then bled by cutting the carotid artery and jugular vein. The blood may weigh as much as 4.5 percent of the body weight. Blood should be collected so that it does not enter the wastewater.

The hide is then manually removed, cured with salt, and sold. Excess trimmings and feet from the hide removal process should be placed in inedible barrels for disposal to a rendering company. This will avoid particulate matter in the waste-disposal system.

Evisceration removes the internal parts of the animal, and the heart and liver are usually saved. The stomach and intestines are known as the paunch. Although parts of the stomach can be saved, it is not economically beneficial to many plants. A more economical approach is to tie off the bung (end of the anal canal) before evisceration, which prevents fecal contamination of the carcass and the intestinal contents from entering the wastewater system. The entire contents will then be picked up by a commercial rendering company and processed into animal feed.

Figure 2. Randolph Packing Company



The eviscerated carcasses are inspected by a state or federal employee to. assure they are suitable for human consumption. The carcass is washed and then placed in **a** refrigerated room to remove the body heat.

Since the potable water supply is pressurized, loose particles can be removed from the carcass during the washing process. All loose material should be removed to avoid disposal in the wastewater **system.** Trimming the neck area of blood clots and the entire carcass of loose pieces will help to prevent this material from being washed to the drain.

Survey for Product Losses and Wastes

The research team surveyed Randolph Packing Company utilizing the following format:

1) Drawings of product flow and equipment layout were reviewed.

2) Literature was surveyed for known recovery methods.

3) Equipment manufacturers and other meat plant managers were contacted for ideas and suggestions.

4) The **team** visited the plant on several occasions and reviewed its independent and **joint** findings.

5) Key employees were interviewed at their work stations.

6) The research team prepared a list and mutually reviewed the sources of waste, product and by-product losses. Safety, costs and feasibility of recovery were discussed. Notes were made on how management might prevent the loss and/or waste.

7) City of Asheboro officials were contacted for their input.

Each area of the plant was surveyed for losses and wastes, including pens, receiving, kill floor and products processing. In each area of the plant, every process and operation were observed for activities that let product escape to the floor or drain. Losses and wastes are summarized in Table 8. The benchmark waste load was 6870 lb BOD, per month out of the potential of almost 30,000 lb BOD_5 per month (Table 8). The plant currently recovers as by-products about 77 percent of the potential BOD_5.

Water Use and Waste Load

Water Use. Randolph Packing Company receives its water from the City of Asheboro. City records were reviewed, and water use for 1986 was tabulated in Table 9. The average water use was calculated to be about 15,000 GPD. Water use for the benchmark period was 14,714 GPD while water use for the project average period was 15,390 GPD.

Table 8. Potential Wastes (BOD_5) from Randolph Packing

Area	Potential Waste Load/Animal	Potential Waste Load/Month
	(lb/1000 lb LWK)	(lb)
Pens	.25	316
Slaughtering		
Blood	15.0	18,975
Paunch	2.5	3,162
Cleanup	2.0	2,530
Hide Curing	1.5	1,898
Processing	2.0	2,530
Total	23.25	29,411

Table 9. Water Use for Randolph Packing Company - 1986

Quarter	Water Use	
	(ft^3/quarter)	(gal/day)[a]
	129,830	14,714
	124,720	14,135
	155,170	17,586
	127,500[b]	14,450

Calculated using 22 work days/month
Estimated

Wastewater Characteristics. Randolph Packing Company discharges all its wastewater to the City of Asheboro. The city staff monitors the wastewater for one week on a quarterly basis. Average results from their testing program are tabulated in Table 10.

The monitoring program includes composite sampling for BOD, COD, TSS, TkN. FOG and chlorides as well as testing for pH and temperature. A benchmark for Randolph Packing was selected using the first quarter ‘sampling results which were determined before the project team began plant visits and training programs. The BOD_5 average value of 2543 mg/l, COD value of 3628 mg/l and TkN value of 347 mg/l exceeded the interim limits and were noted as a violation of the ordinance. Other average parameters were within the limits. Several individual samples exceeded the limits and included TSS but not FOG. The limitations are reviewed in the next section of this chapter.

Management expressed great concern at violating the interim limits. Together, management and the project team have looked toward process changes and addition of systems to reach compliance.

The project team used wastewater analysis encompassing three quarters as the project average for Randolph Packing. The project average was calculated as a mean of the average for each sample period and is presented in Table 10.

As a result of greater attention to detail, better process control and employee training, significant results were obtained considering the benchmark. Project average characteristics were lower than the benchmark characteristics for BOD_5 COD, TkN, and FOG. Benchmark characteristics were lower for TSS and chlorides. The project team believes that increased blood recovery and better control of the paunches helped lower these numbers. The increase in TSS values may be due to the large variations seen in individual samples on a day-to-day basis. Chlorides come mostly from the hide curing operation and the need for better control of salt in this operation has been identified but not addressed.

The ratios of selected wastewater parameters are presented in Table 11. There is a sizable variation between benchmark and project ratios which may explain the difference in wastewater parameter characteristics which occur over time.

Water and waste coefficients are presented in Table 12. Coefficients are the water use or waste load of some parameter presented on a common basis. The basis chosen for this study was 1000 lb of live weight killed, which has been used by EPA in their studies on meat plants. Randolph Packing coefficients for both water use and waste load were lower than EPA averages. The TSS and FOG values are much lower than the industry averages. The BOD and TkN values for the benchmark are very similar to the industry averages.

