THE COST OF

CLEAN WATER

Volume III

Industrial Waste Profiles
No. 7 - Leather Tanning and Finishing

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

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INDUSTRIAL WASTE PROFILE

LEATHER TANNING AND FINISHING

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

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PREFACE

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

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

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

James M. Quigley
Commissioner
Federal Water Pollution Control Administration

SCOPE

The scope of material included in this profile report conforms to the requirements of the United States Department of the Interior Federal Water Pollution Control Administration Contract Number 14-12-101. Within the available 90 day study period, engineering and economic data has been critically studied by means of a total industry approach. The relationship of the product to the alternative sub-system manufacturing processes has been reviewed in the field and office with responsible industry representatives. The cognizent professional associations and industrial experts have presented their data and viewpoint, and have reviewed our draft information. Key plant managers have cooperated in allowing limited spot checks of their plant sub-processes and waste sampling. The literature has, of course, been completely reviewed.

Because of the wide diversity of plants and processes, we have attempted to achieve a comprehensive overview of the approximate subprocesses. We have evaluated the total relationship of products produced, waste pollution load, economics involved, and long term environmental quality factors.

INDUSTRIAL WASTE PROFILE

LEATHER TANNING AND FINISHING

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4. SUMMARY OF INDUSTRIAL PROFILE SIC 3111 - LEATHER TANNING AND FINISHING

The following is a summary of the results and conclusions of a 3 month comprehensive survey of the Leather Tanning and Finishing Industry. This survey included a thorough literature search, administration and evaluation of a comprehensive industry-wide questionnaire, numerous visits and contacts with national tanning association and trade organization representatives, and visits to representative tanning plants.

Although the tanning of animal hides is an ancient industry, consisting of about 7500 tanneries in the United States 100 years ago, the number of tanneries has been decreasing rather steadily. Today the industry is concentrated into only about 250 plants. During the last 15 years, the industry has been changing. Present indications suggest an accelerated and even more dramatic change during the next 10 years. Hides delivered have remained rather constant at about 30 to 35 million per year during the last 15 years, whereas imports of footwear leather have increased about 500 percent (in dollar value). Exports have decreased more than 50 percent. This means that, while our domestic production remains quite constant (despite a doubling of the population, roughly in about 15 years), we are consuming more leather by importation. At the same time, our foreign markets for hides have diminished by at least half. Lower labor costs in foreign countries and the substitution of rubber and plastic materials for leather in our country are the major reasons given by the industry for this lack of growth. Since this study is primarily concerned with wastewater discharged by the industry, we will forego a detailed discussion of the marketing problems facing the industry. However, the wastes discharged may be closely correlated to changes in production. The industry will change its production to alter costly processes, especially those involving excessive labor. The tanning industry currently represents a $5 billion enterprise with about 27,000 workers. Each person in the United States spends about $29 per year for all leather products - including an average of 3.28 pairs of shoes. The industry uses about 18 billion gal of water annually and adds $340 million of product value to our economy each year.

When possible, industrial waste treatment methods currently employ low cost processes developed for domestic sanitary sewage. Additionally, screening and equalizing basins are used for pre-treatment.

Most industrial effluents containing waste materials similar to the constituents of domestic sewage can be effectively treated to any degree desired within the constraints of process technology and related treatment facility expenditures.

Segregation of types and concentrations of industrial wastes and recycling of process fluids can reduce total water consumed and solids generated. Pre-treatment of industrial wastes containing chemical constituents that are complex, or not readily bio-degradable, or are odorous, highly acidic, basic, or otherwise toxic may require special additional costly pre-treatment plants. Chemical-mechanical facilities involving such processes as precipitation, flotation, chelation, scrubbers, neutralization tank, and other processes can be used to produce an effluent with more acceptable bio-degradable characteristics. The conversion of wastes into a useful resource, or alternatively, the modification of the waste producing subprocess to reduce waste, is a generally desirable goal.

Cattle hides resulting from slaughterhouse activity are presently used for most of the leather tanned in the United States. About 2/3 of all the hides from this source are tanned. The remaining 1/3 are exported. About 85 percent of all leather used is made into shoes. Of this shoe leather, 80 percent by weight is used for upper shoe leather and the remaining 20 percent for sole leather. Upper shoe leather is tanned almost exclusively by chromic sulfates and alkaline salts. On the other hand, sole leather is tanned by the ancient methods using vegetable compounds such as bark extracts. Processing of sole leather is expensive and results in a highly pollutional waste. Since cheaper substitutes for sole leather are reaching our market, the trend has been towards less sole leather production. This trend is likely to continue in the future.

Historically, tanneries were located in rather remote areas of the country; today the major portion of the tanneries are located in or near large metropolitan areas such as Chicago, Milwaukee, and Los Angeles. The trend is towards even greater centralization of tanneries, and this will permit increased combined treatment of municipal sewage and tannery wastes for the future.

New tanneries are also attempting to locate as close to slaughterhouses as possible to eliminate the curing process. Where this is not possible, there is some interest in encouraging the meat packer to green flesh, wash, soak, and dehair before drying and shipping the beamed hides to the tanneries for conversion to leather. While this development has great potential from economic and pollution standpoints, its adoption as a standard practice has been slow and is fraught with many difficulties. For example, although the curing step can be eliminated, other pollutants will simply be discharged by the meat producer. In addition, the small packers may not find it economical to beam their hides and will be forced to salt and trim them prior to shipping them to a larger hide processor. Many foreign consumers of American hides do not want beamed and trimmed hides but prefer those that are raw and cured. While many of these difficulties may be overcome in the distant future, we do not foresee a rapid adoption of this practice.

Leather tanning and finishing consists of ten separate major processes (see attached Process Flow Chart) which convert animal hides to finished leather. The raw cured hides are shipped to the tannery, stored, and trimmed as the first step (1) in the conversion process. The hides are then soaked and washed (2) to remove the salt, blood, and dirt. This is normally followed by a mechanical process of green fleshing (3) to permit better chemical penetration in the following processes. Unhairing (4) improves the hide appearance and opens up the fiber structure to remove undesirable protein. The exact unhairing process utilized at any particular tannery depends primarily upon whether hair recovery is being practiced, which in turn depends upon the current or expected market for hair. In the New England area the tendency exists to burn hair removed from the hide and thus a strong solution of sodium sulfide is used. In Chicago hair is generally recovered, and a less damaging unhairing solution is used. Weaker unhairing solutions are generally less pollutional and contain fewer sulfides. The next step, lime splitting (5) is seldom used today. It consists of splitting the hide mechanically into two layers, the more valuable grain layer and a "split" composed of the flesh side layer. These series of five processes comprise what is commonly known as beamhouse operations. Bating (6), the next process, is the first process normally carried out in the tanhouse. By adding a mixture of salts and enzymes in a drum, the grain gains the 3 "s's" (silkiness, slipperiness, and smoothness). The next step (7), pickling, is normally carried on in the same drum by adding sulfuric acid and some salt to prevent precipitation of chromium salts during tanning. Degreasing (8) is another seldom-used process today. When sheeps, pigs, or goats are tanned, detergents or organic solvents must be added to the hides to eliminate grease which causes uneven dyeing and finishing. Tanning (9) is the major process converting the fibers in hides to leather. Even when wet, leather fibers will not putrefy after hundreds of years, whereas untanned hide fibers, while stable when dry, will putrefy when wet. Chrome and vegetable tanning are the major types of processes used in this step. The former type of tanning has been used for the majority of light leather, producing a more heat-and moisture-resistant leather. Although the tanning process takes longer, vegetable tanning yields more leather and produces a more workable leather. Wastes from either tanning process are highly pollutional and represent an economic loss if not recovered and reused. Therefore, wastes seldom reach a watercourse directly. Tanning represents the last process carried out in the tanhouse. The last set of wet operations is the retan-color-and fatliquor (10) processes. As a result of the advantages and disadvantages of each type of tanning, a second tanning known as chrome-retan, following a shorter initial tanhouse tanning process, ensures excellent leather. Coloring to specification and oiling or waxing to prevent cracking follow the retan operation and conclude the wet operations of a typical tannery.