Waste Load. Waste loads for various parameters surveyed were calculated from the water use average for the period. They are tabulated in Table 13. The benchmark BOD_5 load was 312 lbs/day while the load for the project average was 184 lbs/day, a 47 percent decrease (Table 13). On an annual basis, the BOD_5 reduction observed is 32,000 lb/yr. Similar reductions were found for COD (21%), TkN (46%) and FOG (2%) . Increases were found for TSS with 25% increase in waste load and for chlorides with a 49% increase..’

Table 10. Average[a] Wastewater Characteristics - 1986

Parameter	Benchmark 1st	Quarter 2nd	3rd	4th	Project Average[b]
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
BOD_5	2543	1045	1858	1396	1433
COD	3628	1881	3796	2561	2746
TSS	842	611	1549	855	1005
TkN	347	133	238	167	179
FOG	126	115	120	----	118
Chloride	915	----	1627	982	1304
	RANGE				
pH	7.2-7.5	7.0-7.4	6.7-6.9	----	6.7-7.4
	OBSERVATION				
Temp. (F)	59	67	81	----	74

[a]Average of four composite samples, sampling and analysis by City of Asheboro
[b]Mean of averages for 2nd, 3rd, and 4th quarter samples

Table 11. Ratios of Wastewater Parameters and COD

	Benchmark	Project
COD	1.00	1.00
BOD	.70	.52
TSS	.23	.37
TkN	.10	.07
FOG	.03	.04
Chloride	.25	.47

Table 12. Water and Waste Coefficients for Randolph Packing Company - 1986

	Average Water Use		
	Benchmark	Project	EPA[a] Survey
	(gal/1000 lb LWK)	(gal/1000 lb LWK)	(gal/1000 Ib LWK)
	256	262	554

	Average Waste Load		
	Benchmark	Project	EPA[a] Survey
	(lb/1000 lb LWK)	(lb/1000 lb LWK)	(lb/1000 lb LWK)
BOD	5.43	3.14	6.0
COD	7.74	6.00	----
TSS	1.79	2.20	5.6
TkN	0.74	0.39	0.68
FOG	0.27	0.26	2.1

[a]Table 3

Table 13. Benchmark and Project Waste Loads[a]

	Benchmark[b]	Project[c]	Increase (Decrease)	Increase (Decrease)
	(lbs/day)	(lbs/day)	(lbs/day)	(%)
BOD	312	184	(128)	(41)
COD	445	352	(93)	(21)
TSS	103	129	26	25
TkN	42.6	23	(19.6)	(46)
FOG	15.5	15.2	(0.3)	(2)
Chloride	112	167	55	49

[a]Calculated using wastewater characteristics (Table 10) and water use (Table 9)
[b]January testing prior to project initiation (14,714 GPD)
'April, July and October average (15,390 GPD)

Wastewater Discharge Limitations and Costs

The discharge from Randolph Packing Company flows directly to the sewers in the City of Asheboro and to the publically owned treatment works (POTW). Asheboro adopted a Sewer Use and Pretreatment Ordinance on June 23, 1983. The ordinance contains specific prohibitions and limitations that relate to meat processing plants such as Randolph Packing.

Prohibitions are found in Section 2.4 of the ordinance. Prohibited from discharge are substances that might cause fire or explosion, obstruct flow in sewers, create hazard to sewer personnel, and interfere with treatment operation and sludge disposal.

> "Specifically prohibited are solid or viscous substances which may cause obstruction to the flow in a sewer or other interference with the operation of the POTW such as, but not limited to: floatable oil, animal guts or tissues, paunch manure, bones, hair, hides or fleshings, whole blood . . ." Section 2.4(3).

Limitations for pollutants are found in Section 2.7. Specific limitations that most affect Randolph Packing Company are tabulated in Table 14. Limitations on BOD_5 (800 mg/l), COD (2000 mg/l), TSS (600 mg/l), TkN (80 mg/l) and FOG (100 mg/l) are the most restrictive for a meat plant.

The City of Asheboro has provisions in its ordinance to allow interim limits if the treatment systems have adequate capacity and no permit violations will occur. Under this provision, Randolph Packing Company has received interim limits as listed in Table 14.

Even though the interim limits allow higher concentrations, all discharges with parameters above certain limits must pay an excess charge above the normal sewer charge. The concentrations above which excess charges are computed are tabulated in Table 14.

Randolph Packing Company must examine the economics of paying for excess wastewater parameters versus the costs of pretreatment systems. Sewer rates and user charges are detailed in Appendix I. Most of the monthly charge to Randolph Packing is for excess BOD_5 which is charged at a rate of $0.0915 per excess pound.

Table 14. Asheboro Pretreatment Ordinance Limitations and Interim Discharge Limits[a] for Randolph Packing

Parameter	Limitation Composite	Limitation Peak	Excess Charge Above	Interim Limits[a] Concentration	Interim Limits[a] Waste Load
	(mg/l)		(mg/l)	(mg/l)	(lb/day)[b]
BOD_5	800	1200	300	2000	245
COD	2000	3000	750	4000	491
TSS	600	1000	300	1000	123
TkN	80	200	45	300	37
FOG	100	100	NA	250	31

[a]Allowed by City of Asheboro (subject to revision and/or revocation)
[b]Utilizing benchmark water use of 14,714 GPD and interim concentration limits

WASTE CENTERS, CHANGES, COSTS AND RESULTS

In-Plant Control Measures

There are many effective measures that a food plant can use to efficiently and economically reduce water use, product losses and waste loads, as shown in Table 15.