The beamhouse unhairing process (4) and the tanning process (9) in the tanhouse are of major concern to sanitary engineers. Unhairing wastes are usually highly alkaline, milky-colored, sulfide-laden and contain at least 50 percent of the total tannery BOD in about 33 percent of the total volume of the waste. Tanning liquor wastes, on the other hand, represent only about 5 percent of the total plant BOD and volume, but are highly colored and contain a considerable amount of dissolved solids. Significant pollutants from a tannery include: 1) freelime; 2) high pH; 3) potentially toxic chromium; 4) high BOD: 5) high suspended solids (hair and fleshings; 6) milky color from lime or green-brown color from tanning; 7) hardness; 8) high sulfides.

In 1963 - prevalent practices - a typical tannery produced about 1000 gal of waste per 100 lb of hide processed. Pollutants measured in terms of BOD amounted to 9.0 lb per 100 lb of hide. About 700 gal and 6.5 lb of BOD came from the beamhouse while the remainder came from the tanhouse operation. Unhairing alone accounted for almost one-half the total plant volume and BOD. A typical tannery processing 1000 hides per day averaging 60 lb per skin discharged almost 600,000 gal of waste per day and about 5000 lb of BOD.

More recently (1966-1967) the changes in the industry of 1) moving to metropolitan areas, 2) increasing the ratio of upper leather to sole leather, and 3) the increase in the hair market have resulted in a reduction in wastewater volumes and loads. Surcharges imposed on tannery wastes by municipalities have made the tanneries more aware of the problems of waste treatment. The industry appears now to be increasingly water-conservation oriented. Water reuse is being practiced to reduce pollution abatement costs. Recent changes in the character of tannery wastes are somewhat lowered BOD loads, lessened volumes, fewer sulfides, and more chromium. A newer tannery operation produces about 8.5 lb of BOD per 100 lb of hides processed and uses about 900 gal of water for the same 100 lb of hide.

In many instances during field visits and discussions with industry officials, the tanning industry was found to be substantially unaware of waste problems. Increased use can be made of heavily loaded waste stream segregation, recycling of subprocess waste, reuse of rinse water for make-up and treatment of concentrated blowdown waters. Research and development in these areas plus in-plant demonstration can greatly reduce wasteload quantities.

In 1968 to 1972 the lower limits of water use are expected to be 250-300 gal per hide processed for sole use and 600 to 700 gal per hide for upper leather. If the meat processors include washing, soaking and unhairing processes during the 1977 to 1982 period, one can expect volumes to be reduced by as much as 50 percent.

In 1963, tanneries in the United States processed 1.875 billion lb of hides and discharged 16.0 billion gal of wastewater containing 150.0 million lb of BOD. If we assume that newer technologies will prevail from now until 1982, we can expect wastewater volumes to decrease from 16.0 to 14.0 billion gal per and wastewater BOD loads to decrease from 150 to 145 million lb. These assumptions are valid only if the majority of beamhouse operations are not transferred to the slaughterhouse or reduced by tannery relocation adjacent to slaughterhouses. In addition, these volume and load reductions can occur during the next 15 years only if the total annual hide deliveries remain at the constant level of about 32 million per year.

At present, tannery wastes are treated largely by screening, equalization, sedimentation, chemical coagulation, lagoons, trickling filtration, and activated sludge. BOD reductions up to 5 percent are accomplished during screening; 85-95 percent reduction may be expected for activated sludge processes. Usually the first five treatment processes listed above are carried out at the tannery while the last two are handled by the municipality when combined treatment is practiced. However, there is no accepted pattern for successful tannery waste treatment under all situations. Because tannery effluents contain pollutants which may be toxic and create nuisances as well as require proper physical, chemical, and biological treatment, each case must be decided after a detailed study of all the data and facts. It is estimated that about 75 percent of all tannery wastes are presently being discharged into municipal sewer systems; this is likely to increase to 80 percent by 1972. Waste treatment both by tanneries and by municipalities receiving tannery effluents is expected to increase in efficiency during the next 15 years.

While the gross annual BOD pollutants generated by the tannery industry are expected to decrease from 150 to 145 million lb by 1982, the net annual BOD pollutants are expected to decrease even further from 50 to 33 million lb. The greater decrease in net

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BOD is largely due to the expected increase in the percentage of waste treated and a gradual increase in treatment removal efficiencies.

The estimated replacement value of waste reduction facilities treating tannery wastes, including the cost of municipal treatment facilities attributable to this industry's wastes, is $11.6 million. Estimated annual operating and maintenance costs on the same basis is $1.6 million. At present this amounts to between 1 and 1.5 percent of production costs and does not appear to be significantly restricting to the industry. If, however, waste treatment costs increase significantly, some marginal profit plants may be critically affected.

INDUSTRIAL WASTE PROFILE STUDIES
TANNERY INDUSTRY

SIC 3111, TANNERIES

INTRODUCTION

In 1865 there were about 7500 tanneries. At the turn of the century (1900) there were approximately 1000 tanneries in the United States. In 1952 there were 443 tanneries in the United States - approximately 60 percent located in the Northeast. In recent years (1965) this number has been reduced to about 250 - mostly larger ones, as reported by the Tanner's Council of America.

In 1952 it was reported by one source (Harnly) that the tanneries in the United States generated about 20 billion gal of waste yearly; however, the census of manufacturers reported that in 1963 (about ten years later) only 14 billion gal were discharged from 81 tanneries. We estimate 16 billion gal were discharged in 1963 by the industry. The majority of the tanning plants (50-60 percent of all tanning activity) are located in Chicago, Milwaukee, the Northeast and Los Angeles area. The trend toward centralization is continuing. There are, however, plants scattered throughout the United States.

Currently the tannery industry represents a $5 billion enterprise with about 27,000 (1966) production workers. Per capita expenditures for leather footwear are over $20 per year and for other leather products slightly over $9 per year. In addition, hide and skin exports have been increasing to $155 million in 1966.

The industry appears to be changing in the United States. More hides are being exported to countries which can produce leather at a lower cost. This is primarily due to inexpensive labor in many foreign countries and international tariff policies. The United States exports very little tanned leather. Therefore, tanneries depend on domestic leather goods manufacturers for a market. This has forced a number of small U. S. tanneries out of business. In addition, substitution of other materials, such as plastics for leather, has cut into the United States leather tanners' market to some degree. The ability of United States tanners to meet foreign competition and the advent of leather substitutes depends on economic factors and American ingenuity.

Five types of animal skins are in general use today in addition to largely imported rare skins such as alligator, crocodile, seal, etc: (1) Cattle: for shoe upper leather, shoe sole leather, patent leather, upholstery leather, harness and miscellaneous items; (2) Sheep: for shoe linings, gloves and some garments; (3) Goat and Kid: for shoe upper leather, gloves, and leather linings for shoes; (4) Pig : for fine leather in gloves, shoes, pocketbooks, luggage and upholstery; and (5) Horsehide: for aprons, gloves, garments, and cordovan shoes.

Most American horses are used for pets and recreation and disposed of following normal old age without being skinned for leather.

The Tanners Council of America reported for 1966 that the total skins tanned were:

Calf	- 4.72 million	
Cattle	-23.83 million	
Goat and Kid	-13.37 million	Imported
Sheep	-29.42 million	Imported
Horse	- 0.28 million	Imported

Cattle hides are now used for most of the leather tanned in the United States. Of the estimated 34 million cattle butchered annually in the United States, nearly 25 million skins are tanned. The remainder is exported to foreign markets, principally Japan. About 85 percent of all leather used is made into shoes, with the balance employed for baggage, saddles, clothing, upholstery and accessories. The upper leather consumes some 80 percent of the total by weight used in shoes, with the remaining 20 percent manufactured into the soles.

Production practices vary in the various tanning centers. For example, in the New England area, because it is customary to burn or pulp hair removed from the hide, a strong unhairing chemical solution (more sulfides) is used. In the Chicago and Milwaukee regions, where hair is generally recovered, a less polluting unhairing agent containing fewer sulfides, and more dimethylamine sulfate, is used. It naturally follows that the resulting wastes will be different in character and pollutional loads.

The Tanners Council of America also reported that in 1962 the total shoe production was more than 600 million pairs. The leather industry furnished sole material for about 28 percent of this production. The upper sole, insole and lining business represents about 85 percent of the total leather production.

Washing, fleshing, and unhairing are responsible for over 50 percent of the total volume and up to about 70 percent of total pollution load. Tanning is responsible for about 5 to 20 percent of the volume and pollution. Vegetable tanners (approximately 20 percent of the industry) can fortify and reuse tanning liquor. This is not generally practical for the remaining 80 percent who are chrome tanners, although it was done during World War II.

TABLE 1
DELIVERED EQUIVALENT HIDES[1]

Year	Total U.S. Hides
1951	33,291,000
1963	31,256,000
1966	32,158,000

TABLE 2
U.S. FOREIGN LEATHER TRADE

	Leather Footwear		All Leather	
Year	Imports ($)	Exports ($)	Imports ($)	Exports ($)
1951	24,647,000	19,063,000	--	--
1963	80,687,000	8,628,000	143,000,000	17,084,000
1966	128,255,000	8,856,000	243,365,000	24,539,000

These tables show that the United States delivered hides that remained relatively constant from 1951 to 1966. On the other hand, imports of leather footwear have increased about 500 percent in dollar value during the same period, while exports have decreased more than 50 percent.

1. Equivalent hides means in terms of cattle hides. Statistical sources will indicate a far higher number of total hides,but these include sheep, goat, etc.

INDUSTRIAL WASTE PROFILE STUDIES
TANNERY INDUSTRY

SIC 3111, TANNERIES

I. PROCESSES AND WASTES

A. Fundamental Processes

1. Storage and Trimming
2. Washing and Soaking
3. Green Fleshing
4. Liming and Unhairing
5. Lime Splitting or Chrome Splitting after tanning
6. Bating
7. Pickling
8. Degreasing
9. Tanning
10. Finishing, including retan, color and fat liquor.

Ten separate physiochemical or biological processes are generally utilized to convert animal (primarily cattle) hides into leather. According to the Tanners Council of America, the leather industry is actually many separate industries since "each type of leather constitutes a different process with little standardization".

There are several chemical tanning methods and chemicals (tannages) in general use. The two major methods are: Chrome tan for shoe upper leather; Vegetable Tan (infusion of barks, wood, nuts and leaves) for shoe sole leather, belting and saddlery. Other minor methods include: Formaldehyde for some leathers; Zirconium salts; certain synthetic and resin tans, oil tan, and alum.

1. Storage and Trimming: Much of the industry still cures skins by partial dehydration. The skins are treated with salt or dried in air to prevent bacterial degradation before they can be properly stored. As soon as the hide is removed from the carcass, it is covered on both sides with a layer of salt and stored in layers with the flesh side up until a "pack" is obtained. A pack is approximately 3200 cu ft of skin (usually 20 ft x 40 ft x 4 ft deep). The pack is arranged so that any brine solution will drain away from the pack along with dissolved blood or organic matter. The pack is usually cured for at least three weeks during which time the hide loses part of its moisture and absorbs some salt. Net weight loss will be about 20 percent with a resultant cured moisture content of about 40 percent. Air drying (usually kid,goat, or sheep skins) produces a lower moisture content hide but risks bacterial decomposition and possible skin damage. Slow and improper drying encourages damage from bacterial growth. Rapid drying may also cause biological degradation as a result of incomplete interior

moisture removal. There is also substantial use of brine baths instead of salt packs. This generally produces slightly more NaCl in the waste. Sheepskins may be de-wooled immediately after slaughtering and pickled with acid and salt before shipping to the tannery. Curing is not necessary with sheepskins treated (pickled) in this manner.

No great quantities of wastes occur in the curing because of bath reuse. However, an understanding of the process is necessary because subsequent wastes are affected by the method of curing. Bactericides, such as sodium hypochlorite and sodium pentachlorphenate, are used to sterilize and to prevent or arrest decomposition.

Hides are trimmed by almost every marketing agency in the hide and leather industry. In the packinghouse, dewclaws, pizzles, ears, snouts, pates and tails are trimmed from hides. On entering a typical hide cellar for curing, each hide is given a second trim which removes 3 to 6 percent. At the tannery, hides are unbundled and each is given a third trim which removes another 2 to 3 percent of the original hide. Throughout the tanning process, fringe areas are trimmed from hides. At the final grade-sort, the leather is given a fourth trim -- generally in the pocket and head areas. The net result of all trimming during processing amounts to about 20 percent of the original hide. (The U. S. Department of Agriculture hide trim is a one-time trim; however, it is not commonly used.) The trim facilitates segmented marketing practices (product differentiation), improves quality, and reduces processing costs at all levels. The basic trim removes the heads, bellies, and shanks.

Currently there is a strong impetus to beam (remove hair) and flesh hides at the source of supply to produce a more uniform semi-processed raw product. Also, since semi-processed hides weigh less than cured hides, freight costs are reduced. Although it has not been definitely proved, some tanners believe that better leather can be produced from hides that are semi-processed fresh than from those that have been salt-cured. In 1965 there are two firms doing this, and several more were anticipated in the foreseeable future.

2. Washing and Soaking: Washing and Soaking removes the dirt, salts, blood, manure, and non-fibrous proteins and restores the moisture lost during curing. Although there is no standard procedure for washing and soaking, a common method is to float a lot (about 3000 lb) of whole hides in twice its weight of water and drum wash for about one half hour. Following this, the hides are cut into sides and green-fleshed and soaked for about one to five hours with three times their weight of water in paddles used for both soaking and liming. If a preliminary rinse is used before soaking, part of the salt (70 percent NaCl) could be removed.

3. Green Fleshing: Green or Lime Fleshing removes the areolar tissues from the flesh side of hides or skins. Attached fat, connective tissue, blood vessels, nerves, voluntary muscle, and unremoved meat left as a result of poor flaying are also removed. The process is carried out on a fleshing machine

consisting of two long rolls -- one of corrugated metal and the other of rubber. These grip the skin with a pressure triggered by a foot lever and draw the flesh side across a revolving cylinder set with spiral blades. The fleshings are saved and usually sold to plants for rendering or conversion to glue. Fleshing -- done either before or after soaking -- allows easier and more effective penetration of chemicals used in the tannery.

The other common method of fleshing is called lime fleshing and is done in conjunction with the unhairing process (described below) when the hair is not recovered.