The best and most modern engineering design and equipment alone cannot control water, product losses and waste within a plant. For any plant, the controlling factors in reducing water use, product loss and waste will always be management attitude and action.

Management must do its part to have an effective water and waste control program. Management's role must include the following for a successful program:

1) Understanding water and waste control

    a) Needs for program
    b) Economic benefits
    c) Awareness of all interrelated factors

2) Developing job descriptions for all personnel

3) Providing an environment that permits supervisors to control water use, product losses and waste load

4) Utilizing an effective and continuing education program for management and employees

Water Conservation

The goal of every food plant manager should be to use an absolute minimum of water for the essentials of sanitation. A water conservation program for the plant can be summarized as follows:

- Employees should be trained to use water wisely-only enough to get the job done.

- The acquisition of a high-pressure cleanup system should be explored.

- Employees should be trained and expected to use the minimum pressure and volume for washing product, consistent with quality control and regulations.

- Valves should be installed and used on all hoses.

Table 15. Measures to Control Water Use, Product Loss and Waste Load

Number	Measure
1.	Management understanding, interest and support
2.	Installation of modern equipment and piping to reduce loss of product and to facilitate recovery of by-products
3.	Appointment of water-waste supervisor
4.	Employee training
5.	Accurate records of water use and waste load
6.	Scheduling to reduce water use and waste
7.	Proper cleaning procedures
8.	Wastewater monitoring
9.	Planned maintenance program to reduce losses and waste
10.	Planned quality control program to reduce losses and waste
11.	Planning systems for recovery of wasted product and by-products
12.	Development of alternatives for wasted product recovery

The team predicts the plant could achieve a 25 percent reduction in water use by following the above suggestions and others found throughout this report. Management action and employee attitude are paramount to this worthy goal. The yearly water savings would approach l,000,000 gallons annually.

Recovering Products, By-Products and Reducing Waste Load

Wastewater control need not be complicated or expensive. The principal effort should be applied toward preventing product (and contaminants) from entering the waste stream and toward reducing water use to a minimum. High waste load areas were investigated first. Accurate sampling, chemical analysis, and flow measurements need not be performed initially, but can be deferred until after the gross problems have been solved. The project team used this approach.

Most suspended solids in meat wastewaters are organic. Their removal results in a reduction of BOD. Suspended solids concentrations (after screening) are a rough measure of BOD which can be measured quickly and easily. Dissolved solids can be measured with a conductivity meter. Red color indicates the presence of blood, a very large contributor of BOD.

Blood Conservation

John Killebrew (1976) reported that blood has the highest BOD of any liquid found in a meat processing plant. He noted that one cattle contains approximately 50 pounds of blood, which if discharged into the sewer contributes a pollution load equivalent to that of fifty people. Important aspects of a good blood conservation program were detailed.

Blood first presents itself on the kill floor in the sticking or bleeding area. This area should be curbed and equipped with combination blood and water floor drains. During operation and before cleanup periods, the blood must be carefully squeegeed to the blood side of the drain, minimizing blood loss to the sewer when the drain plate is changed. In many plants, the floor of the bleeding area is given an initial rinse with a fine spray nozzle under high pressure which is sent to the blood sewer. The cost of removing this small amount of water from the blood is probably less than removing the blood from the waste treatment system.

Management should always be alert to see that the flow of cattle through the bleeding area allows ample time for thorough bleeding, and that operators do not hurry up the process to gain extra breaks for themselves, etc. They should also see that floor cleanup is done often enough that blood does not coagulate on the floor, requiring large amounts of water to remove it. Meters could be installed on the hoses to quantify and thus control water use in this area.

Various operations along the dressing chain route, such as head washing and brisket opening, result in large amounts of blood being spilled on the floor and then washed down the sewer. Attempts should be made to design or alter these areas so this blood can be saved.

Killebrew (1976) reported that a firm in Sweden is marketing a hollow sticking knife, designed to collect blood from cattle or hogs for edible purposes. Blood could be kept off the floor and sold as a more valuable product. He postulated that blood lost to the sewer in a meat packing plant can be on the order of 30 percent, despite collection systems. specifically installed for its recovery. Two methods of removing it from the waste stream consist of the use of lignosulfonic acid (LSA) process described by Hopwood and Rosen (1972) and electrocoagulation as described by Beck et al. (1974).

In the LSA process, raw wastewater is chemically treated with sulfuric acid and lignosulfonic acid. This treatment precipitates soluble proteins, forming a flocculent mass suspended in the wastewater. The mixture is then subjected to dissolved air flotation that separates the precipitate and other suspended organic matter from the wastewater. The clarified waste is then neutralized with lime. The effluent has greatly reduced levels of nitrogen, grease, suspended solids, biochemical oxygen demand and live organisms. Sludge from the flotation unit contains about 40 percent protein (dwb) and can be sold as an animal feed ingredient.

Electrocoagulation, can recover blood lost to the sewer when used in conjunction with chemical treatment. The process electrolytically neutralizes the negatively charged particles in the wastewater. Passage of a direct current through the wastewater forms large quantities of microbubbles of oxygen and hydrogen in the wastewater due to electrolysis. The addition of coagulant aids, such as ferric sulfate and an anionic polymer plus calcium hydroxide for pH adjustment prior to electrocoagulation, is necessary to remove the proteinaceous organics contained in the blood.