4. Liming and Unhairing: Unhairing of hides is necessary so that the leather will have an attractive appearance when it is finished. It also aids in opening up the fiber structure to remove unwanted protein. Hair may be removed by loosening followed by machine or manual pulling, or by complete destruction (pulping), or dissolution (burning off). Hair is usually recovered following loosening and mechanical pulling and sold. Lime has been in use since leather tanning began for hair loosening and alkaline swelling. A series of pits or paddle vats is used. Packs of hides are usually tied together and reeled mechanically from pit to pit in sole leather tanning. For side leather, paddles are used. Actual rinsing is carried out in the first pit and various lime concentrations are used in succeeding pits to suit the operator in charge of unhairing. As mentioned previously, when the hair is to be destroyed the fleshing step is often also accomplished by the strong lime solution. The whole cycle usually requires about one week. Sodium sulfide and sodium sulfhydrate are the most important and most widely used depilatory agents in the industry today. Typical unhairing chemicals include about 0.1 - 3.0 percent Na_2S and 4 - 12 percent lime on a hide weight basis. The strength depends on whether hair saving or hair pulping is desired. Water to hide ratios of two to one to four to one are generally used. Dimethylamine sulfate is becoming more widely used because it promotes more complete unhairing and liming within practical time limits. Few tanners now use the painting process for hair removal; Na_2S and lime paste were padded onto the flesh side of the hide, thus loosening the hair from the roots up. The hair was subsequently removed by hand scraping or mechanically. Liming gives the additional benefit of altering protein structure in the hide to prepare it for later tanning.

5. Lime Splitting: Lime Splitting is a mechanical process usually not involving any liquid waste. The unhaired hide is slit through the middle of its thickness to produce two distinct layers; the upper is the flesh side and is called a "split". Some of the tanneries process only the grain layer and sell or discard the "splits". Of prime importance in lime splitting is the conditioning (slipperiness and plumpness) that enables the hide to be fed to the machine smoothly in order to split off the grain layer to the

desired uniform thickness across the full length and width of the hide.

6. Bating: Bating prepares the swollen and alkaline hide for tanning. It must delime to reduce the pH, reduce the swelling (falling), and remove the protein decomposition products. Bating is generally accomplished with ammonium salts and a mixture of commercially prepared enzymes. Bating renders the grain silky, slippery, smoother, more porous, and reduces the wrinkles. The changes have been obtained through both deliming and enzyme action on the hide's proteins. Bating may be done in drums or paddles. Usually the hides are washed with room temperature water for about one half hour and once again with 85^{o} - 90^{o}F water for another half hour before the bate is added. The hides are bated for one half to five hours with about 1 to 2 percent OWH chemicals. The bate digests parts of the epidermal matter, loosens it, and allows its removal with the attached "scud" (hair roots). The cleansing action as well as the alteration of the proteins by the enzymes accounts for the results of bating.

7. Pickling: Pickling makes the skin acid enough to prevent precipitation of insoluble chromium salts on the skin fibers during mineral tanning. It is not generally used in vegetable tanning. Pickling can be used as a means of preserving the hides during storage prior to tanning. Pickling takes place at room temperature for various lengths of time up to twelve hours. Typical pickling chemicals are 1 to 2 percent H_2SO_4 and 7 to 10 percent NaCl. Variations in process usually involve different equipment or lengths of pickling time. Pickling can be done in drums or paddles. The duration depends on whether a short pickle or equilibrium conditions are desired. Most tanneries utilize the drum pickle today. In all processes, salt is added first to prevent acid swelling.

8. Degreasing: Degreasing is done to eliminate fatty spues, uneven dyeing and finishing, and greasy areas to allow more even penetration and action of tanning liquors, fatliquors, and dyes. It may be done by three different procedures: (1) Emulsification with an aqueous solution of a synthetic detergent*, (2) use of an organic solvent for extraction**, and (3) squeezing out the skin greases by pressure and mechanical action***. Solvent extraction with kerosene or Stoddard solvent is widely used. Usually about 50 gal of kerosene per 1000 lb of pickled hide along with some salt brine and a penetrating agent are heated to 85^{o}F with steam or hot water for about three hours. Excess solvent and brine are usually drained and recovered for reuse since both economics and pollution abatement dictate this procedure. The kerosene, as well as the grease, may be readily recovered by steam distillation in recovery stills. In some mills the brine is also recovered from the kerosene by gravity separation and reused. Degreasing is seldom used today except in certain tanneries which convert primarily sheep, goat and pig skins.

* Shoe side upper leather

** Pickled Skins

*** Sheepskin

9. Tanning: Tanning is the process of converting the fibers in hides to leather. Leather fibers will not putrefy when in the wet state after thousands of years, whereas hide fibers, while stable in the dry state, will putrefy in the moist condition. Although there are five tanning agents, only two types of tanning are common in our country, vegetable and chrome. In the United States the ancient method of vegetable tan with quebracho, wattle, chestnut and eucalyptus extract provide the source of tannin used; however, some amounts of mangrove, myrobalans, valonia, spruce, oak bark, hemlock bark, gambier, and sumac are used in much smaller volumes.

Hides are tanned by immersion in tan solutions which increase in concentration from 0.3 percent to 6 percent tannin. The preliminary tan, taking about three weeks, is usually done in rocker vats in which the frame for holding the leather is equipped with a rocking device to prevent the hides from touching one another, thus preventing "kiss" spots. The leather is then thrown into layer vats where it remains for another three weeks in 6 percent tannin. Some more recent tanning processes use a higher concentration of tannins (12 percent) for shorter periods by putting the hides in drums during twelve hour periods. Following the completion of the four to six week tanning operation, the hides are removed, covered to prevent oxidation and drying, and allowed to stand for 48 hours, then washed for removal of excess tannin, and processed. In general, because of the high cost of the tan solution, reuse and recovery is practiced in all vegetable tanneries. The tan liquors discharged are low in volume and high in pollution load.

One of the most important of the newer synthetically produced compounds (syntans) is a complex of phenolsulfonic acid and formaldehyde. These are widely used for the production of white leather and have especially good tannin penetrating qualities.

Chrome tanning has been used since the turn of the century for tanning the majority of light leathers. Its major advantage is that it shortens the tanning time to less than one day; moreover, it produces a leather with more resistance to heat and abrasion. Older chrome tanning processes used a two bath method. The hide was first impregnated with $Na_2Cr_2O_7$ and acid in one bath followed by immersion in a second bath containing $Na_2S_2O_3$ and acid. Today, the bulk of chrome tanning is done by the one bath method using proprietary mixtures of basic chromium sulphate. The tanning achieved is the result of the action of the trivalent (Cr^{+3}) form of chromium on the skin protein. Although variable, from 3 to 7 percent based on the weight of leather, Cr_2O_3 is generally combined with the hide substance.

Since vegetable tanning generally produces leathers which are fuller, plumper and more easily tooled and embossed, leather tanned by the chrome method is sometimes given a subsequent tan in vegetable tannin. This is called retanning.

10. Finishing: Finishing converts, through many wet and dry processes, the tanned leather to the final end product used in the industry. The wet processes which are of concern in water pollution are bleaching, stuffing, and fatliquoring, and dyeing and coloring. Bleaching is designed to give the leather a lighter and more uniform color before it is fatliquored.

Stuffing and fatliquoring involve adding many types of oils and greases to the tanned hides to prevent cracking and to make the leather soft, pliable, strong, and resistant to tearing. The amount of oil or wax used varies with product specifications from 2 to 3 percent in sole leather to 30 percent in waxed leather for waterproof shoes. Stuffing describes the direct application of oils and greases either by hand or by drumming the molten greases. Fatliquoring is used when small, uniformly distributed amounts are desired, by applying the oil in the form of an emulsion (0.5 to 8 percent). Chrome leather is usually fatliquored at 110^{o} - 140^{o}F for 1/2 to 1 hour, while vegetable tanned leather is usually drummed at about 120^{o}F.