Both processes - LSA and electrocoagulation with chemical treatment - increase the protein content of the waste sludge to a level such that by-product recovery alone might make the process economically desirable in addition to allowing the plant to meet effluent requirements.

Blood Collection System: The project team reviewed the blood collection practices of the plant. Blood is collected manually and disposed of with the by-products. On most days, the employees did a good job and much of the blood was collected. However, to assure systematic and thorough collection, a blood recovery system was investigated.

The system studied was the installation of a blood drain system with piping and a heavy duty pump connected to a collection tank. The renderer would empty the tank when he collects the other by-product materials.

Initial costs were estimated at $7,000 (Table 16). An annual budget (Table 17) for the blood collection system indicated a net savings of $1,925 annually. However, the renderer is not anxious to handle the blood because of drying problems and extra costs. Thus, the anticipated revenue may not be realized. The blood collection system would be a break-even proposition. The project team predicted blood recovery equivalent to 3 lb BOD_5 per animal. This increase would be a 20-30 percent improvement over current practices. Even though there would not be a monetary benefit, the BOD_5 reduction can help the plant meet its limitations with the city.

Table 16. Initial Costs of Blood Collection System

Item	Amount
Material :	
Vessel, pump and lines	$ 5,000
Installation:	
Welding, plumbing and electrical	2,000
Total (Includes tax and labor)	$ 7,000

Table 17. Annual Budget for Blood Collection System

Item	Quantity and/or Rate	Amount	
Revenue and Reduced Costs			$ 5,480
Revenue Increase in Blood Collection @$20/ton		$ 1,880	
Reduced Costs			
Surcharge		3,600	
Increased Costs			3,555
Maintenance		500	
Cleaning and operation		1,500	
Depreciation		1,000	
Utilities - electricity/water		240	
Interest charges		315	
Net savings per year			$ 1,925

Paunch Handling and Processing

Witherow and Lammers (1976) reviewed paunch handling in beef slaughtering. There are over 35 million head of beef slaughtered annually in the United States which results in over 1.7 billion pounds of paunch manure to be handled and processed per year.

Paunch manure is the partially digested feed contained in the rumen, first stomach. Fresh paunch manure is a yellowish-brown color containing recognizable fiber and grain with an obnoxious odor. The material is acidic with a pH ranging from 5.6-7.0. Even with its 85 percent water content, only minor solid-liquid separation will occur on standing.

The wet weight and dry weight of paunch manure average 54 lb/animal and 8.5 lb/animal, respectively. Mean values for paunch manure were Chemical Oxygen Demand (COD)-177,300 mg/l and five day Biochemical Oxygen Demand (BOD_5)-50.200 mg/l. Paunch manure has such an extended oxygen demand that the BOD_5 is less than 40 percent of the carbonaceous oxygen demand. Paunch manure has a BOD_5 of 2.5 lb/1000 lb LWK and can constitute 20 percent of the waste load from a packinghouse.

Witherow and Lammers (1976) reviewed the three systems of paunch handling - no-dump, wet-dump, and dry-dump. In the no-dump system the paunch sack is left unopened and both the sack and the paunch manure are sent to rendering. In the wet-dump system, the paunch sack is sliced open and the contents are water flushed from the sack into a sewer. In the dry-dump system the paunch sack is sliced open and the contents are dumped and transported from the plant in a separate non-water carriage system. The emptied sack is then rinsed and the rinse water goes to the sewer. In the wet-dump or dry-dump systems, the sack is sent to rendering or is used to produce tripe.

No-Dump System. When the paunch sack is not dumped, the contents and sack are sent to rendering and become part of the meal by-product. Sending paunch manure to render lowers the protein content of the meal, increases the percent of water to be vaporized, discolors the greases and increases the odor control cost. The potential use of the paunch sack for production of an edible product (tripe) is also lost. Because of these negative economic factors, the no-dump system has been practiced only on condemned paunches which is a minor percent of the viscera rendered. Current practice at Randolph Packing best could be described as the no-dump system.

Wet-Dump. System. The sluicing of paunch manure with spray washer is undoubtedly the poorest system from the viewpoint of pollution control. Nevertheless, a 1967 survey showed that 84 percent of the industry employed the wet-dumping system. Sending all the material for treatment was practiced by 13 percent of the industry. Liquid solid separation with off-site disposal of the solids was practiced by 70 percent. Using a water carriage system will result in 60-85 percent of the BOD_5 and about 5 percent of the fine solids passing through the typical screens used for solid-liquid separation. This material loss to the treatment system will be 2.0 lb BOD_5/1000 lb LWK and 0.4 lb TSS/l000 lb LWK.

Paunch manure was noted to be untreatable in a conventional sewage treatment plant for the following reasons: 1) the manure solids settle out and tend to harden to the consistency of low-density rock; 2) the solids clog hopper bottoms, pits and pump suctions; 3) augering may be required to remove the solids from pipelines; 4) the cellulose material does not decompose in digestors and forms straw blankets which clog and eventually fill digestors; and 5) the entrapped moisture in the cellulose material cannot be dewatered by vacuum filters.

The use of vibrating, rotating or stationary screens serve a most valuable function in separating the solids for transport to ultimate disposal. Without screens the wastewater treatment system must include specially designed liquid-solid separation. solids handling and stabilization facilities. The required treatment will necessitate not only reduction of the oxygen demand, but also separation and disposal of the paunch fines and biological solids produced in treatment. The wet-dump system is no longer the most economical one because of the increased treatment costs.

Dry-Dump System. The dry-dumped paunch will have a moisture content of 85 percent. The elutriated paunch solids in a water carriage system when separated on screen have an 81-82 percent moisture content. The dry-dump handling system can incorporate the same transporting and processing methods used for screened paunch solids.

Transporting paunch solids out of the plant has run into problems where pumps and pipelines are involved. The solids tend to plug the line and pump intake facilities. Two satisfactory transporting methods are a screw conveyor and an air-energized system in which the material is intermittently blown through a pipeline. Paunch material has been successfully blown 700 ft. with an elevation increase of 45 ft. If the material is transported away from the plant site without processing, it is commonly moved in specially designed trailers. The trailer must prevent spillage and is commonly shaped like a tank truck with a covered top to contain odors and a rounded or sloped base to prevent paunch solids from sticking in the corners.

Processing System. Though the future for paunch handling is seen as the dry-dump system with auger or “blow” transport systems, the method of processing and disposal is far from clear. Technology on a series of processes and operations for paunch manure has been developed over the years and the potential is noteworthy for transferring technology from agricultural investigations on animal manures. Table 18 is a listing of paunch processing technology with a description of operations and by-products.

Summary. Paunch manure is a major waste (2.5 lb BOD_5/1000 lb LWK) in beef processing and is equivalent to 20 percent of the average waste load from a packinghouse. This percentage would be higher based on longer term oxygen demand values as the BOD_5 of paunch is less than 40 percent of its carbonaceous oxygen demand.

Table 18. Paunch Processing Technology

Process	Operation	By-Product
Stabilization	Surface Spreading	Soil Conditioner
	Subsurface Spreading	Soil Conditioner
Moisture Transfer	Mixing with Refuse	Landfill
	Lagooning or Stockpiling	Landfill
	Mixing with Feeds	Feeds
Thermal Drying	Rendering	Feeds
	Rotary Dryer	Feeds
	Fluid Bed Dryer	Feeds
	Solar & Air Drying	Feeds
Mechanical Dewatering	Presses	-------
	Screens & Filters	-----e-
Thermal Conversion	Incineration	Gases &(Ash
	Pyrolysis	Fuel & Chemicals
Biological Conversion	Composting	Soil Conditioner
	Ensilage	Feeds
	Single Cell Protein	Feeds
	Digestion	Methane
Physical Conversion	Board Mill	Wall Board

Between 60-85 percent of the BOD in paunch manure is water soluble. Use of the wet-dump handling system even with solids-liquid separation adds 2 lb BOD_5/1000 lb LWK in the water carriage and significantly increases the wastewater treatment costs. Because of these increased costs, dry-dump handling is the system of economic choice.

The constraints in processing paunch manure are the water pollution potential due to the high BOD, the problem of odors and flies, the high moisture content, and the low protein content. A number of processes to utilize paunch manure have been investigated in the laboratory, in pilot plants and at full-scale. Of the processes reviewed, the production of soil conditioners by surface and/or subsurface spreading and the production of feeds by ensilage or drying appear to be the most feasible.

Paunch Processing System. A paunch processing system was explored for Randolph Packing. Parts of the stomach can be saved. cooked for processing as human food, packaged and frozen.

The system would consist of a specialized cleaning table and cooking unit. Costs were estimated at $16,000 plus $4,000 for installation (Table 19). The project team estimated the system would require an additional 1.5 people, and chemicals and water for washing to produce about 25 lb of edible product per animal. The market value of the product is from 0.10-0.25/lb.

A summary of the process is presented in Table 20 with the annual budget. Net losses per year could approach $6,685 annually with a $0.l5/lb value for tripe but a loss of $37,935 would result from a $0.05/lb return for product. The project team also believes that this process would result in an increase in waste load as the extensive cleaning and washing required would release the paunch materials to the sewer. An additional 1,250,000 gallons of water per year would be needed for the washing.

In the final analysis, the project team feels that the most economical approach to paunch handling is to tie off the bung and send the paunch to a renderer. It is recommended that Randolph Packing pursue the incorporation of this practice into their daily operation. The time is estimated at two minutes per animal. Also, the auger carrying the paunches is too small to move the paunches without losing some contents. A closer look at this operation is necessary to dispose of paunches with minimal waste load.

Pens. Wells (1976) reviewed the handling of wastes from pens. He noted that this is probably one area where wastes are most easily segregated from the other waste streams of the plant. Pen design was recognized as an important factor in cleaning.

Settling basins have been used successfully for catching wastes from pen cleaning. These basins work best with floors sloped at a five percent grade to permit hosed-down pen wastes to settle. Then a front-end loader is used to remove these wastes for disposal to a landfill or agricultural land. These settling basins are capable of removing 40 percent of the BOD_5.

Table 19. Paunch Processing System

Item	Amount
Material	
Cleaning table/cooking unit	$ 16,000
Installation	
Welding, plumbing and electrical	4,000
Total (Includes tax and labor)	$ 20,000

Table 20. Annual Budget for Paunch Processing System

Item	Quantity and/or Rate		Amount
Revenue	312,500 lb tripe @ $.15/lb		$ 46,875
Reduced Costs			
Increased Costs			53,560
Maintenance		$ 1,600	
Labor		18,720	
Depreciation		2,290	
Utilities - water and steam		1,925	
Interest		900	
Packaging/Freezing	@ $.09/lb	28,125	
Net Savings (Loss) Per Year			($6,685)

Some pens are cleaned mechanically with the aid of front loaders. Bedding materials used are wood chips and/or sawdust. Pens should be dry-cleaned two or three times daily, with the bedding and waste mixtures hauled to landfill. Randolph Packing had initiated a daily dry cleanup prior to the initiation of this project.