Coloring or dyeing of tanned leather may be done either before or after fatliquoring and uses both the older (natural) and the newer (artificial) dyestuffs. The dye solution is dumped at the end of a run or when it is exhausted.

B. Significant Pollutants

Significant pollutants from tanneries include:

- Free lime and sulfides
- High pH
- Potentially toxic chromium
- High BOD
- High suspended solids (primarily hair, greases, and proteinaceous fiber)
- Milky color from lime, green-brown or blue color from tanning, and varied colors from dyeing.
- Hardness
- High mineralization (TDS)

C. Process Water Reuse - 1964

Little tannery plant water is reused today. Instead, the trend is toward conservation of water by other means. In 1964, we estimate that approximately 10 percent of process water was reused by the industry as a whole, which, by definition, means that 90 percent of the water intake was used only once and then discharged.

It appears that water reuse is an area of pollution reduction that has been sadly neglected in the average tannery. Use of countercurrent washing techniques, clean-up and reuse of process waters, wash sprays instead of baths, automatic controls on process water, dry waste disposal instead of water carriage, and other methods could be used to reduce the quantity of process water required. It is not within the scope of this report to make a specific study of the application of water conservation techniques, but this is an important area for future study.

D. Subprocess Trends

As previously indicated in the description of fundamental manufacturing processes, there are often alternate methods to accomplish a particular operation in the leather-making process. Which method is used depends upon such factors as kind and volume of hides being processed, type and size of process machinery available, skill of available operating personnel, end product use of the leather, and other factors. We have purposely left out the factor of wasteload produced because this does not seem to strongly influence subprocesses selection. The plant manager is interested in increasing his production efficiency and product quality, and any decrease in wasteload produced by selection of an alternate subprocess is merely a bonus. Currently this aspect is receiving more attention by tanners.

Table I-1, which projects subprocess trends in the tanning industry, is the result of information received from operating plants, tanning industry consultants, machinery manufacturers, chemical manufacturers, and a thorough survey of existing literature on the subject. It is intended to show the direction the industry is going in 1967 on the basis of the techniques now available. It is probable that scientific advances will make some of the processes shown obsolete within the next 10 years.

TABLE I-1
SUBPROCESS TRENDS

Production Process and Significant Subprocesses	Estimated Percentage of Plants Employing Process in: 1950	1963	1967	1972	1982
Storage & Trimming of Cured Hides					
Air drying	10	0	0	0	0
Salting	70	60	50	40	40
Salt & Air Drying	20	20	20	20	20
Brine Curing	0	30	80	85	90
Washing & Soaking	100	100	100	100	100
Soak or Green Fleshing	70	90	90	80	40
Lime Fleshing	30	10	10	20	60
Re-Soaking	-	-	-	-	-
Hair Saving	60	45	45	45	45
Hair Pulping	40	55	55	55	55
Bating & Pickling	100	100	100	100	100
Tanning					
Vegetable	30	20	20	20	20
Chrome	70	80	80	80	80
Synthetic or Resin	-	-	-	-	-
Retanning					
Vegetable	70	75	70	60	45
Mineral	5	5	5	5	5
Syntan & Resin	15	20	25	35	50
No Retan	10	0	0	0	0
Coloring	80	90	90	90	90
Bleaching (Hypo, oxalic + syntans)	45	35	35	35	35
Fatliquoring	80	90	90	90	90
Stuffing (Hot Drum Method)	20	10	10	10	10
Filling & Pigmenting in the Drum	70	80	85	85	95

Analysis of Table I-1 shows the industry in general is changing very slowly in terms of basic subprocesses used. As brought out later in this report, however, certain reductions in wastewater quantity and pollution load per product unit have been achieved by use of modern machinery, new chemicals, better housekeeping, and superior hide removal techniques in the slaughterhouse. It is an inescapable fact, however, that to produce leather from a raw hide, the tannery must remove most of the organic matter. Therefore, the amount of organic pollution produced is largely a matter of the number of hides processed. Organic by-product reclamation may be a future subprocess.

E. Waste Control Problems

The two most difficult waste problems in the tanning industry originate with unhairing and tanning. Unhairing wastes are usually highly alkaline, milky colored, sulfide laden and contain at least 50 percent of the total tannery BOD of a highly proteinaceous nature in about 33 percent of the total volume of waste.

Tanning liquor wastes, on the other hand, represent only about 5 percent of the total plant BOD and volume, but are highly colored and contain a relatively high concentration of dissolved organic solids, if vegetable tanned, and dissolved inorganic solids, if chrome tanned. In addition, if chrome tan is used, the waste contains a high concentration of chromium which represents potential toxicity to any biological life it contacts. Housekeeping to reduce odors within plants has been a major problem. Ozone and odor masking chemicals have been used to control the problem. This problem is expected to decrease in the future as better housekeeping is practiced.

The tanning industry needs water metering and more chemical balances to effect better quality control. The skin normally contains about 70 percent water. Thirty percent loss in weight occurs as a result of defleshing and curing. Another 30 percent is lost in the tanning operation.

As mentioned earlier, if hair recovery is practiced, the unhairing process generally includes the addition of dimethylamine sulfate to reduce the sodium sulfide concentration. This will lessen the following problems:

Objectionable odors caused by sulfides in receiving waters and in the surrouding air environment.

Toxicity of sulfides to micro-organisms during biological waste treatment.

Waste resulting from hair pulping contains considerable lime, sodium sulfide, and high dissolved proteins. Lime and untrapped hair which find their way into the sewer make an excellent plaster material which often leads to clogging of sewer lines. The market price of hair is one of the major factors in determining whether it will be pulped or recovered. In the past (20-30 years ago) hair sold for $.20 per lb and labor to recover it was relatively inexpensive. The price of hair dipped to $.04 per lb but it has recently recovered to about $.16 per lb. However, labor costs have soared, thus making hair recovery expensive. Approximately 60 percent of tanneries pulp hair and about 40 percent recover it today. If the price of hair goes higher than $.16 per lb more hair recovery will be done.

The inducements towards hair pulping are:

No fine hair carry over.

Single drum or paddle operation requires minimum manhours.

The detractions of pulping are:

High solids and BOD surge - some local governments will not permit this practice.

It is a more astringent process and can lower square footage yields of leather.

Increased cost and difficulty of waste treatment

F. Subprocess Technologies

Changes in the subprocess technologies of tanneries have been slow due to the slow growth of the industry, the fundamental nature of the raw material and end product, and lack of research and development expenditures by the tanning industry or the machinery manufacturers which supply it. In the following Table I-2, typical subprocesses are shown for older technology (1950), prevalent technology (1963), and newer technology (1967).