Vacuum-type cleaning systems using septic tank pumps with an intake nozzle similar to a vacuum cleaner can reduce the BOD_5 by 25 percent. Wells (1976) reported that these can be effective without washing except in the warmer months when the pens need to be washed at least twice a week.

Usually runways and pens are hosed down periodically. Consideration should be given to segregation of this strong liquid waste for disposal by trucking or piping directly onto farmland, within the limits of regulations regarding land disposal. A settling basin should be investigated to allow recovery of solids.

Scraps and Bone Dust. Plant operations in cutting and trimming should be examined carefully for opportunities to intercept waste solids before they enter the sewer. Scraps and liquids from the splitter should be caught in a container directly beneath the washer. Collected contents should be routed directly to rendering. Bone dust from sawing operations is a considerable source of pollution and contains a high concentration of phosphorus. Bone dust is of fine texture and when diluted with water is difficult to recover. Therefore, it should be recovered intact by catching directly in containers, or by sweeping up and hauling to the inedible rendering truck.

Hide Curing. Hide-curing operations are becoming increasingly involved as segments of tanning operations are transferred from tanneries to beef-slaughtering plants. During winter months, a single hide can contain 60 lb of attached lumps of manure, mud, and ice. In addition, salt and waste enter the sewage stream. This water should be recycled or retained. Salt use must be controlled. The project team recommends management control over water use and salt use in the hide curing operation.

Summary of Process Changes

A summary of process changes is presented in Table 21. Many of the changes could not be costed out nor could their impact be estimated by the project team. The recommendations are not as extensive as they would be for many meat plants because Randolph Packing Company was already recovering an estimated 77 percent of their potential pollution load through efficient processing and byproduct recovery practices. The project team believes that Randolph Packing may be able to increase this recovery without pretreatment to 95 percent.

The tabulation of the process changes (Table 21) presented the project team with several challenges. First, if all the waste load reductions predicted were achieved simultaneously, the plant would have a negative waste load. The individual waste load reductions are merely estimates. As these estimates cannot be added without resulting in a negative waste load, further calculations, extensive sampling and testing involving a costly project would be needed.

Table 23. Changes for Waste Load Reduction

System	Description	Initial cost	Annual costs	Annual Savings (Loss)	Waste Prevented
					(lb BOD_5)
Improved cleanup of pens[a]	dry cleanup of pens-manual system	$ 0	$ 3,000	($2,600)	3,000
Settling basin for pen waste	chamber to recover solids for disposal to land	1,000	1,000	(600)	3,000
Improved paunch handling	tie off the bung to contain solids	0	2,500	300	30,000
Continued employee education	training and records to help prevent excess water use and waste	0	500	2,400	32,000
Blood Collection		7,000	3,555	1,925	39,000
Paunch processing		20,000	53,560	($6,685)	(30,000)

[a]Instituted prior to the initiation of this project but shown to demonstrate value of this practice.

Seeming inaccuracies in waste load reduction can be further attributed to the fact that aggressive employee action to reduce waste load has accomplished many of the predicted results. Effective blood collection is an example of this.

Management faces a real challenge in the constant motivation and support necessary to maintain peak performance. For instance, maybe 20,000 lb of BOD, reduction attributed to employee education was achieved through better and more thorough blood collection practices. This is approximately 50 percent of the total BOD load that could be recovered by a blood collection system. Now managemen must decide, "Is this 50 percent reduction adequate? And can we maintain this performance?"

Several thousands of dollars annually could be saved in excess charges with the successful continuation of these reductions. Further, violations of limitations established by the city would be minimized.

Pretreatment

Every food processor is faced with choices in disposal of wastewater. First, a decision must be made whether to treat the waste load in-house or dispose of water to a POTW. For plants located in municipalities, most are required to discharge to the POTW although many larger food processing plants have been allowed to treat their own waste by installing appropriate treatment equipment. Municipalities condition discharge with sewer use and pretreatment ordinances.

When not prohibited, food processors discharging to POTW's must decide on whether or not to pretreat. Economics strongly affect the decision and should govern the level of pretreatment. Systems for pretreatment in meat processing plants were thoroughly reviewed by EPA in a Technology Transfer Publication in 1973 and are listed in Table 22.

Advantages and Disadvantages of Pretreatment

Compliance with municipal regulations regarding the quality of wastewater for discharge to the city's sewer will usually determine the degree of pretreatment. However, there are some factors that may encourage pretreatment beyond the levels required by ordinance. Advantages of pretreatment usually include lower surcharge costs and improved relations with the POTW. They also include the following:

- A higher quality of pretreatment may be justified economically if the city's charges and surcharges are at an unusually high level.

- The meat packer may prefer to assume treatment responsibilities to avoid complaints from the municipality.

- There may be indications that the future will bring increases in the city's rate structure.