TABLE I-2 SUBPROCESS TECHNOLOGIES

Technology Level

Older 1950	Prevalent 1963	Newer 1967
Salting of Hides	Salting of Hides and Brined Hides	Brine Cured Hides or Salted Hides
Wash and Overnight Soak	Wash and Short Soak	Wash and Short Soak
Green Fleshing	Green Fleshing	Green Fleshing
Unhair Na_2S + $Ca(OH)_2$	Unhair Na_2S + $Ca(OH)_2$,	Unhair $[(CH_3)_2\ NH]_2 \cdot H_2SO_4$ Some NaSH + Na_2CO_3
Lime Fleshing	-	-
Lime Splitting	-	Little Lime Splitting
Paddle or Drum Bating	Paddle or Drum Bating	Drum Bating or Paddle Bating
Paddle or Drum Pickling	Drum Pickle	Drum Pickle
Chrome Tan in Drums or Paddles or	Basic Chromic Sulfate Tan in Drum Machine	Basic Chromic Sulfate Tan in Drum Machine
Rocker Veg.Tan + Layer Veg. Tan	-	-
Chrome Splitting	-	Mostly Chrome splitting
Retan, Color Fatliquor	Retan, Color, Fatliquor	Retan, Color, Fatliquor

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As can be seen from the table, the principal changes in the industry are a trend toward brine cured hides instead of salt cured; a short soak after wash instead of overnight; slight modifications in the unhairing chemicals used; increasing use of drum machines instead of paddle machines in the bating, pickling and tanning operations; and use of chrome splitting instead of lime splitting.

4. Plant Classification: Only 20 percent of today's tanneries were built during the last 20 years. During this time many tanneries also went out of business, mostly the smaller ones. As a result, the industry today can be classified as older in terms of plant age, prevalent (1963) in terms of technology level and tending toward fewer and larger plants. Technology level and plant age do not coincide due to modernization programs.

Our estimate of the percentage of plants falling into the three previously described technological levels is as follows:

	Technology	
	Older	Prevalent & Newer
Percentage of Plants	20	80

The ranges of plant sizes connected with these three technology levels are estimated as follows:

	Technology	
	Older	Prevalent & Newer
Plant Size (hides per day)	Less than 300	Over 300

There is so little difference between the prevalent and newer technologies in the tanning industry that we have simply lumped together newer and prevalent in the foregoing estimates.

The relative proportion of small, medium, and large size plants (as the industry regards plant size) included in each technology level is estimated as follows:

Plant Size	Hides No/day	Percent Plants of This Size	Percent of Plants This Size in Technology Level	
			Older	Newer & Prevalent
Small	300	10	55	45
Medium	300-800	50	30	70
Large	800	40	5	95

We expect that there will be fewer and larger plants in the future. There is a trend in the industry to construct new plants near the source of hides; i.e., the slaughterhouse. There is also some indication that in the future, the beam house operations such as washing, soaking, green fleshing and unhairing may be performed in the slaughterhouse and a semi-processed hide sent to the tannery. If this should occur on a large scale, pollution generated by tanneries would be reduced greatly, and the slaughterhouse pollution production would increase proportionately.

II. GROSS WASTE QUANTITIES

A. Daily Waste Load Quantities

In order to provide a basis for subprocess selection on the basis of pollution reduction, Table II-1 has been prepared. In this table the average BOD (organic pollution), average SS (suspended solids pollution), and average TDS (dissolved chemical pollution) generated by each of the subprocesses is estimated. The subprocesses are further classified by the technology level in which they belong.

TABLE II-1
DAILY WASTE QUANTITIES

Subprocesses of Older Technologies		Approx. % of Hides Treated	Wasteload lb/day For Average Size Plant Processing 500 Hides/Day BOD	SS	TDS	Waste Water Volume (mgd)
Long Wash & Soak		100	450	1,500	3,900	0.105
Unhair	[Save Hair	50	800	2,200	2,000	0.06
	[Pulp Hair	50	1,050	3,200	3,500	0.06
Paddle Bating		100	250	50	500	0.04
Paddle Pickling		100	-	-	500	0.02
Tanning	[Veg.	20	50	50	250	0.005
	[Chrome	80	100	150	650	0.015
Finishing		100	50	50	100	0.015
TOTAL			2,750	7,200	11,400	0.315
Subprocesses of Prevalent and Newer Technology						
Wash & Short Soak		100	350	1,300	3,000	0.095
Unhair	[Save Hair	40	700	1,750	1,750	0.045
	[Pulp Hair	60	1,200	3,350	4,000	0.065
Drum Bating		100	200	50	400	0.03
Drum Pickling		100	-	-	400	0.015
Tanning	[Veg.	20	50	50	250	0.005
	[Chrome	80	100	150	650	0.015
Finishing		100	50	50	100	0.015
TOTAL			2,650	6,200	10,550	0.285

Hides assumed to average 60 lb each.

Table II-1 was derived from information feedback from operating industry, tanning consultants, chemical manufacturers, equipment manufacturers, and a thorough review of the literature. The tabulated data shown are averages for the industry. Individual plants may show rather wide variations because of differences in raw hide quality, end leather product, accuracy of testing procedures and metering, process control, skill of operating personnel, percentage of plant capacity being utilized, and many other factors.

The important generalizations are that the tanning industry has not made great improvement in reducing pollution produced per unit of hide processed; modern tanning machinery is not designed with wasteload reduction in mind; and no real breakthroughs are in sight. It is difficult to reduce the pollution produced by tanneries because essentially, the basic process consists of removing organic matter from hides. Volumes can be reduced substantially by conservation of water.

Some specific discussion on subprocesses follows for the interested reader:

There are 4 major subprocesses which contribute large volumes of waste and/or BOD to the total treatment picture. These are soak, unhair, bate, and tan. Alternate subprocesses for bating are currently non-existent. Recently, however, bating in drums rather than in paddle wheels has been increasing. It results in a nearly continuous process which has much the same quantity of contaminants in less wastewater than the batch-type paddle process. Similarly, the one alternate subprocess for soaking results in very little change in overall waste character or quantity. Unhairing and tanning, on the other hand, can be carried out be several alternate subprocesses, each of which affects the quantity and character of waste. In unhairing, substituting caustic soda for lime will result in a more alkaline and less milky wastewater with a somewhat higher BOD because of its greater causticizing ability. Unhairing time can also be reduced by this substitution. The relatively new method of unhairing with dimethyl-aminesulfate and lime results in a less alkaline, lower BOD waste containing little or no sulfide ion. DMAS,in conjunction with a lowered percent of lime plus sodium carbonate, promotes fast and efficient action. The addition of NaSH effects a very acceptable system which is currently in active practice. From a waste treatment standpoint, the replacement of tne sodium sulfide eliminates the problems associated with the sulfide ion and the high pH. Because of the process contact time and/or concentration of $(CH_3)_3 \cdot NH:SO_4$ used, the resultant BOD is somewhat less than that of the conventional lime-Na_4S unhairing subprocess. Another alternate subprocess uses Na OH and/or NH_4OH to replace both lime and Na_2S when hair recovery is practiced. Since its current use is experimental, it is only considered as a potential subprocess to eliminate both the sulfide and lime sludge problems associated with waste treatment.

The other major subprocess where substitution would slightly affect waste quantity and character is in the tanning process. Although the BOD of vegetable tan wastes is about 5 times as high (25,000:5,000 ppm), the volume of waste normally discharged is only about 1/125 of the chrome tan. Chrome tan BOD load, then, will be approximately 25 times as great as that from vegetable tanning, primarily because of the greater reuse of vegetable tans and the apparent inability to recover and reuse chromium from chrome tan wastes.

In any event, when hides are tanned with chrome rather than vegetable process, high BOD loads with potentially toxic concentrations of chromium will result. Unfortunately, the trend is toward more chrome tanning and less vegetable tanning since the percentage of sole leather in shoes is decreasing. Some tanneries, however, have been renewing the chrome tan solution with more concentrated chromic sulfate rather than discharging it as waste. It is claimed that this enables the chromium solutions to be reused as many as 15 times without detrimental effects.

B. Wasteload Production Rates

A summary of previously developed data gives the following wasteload generation per lb of leather processed.