Table 22. Pretreatment Methods for Meat Plants

Method
Flow Equalization
Screening
Static
Vibrating
Rotary
Centrifuges
Grease and Suspended Solids Separation
Rectangular Basins
Round Basins
Dissolved Air Flotation
Other Systems
Electrocoagulation
Lignosulfate
Biological Processes
Aerobic
Aerobic Basins
Trickling Filters
Contact Stabilization
Anaerobic
Anaerobic Basins
Digesters

- Grease and solids may have a good market in the area. Close proximity of a soap plant or similar grease market may produce economic advantages for grease recovery, or permit some expense in improving quality of the finished inedible grease or tallow. Such improvements will also improve the wastewater effluent.

Disadvantages of pretreatment are more prevalent for smaller processors because pretreatment systems are often costly to purchase and operate:

- The pretreatment will be placed on the property tax rolls, unless state regulations permit tax-free waste treatment for industry.

- The maintenance, operation, and record keeping may be too expensive.

- The burden of good operation increases as the treatment becomes more complex and extensive.

- A system will require 25-50 percent of one employee's time per year for operation. Sampling and analysis can cost thousands of dollars.

- Pretreatment leaves a residue or sludge that must be stored, deposited and properly handled. Legal disposal alternatives are limited and trucking is expensive.

Pretreatment Systems

The project team reviewed the use of two pretreatment systems-a simple settling basin and a dissolved air flotation (DAF) system.

Settling Basin. In an EPA (1974[a]) publication on poultry processing, a small settling basin was utilized to recover solids from poultry processing wastewater. A similar system was deemed useful to a small meat packer. Septic tank-like structures have been used for similar settling basins.

A 1500 gallon septic tank with internal baffles would yield up to 30. minutes' retention time. The poultry plant reduced BOD_5 by more than 16 percent with only a seven-minute retention time. Longer retention times would increase the recovery; and more than 30 percent BOD_5 removal in poultry processing wastewaters has occurred with more than 15-minute retention times.

Dissolved Air Flotation. The use of dissolved air flotation (DAF) units is one of the more common pretreatment methods for meat processors. Lively (1976) noted a DAF manufacturer's guarantee of 80 percent removal of TSS when chemicals were added. An EPA study (1974[a]) of poultry processing effluent found a 45 percent TSS, 28 percent BOD and 56 percent FOG removal without the addition of chemicals. The addition of alum and polymers, although often practiced, makes the recovered solids illegal for use in food for animals intended for human consumption such as cattle, chickens, etc. Approved florculants such as chitosan and lignosulfate can be used for animal feed recovery.

Table 23. Initial Costs of the Air Flotation System

Item	Amount
Material	
Chamber and Pumps	$ 40,000
Installation - including site preparation, welding, plumbing and electrical	20,000
Total (Includes tax and labor)	$ 60,000

Table 24. Annual Budget for Air Flotation System

Item	Quantity and/or Rate	Amount
Revenue and Reduced Costs		$ 9,320
Grease and materials		
Reduced Costs		
Surcharge 60 percent reduction in BOD_5[a]	$ 9,320	
Increased Costs		
Chemicals - Alum, caustic, polymer	1,000	22,620
Maintenance	4,000	
Cleaning and Operation	4,900	
Depreciation	5,720	
Utilities - water and electricity	1,200	
Interest on Investment	2,700	
Sludge Disposal	3,100	
Net savings (loss) per year		($ 13,300)

[a]TSS and FOG assumed negligible.

A DAF unit consists of a chamber into which air is bubbled or into which wastewater pressurized with air is released. Grease and other solids rise to the surface and are skimmed by a scraper blade assembly. Chemical addition (alum, polymers) and pH adjustment may increase the efficiency of removal.

The initial costs for a DAF system for Randolph Packing were estimated at $60,000 (Table 23) by one manufacturer. Exact costs were difficult to obtain unless a site was selected and accurate pumping and piping were estimated.

Utilizing the initial costs estimate (Table 23) and assuming a 60 percent reduction in BOD_5, an annual budget was developed (Table 24). Reduced costs would include the surcharge reduction of $9,320 annually. Increased costs include chemicals, maintenance, cleaning and operation, depreciation, utilities, interest or investment and sludge disposal. Randolph Packing would lose over $13,000 annually by putting in DAF. Also, if other lower cost practices previously discussed in this report were adopted, the surcharge reduction would not be as great, further increasing the loss.

Sludge disposal was estimated at only $3,100 per year and this may be too low considering the nature of the recovered materials. Without the use of chemicals, the renderer may take the sludge. The reduction in cost of chemicals and sludge disposal would be offset by the decreased efficiency in BOD_5, TSS and FOG removal.

Summary. The research team could not recommend a DAF unit until the recommended process changes have been thoroughly evaluated and operating parameters established. The annual budget suggests that it is not economically practical for Randolph Packing Company to consider costly pretreatment options such as DAF.

CONCLUSIONS AND RECOMMENDATIONS

Management's encouragement is an important factor in making any loss prevention/waste control program successful. For the program to function, it must have top management backing and be thoroughly understood at all employee levels. Randolph Packing has demonstrated its dedication to pollution prevention through initiation of recommended programs and training. They are eager to consider the new approaches suggested in this study.

To decrease waste load in the plant, systems were designed to recover solids and blood for rendering. Implementation of all changes suggested would eliminate 60,000 lb BOD_5/yr and save about l,000,000 gallons of water. Suggestions include:

1. A collection tank for pen waste
2. A procedure for improved paunch handling
3. An education program for employees
4. A blood collection system
5. Pretreatment alternatives should be explored and consideration given to a settling basin
6. Water reduction program should be planned

An initial capital investment for the above changes is estimated at less than $10,000. Annual increased costs are estimated at approximately $10,500. Net savings for the changes are expected to be $1,500 per year. Even though $1,500 is not a large return, it proves that pollution prevention does pay.