Technology	BOD / lb	SS / lb	TDS / lb	Volume / gal
Older	.0916	.260	.380	10.5
Prevalent-Newer	.0883	.250	.350	9.5

C. Total Wasteload Produced

It is estimated on the basis of data previously developed that the tannery industry generated the following wasteload in 1963.

Wastewater Volume	..... 16 billion gal
BOD	.....150 million lb
SS	.....425 million lb
TDS	.....650 million lb

D. Gross Wasteload Projections

Future gross wasteloads are projected on the basis of projected growth of the industry, anticipated improvement in technology, and other factors detailed at the bottom of Table II-2.

TABLE II-2
GROSS WASTELOAD PROJECTIONS

Year	Volume Billion Gal	BOD Million lb	SS Million lb	TDS Million lb
1963	16	150	425	650
1967	16.2	160	440	670
1968	16.2	160	440	670
1969	16.2	160	440	670
1970	16.1	155	430	660
1971	16.0	155	430	650
1972	16.0	155	430	650
1977	15	150	420	640
1982	14	145	410	630

The above predictions are based on the assumptions that:

The trend toward hair pulping will continue.

There will be a very slow transfer of beamhouse operations to the slaughterhouse.

There will be some increase in water reuse and waste segregation.

The value added in manufacturing projections by F.W.P.C.A. are accurate.

E. Seasonal Variations

Based on industry information available, there is no significant seasonal variation in hides tanned. In the winter and spring, however, the hides processed tend to be dirtier and have more hair and fat. This increases slightly the pollution load per hide processed.

III. WASTE REDUCTION PRACTICES

A. Processing Practices

As indicated in Section II, it is possible to reduce the pollution generated in a tannery by using alternate subprocess techniques. Table III-1 outlines the relative pollution reduction potentials of the various alternate subprocesses. The subprocess method generating the most pollution is used as a basis of comparison. The values shown are generally the highest reported reductions for a particular alternate subprocess.

In general, the pollution reduction achieved by alternate subprocesses currently in use is not significant. There has been a reduction in the water volume required to process leather, but this generally results in simply the same quantity of pollution in a lower volume of water. Substitution of different chemicals in the unhairing process has achieved some slight decreases in pollution, but the significant pollution factor in this process is whether the hair is saved or pulped.

TABLE III-1

PROCESS POLLUTION REDUCTION

Fundamental Process and Alternate Subprocess	Alternate Subprocess Pollution Reduction Efficiency %				Remarks
	Vol	BOD	SS	TDS	
Wash & Soak					
Long (overnight soak)	0	0	0	0	Most plants report no difference in pollution generated.
Short (short soak)	15	17	15	15	
Unhair					
Pulp hair	0	0	0	0	Which process used depends upon demand for hair.
Save hair	0	25	30	30	
Bating					
Paddle machine	0	0	0	0	Most plants report no difference in pollution generated.
Drum machine	20	10	10	10	
Pickling					
Paddle machine	0	0	0	0	No significant pollution generated.
Drum machine	10	0	0	10	
Tanning					
Chrome	0	0	0	0	Not really alternate methods since they produce a different kind of leather.
Vegetable	90	75	50	80	
Finishing					
A tremendous variety of methods used. Pollution from finishing generally not significant.					

Note: Pollution reduction efficiencies shown are generally the highest reported.

The sequence in which the operations must be applied is not subject to much change. This is particularly true of the processes producing most of the pollution, specifically the washing and soaking, unhairing, bating and tanning. The main trend has been toward continuous rather than batch operations. The higher cost of the continuous machinery is compensated for by a decrease in labor and space requirements.

B. Treatment Practices

1. Removal Efficiencies

The following Table III-2 shows average pollutant reduction percentages for various waste treatment processes currently in use. There are many methods available for treatment of tannery wastes. The best method, or combination of methods, for waste treatment differs from plant to plant. Each situation must be evaluated individually on the basis of such factors as wastewater volume and strength, discharge limitations imposed by regulating agencies, plant location, whether the waste is combined with municipal domestic sewage, land area available, chemical costs, degree of pollution reduction desired, and other variables. Flotation and skimming treatment appears to be a feasible future reuse and waste facility development.

TABLE III-2
TREATMENT REMOVAL EFFICIENCIES

ITEM	NORMAL POLLUTANT REDUCTION EFFICIENCY (PERCENT) BOD	SS	COLOR	CHROMIUM	SULFIDE
In Plant Treatment					
Screening	5	5-10	0	0	0
Equalization in holding basins	0	0	0	5-10	0
Sedimentation	25-62	69-96	5-10	5-30	5-20
Chemical Coagulation	41-70	70-97	6-90	50-80 Est.	14-50 Est.
Lagoons	70	80	25 Est.	10-20	0
Trickling Filtration	65-80	85-90	15-70	25-75 Est.	75-100
Activated Sludge	85-95	80-95	75 Est.	75 Est.	75-100
Sludge treatment by: Lagoons, Digestion, Vacuum Filtration, Incineration					
Municipal Treatment					
Primary	20-54	14-75	20 Est.	10-15	10-15
Primary & Trickling Filtration	85-95	80-95	25-75 Est.	25-75 Est.	75-100
Primary & Activated Sludge	75-95	77-95	75 Est.	75 Est.	75-100
Primary & Chem. Coagulation (lime)	50-90	73-96	90 Est.	50-90 Est.	75-100 Est.

Some examples of treatments used and efficiencies obtained include:

Flocculation, Double Settling and Equalization
Evaporation of Tan Liquor:

90 Percent BOD Reduction
96 percent Removal of Soluble Solids.

Carbonation to pH 8.8 2 hr settling 60:40 mixture in Trickling Filter with Domestic Sewage:

20 percent BOD Reduction
59 percent Sulfide Reduction
76 percent Hardness Reduction

60:40 Mixture on Trickling Filter with Domestic Sewage:

88-89 percent Removal at Loadings of 3500-4500 lb/ac ft/day
100 percent Sulfide Removal
95 percent BOD Removal at Loadings of 100 lb BOD/1000 cu ft
90 percent BOD Removal at Loadings of 170 lb BOD/1000 cu ft

33:67 Mixture through Sedimentation Basin with Domestic Sewage:

54 Percent BOD Removal

Differences in treatment efficiencies reported in the literature stem from differences in subprocess use which usually are not fully described. For example, Soaking from 4 to 96 hours will result in a tremendous increase in pollution load. The largest discrepancies may be caused by differences in hair removed. If hair is pulped, relatively large amounts of Na_2S (2 to 4 percent OWH) and longer periods of contact (1-3 days) are used. This yields higher BOD's due to more sulfide and hair and hide substance. If hair recovery is practiced, lower Na_2S (0.7 - 1.5 percent OWH) and shorter contact periods (4-24 hours) result in lower BOD due to the lessened protein in the waste.

2. Rates of Adoption

Prior to 1915 there were practically no treatment facilities at any tannery. There was a prevalence of small tanneries located on rather large, relatively uncontaminated streams. Today, most tanneries use equalization of beamhouse and tanhouse wastes (exclusive of vegetable tan liquors) as the first step in treatment. Treatment is usually limited to equalization and sedimentation.

If segregation of wastes within the tannery were diligently practiced, 80-90 percent of the BOD could be kept in 10-20 percent of the volume. Then this small volume of high BOD waste could be reclaimed or disposed of separately. This technique is not a current industry practice.