Aggressive employee action can achieve most or all of the reductions possible for many of the waste centers. Past experience indicates that mechanical and automatic controls are also necessary to effectively reduce waste loads.

If the recommendations formulated in this report are fully implemented, the research team predicts an achievable water use reduction of 25 percent and waste load reduction totaling 80 percent. Approximately l,000,000 gallons of water would be saved per year as well as 60,000 pounds of biochemical oxygen demand (BOD_5) prevented. Expected final effluent from the plant should comply with the current interim limits established by the City of Asheboro.

Predicted waste loads and wastewater parameters would be as follows:

Parameter	Waste Load (lbs/day)	Concentration (mg/l)
BOD_5	56	610
COD	80	870
TSS	33.6	366
TkN	3.4	37
FOG	15	160
Chlorides	100	1100

The research team views these as optimistic goals. They are perhaps achievable, with the exception of TkN and FOG, but may not be economically feasible until user charges reach much higher levels than the current ones. Note that almost no reduction is shown for chlorides as current processing technology suggests no feasible alternative to salt (NaCl) curing and its attendant losses.

The numbers and dollar amounts used to detail product loss, product recovery, byproduct recovery, waste load and pollution prevented are merely estimates. This project's time and resources did not allow for the in-depth analysis needed to measure and document these statistics.

Recommendations from the project team for Randolph Packing include:

1. Training in proper water use and waste handling needs to be expanded and continued.
2. An improved blood handling system is needed to comply with the city ordinance and to reduce waste load.
3. An improved paunch handling system needs to be instituted to comply with the city ordinance and to reduce waste load.
4. A continuing record needs to be established detailing water use and wastewater characteristics.
5. These initial efforts need to be expanded to verify the assumptions and estimates generated by the research team.
6. Contact should be made with the city to suggest waste load limitations be established rather than the current concentration limits.

The benefits of this project may extend to all the North Carolina meat industry. There are approximately 400 meat plants in North Carolina processing 338,000 head of cattle and 3,622,000 head of swine with a combined processed value exceeding $500,000,000 per year.

Randolph Packing Company is presently recovering 77 percent of its potential pollution load and ‘is expecting a 10 percent additional recovery - a laudable accomplishment for any beef processing plant. Thus, the project team strongly emphasizes continuous employee training and motivation by management to perpetuate the concept that “pollution prevention pays”...both now and in the future.

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GLOSSARY

BOD - Biochemical Oxygen Demand is a bioassay test which is a semi-quantitative measure of biological decomposition of organic matter in a water sample. It is determined by measuring the oxygen required by standard laboratory conditions.

BOD_5 - A measure of BOD when the test is incubated for five days at 20°C.

COD - Chemical Oxygen Demand provides a measure of the oxygen demand equivalent of that portion of matter in a sample which is susceptible to oxidations by a strong chemical oxidant. Obtained by reacting the organic matter in the sample with oxidizing chemicals under specific conditions. COD does not necessarily correlate with BOD.

DAF - Dissolved Air Flotation.

EPA - Environmental Protection Agency. The federal agency is sometimes referred to as such, but individual states may have an EPA. Preferably use US Environmental Protection Agency when referring to the federal agency.

FOG - Abbreviation for fats, oils and grease.

LWK - Live weight killed.

MGD - Million gallons per day.

MG/L - Milligrams per liter is the accepted unit of measure for wastewater parameters. (For wastewater, mg/l = ppm).

POTW - Publically Owned Treatment Works.

TKN - Abbreviation for Total Kjeldahl Nitrogen. A standard test for nitrogen availability in organic materials. This does not differentiate between nitrogen from proteins and from other sources.

TSS - Total Suspended Solids.

USDA - United States Department of Agriculture.

APPENDIXES

LIST OF APPENDIXES

Appendix I. Water, Sewer and User Charges for City of Asheboro, NC - 1986

Water Rates	Rate ($/100 cu. ft.)
For users using more than 400 cu. ft. per month	0.85

Sewer Rates	Rate ($/100 cu. ft.)
For users using more than 400 cu. ft. per month	0.85

User Charges

Charges for monitoring (sampling and analysis):

	Cost/Analysis ($)
BOD	8.00
COD	7.00
pH and Temperature	4.00
Total Suspended Solids	3.00
Chloride	4.00
Kjeldahl Nitrogen	7.00
Oil and Grease	7.00

	Cost/Day ($)
Sampling	35.00

Excessive Pollutant Concentrations:

Parameter	Charge ($)
Excess BOD_5	0.0915
or '(whichever is higher)	
Excess COD	0.0366
Excess TkN	0.07442
Excess TSS	0.0998

Source: Sewer Use and Pretreatment Ordinance for City of Asheboro, XC. Effective January 1, 1986.

Appendix II. Notes on Costs and Budgets

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1. Maintenance - 10% of material cost
2. Interest - 9%
3. Installation labor - $20/hr
4. Plant labor - $6/hr
5. Electricity - $0.06/kwh
6. Trucking - $0.60/mile
7. Depreciation - Hoses, Nozzles, Tanks, Equipment, etc.
   Expense 7 yrs. (14.3%); Buildings 20 yrs. (5%)
8. Surcharge - $0.0915/lb BOD, $ 0,07442/1b TkN and $ 0.0998/1b TSS