Approximately 75 percent of all tannery wastes are discharged into community sewers and treated along with domestic sewage. Because of the nature of tannery wastes, some form of pretreatment is often required before they are mixed with domestic sewage. Industry representatives state that only a small percentage of all tannery wastes are discharged directly to a receiving water without treatment. Waste treatment processes used include screening, sedimentation, neutralization, chemical coagulation, and lagoons

Waste treatment is expected to increase during the period from now until 1982 for the following reasons:

Concentration of total waste into larger tanneries which require more treatment.

Location of larger tanneries in more highly urbanized areas where more treatment is required and more effective municipal treatment is usually available.

Since tanneries will be larger, they will be in a better financial position to afford adequate waste treatment.

Water pollution capacity in receiving waters will become increasingly more limited, thus requiring more waste treatment.

Certain sequences in waste treatment techniques should generally be adhered to because of the nature of tannery wastes. Screening to remove debris, equalization to produce uniform quality waste, and neutralization (under certain circumstances) to prevent excessively high pH values are almost always required prior to treatment by either the municipality or the individual tannery.

Some substitute techniques cannot be used coincidentally. Treatment processes can be broadly broken down into separation and biological treatment. Usually, there is only one major unit in separation and one major unit in biological treatment. For example, if the activated sludge process is used, a trickling filter would rarely be used on the same waste.

There are other interdependencies among the waste treatment techniques which affect either costs or relative efficiencies. Industrial waste treatment is highly specific for a particular plant. The technique of treatment selected by the waste treatment engineer is influenced by volume and characteristics of the waste, degree of pollution reduction required, climate, land area available, etc. An economic study should be made in each instance to optimize efficiency and minimize cost.

3. Discharge to Municipal Sewers

The percentage of tannery wastes discharged to municipal sewers is estimated as follows:

Year	1950	1963	1967	1972
Percent	60	70	75	80

When industrial wastes are combined with municipal wastes, waste removal problems include compatibility and pretreatment. Odors and clogging of sewers due to pieces of fat, hair, and precipitated lime, are major nuisances. Toxicity of chromium and sulfide ions in biological treatment has also been of concern in combined treatment. High pH values resulting from beamhouse operations may inhibit biological treatment of combined wastes. Large quantities of suspended solids overload primary units and clog secondary units. Excessive grease often creates problems with skimming devices and small nozzle distribution systems.

It is feasible to treat this industrial waste in an adequately designed and operated municipal wastewater treatment plant. Screening, flotation, and neutralization (under some situations) are necessary pretreatments.

C. By-Product Utilization

The following chart details normal by-product utilization in a tannery.

Item	Use
Trimmings - Bellies -	Used for edible purposes.
Others -	Oil production after rendering
-	Protein feed after rendering
-	Gelatin manufacture

Item		Use
Hair	-	Used in manufacturing, upholstering, and rug backing.
Fleshings	-	Glues
Degreasing Exhaust Drum Liquors	-	Reuse of solvent in tanning. Soap
Spent Lime Liquors	-	After settling, the sludge can be mixed with other plant wastes and sold as fertilizer.
Pickle Solution Wastes	-	In the past this solution has been reused within the tannery for pickling a number of times. However, tendency of late has been to omit this reuse through advent of drum bate, pickling, and chrome tanning.
Chrome Tan Liquors	-	a. Holding and reusing in tannery. b. ppt the $Cr(OH)_3$, filtering, redissolving chromium with H_2SO_4. Most tanners consider this economically impractical.
Spent Vegetable Tans	-	Evaporated and sold as boiler compounds.
Spent Tan Bark	-	Used as floor coverings for horse shows, circuses, playgrounds - sometimes used in paperboard manufacturing or in making white lead.

D. Net Wasteload Quantities - 1963

The net waste quantities equal the gross quantities produced less the pollution removed by industry-operated and municipally-operated waste treatment facilities. For the base year, we estimate 70 percent of the waste volume was treated by municipal faciliites, with an average pollution reduction of 80 percent. We further estimate that 20 percent of the waste volume was completely treated by industry-operated facilities, with an average pollution reduction of 62 percent. On this basis, net pollution reaching watercourses in 1963 from the tanning industry approximated:

Item	Gross Produced Million lb	Percent Removed	Net Discharged Million lb
BOD	150	67.5	49
SS	425	79.5	87
TDS	650	38.0	403

E. Projected Net Wasteload

It is expected that the quantity of pollution load reaching the nation's watercourses from the tanning industry will decrease in the future. This will be the result of slightly reduced gross pollution produced, a larger percentage of waste treated, and increased removal efficiencies of waste treatment methods. Table III-3 projects net wasteloads through the year 1982.

TABLE III-3
PROJECTED NET WASTELOADS

Year	Waste	Gross Produced Million lb	Percent Reduction	Net Wasteload Million lb
1967	BOD	160	69	50
	SS	440	81	84
	TDS	670	38	415
1968	BOD	160	69.5	49
	SS	440	81.5	81
	TDS	670	38	415
1969	BOD	160	70	48
	SS	440	82	79
	TDS	670	38	415
1970	BOD	155	70.5	46
	SS	430	82.5	75
	TDS	660	38	409
1971	BOD	155	71	45
	SS	430	83	73
	TDS	650	38	403
1972	BOD	155	71.5	44
	SS	430	83.5	71
	TDS	650	38	403
1977	BOD	150	74	39
	SS	420	86	59
	TDS	640	40	384
1982	BOD	145	77	33
	SS	410	89	45
	TDS	630	45	347

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Table III-3 reflects the anticipated increased emphasis on clearing up rivers and streams throughout the country. Considering the federal and state pollution abatement programs now being effected, it is probable that within the next 15 years no tannery will be allowed to discharge untreated waste into a waterway. In addition, it is probable that the pollution reduction efficiency required of the treatment will be much higher than now required.

IV. COST INFORMATION

A. Existing Facilities Cost

The replacement value of existing industry owned and operated waste reduction facilities in 1966 is estimated at $3.6 million. The annual operating and maintenance cost of these facilities is estimated at $0.5 million.

However, we estimate that in 1966 approximately 74 percent of the waste was discharged into and treated by municipal systems. Since industry pays taxes and surcharges to support these facilities, the true industry cost exceeds the foregoing amounts.

We estimate that the replacement value of that portion of municipal treatment facility construction attributable to this industry waste is $8 million. On the same basis the annual operating and maintenance cost is estimated at $0.8 million.

TOTALS: Replacement Value - $11.6 million
Operation & Maintenance - $1.3 million annually

B. Processing and Treatment Costs

This portion of the survey analyzes costs involved in subprocesses and end of line treatment. These are further broken down into size of plant and state of technology; i.e., older, prevalent, and newer. The following tables indicate the wide ranges in the information feedback from the tannery industry. We believe the table on the entire tannery industry which relates cost of waste treatment to cost of production gives an overview picture of the present tannery industry cost situation.

Furthermore, the end of the line waste treatment has little relationship to the technology of the process or the size of the tanning plant; i.e., an older plant may have an extremely efficient, modern, waste treatment facility, and a modern, efficient tanning plant may have no waste treatment facility at all. The selection of end of the line treatment is based primarily on the requirements imposed by regulatory agencies responsible for the affected watercourses.

Although we are required to estimate costs for plants incorporating pure states of technology; i.e., completely old, completely prevalent, completely advanced, few such plants exist. Most are mixtures of varied subprocess technologies since they have been modernized in stages over a relatively long period of time.

The following assumptions are utilized for the preparation of Tables IV-1 through IV-9.

1. Respective costs associated with the small, medium and large plants are based on a typical plant as follows:

   Small: 300 hides/day
   Medium: 700 hides/day
   Large: 2000 hides/day

2. Old Technology - that technology new in 1950.

3. Prevalent Technology - that technology new in 1963.

4. Advanced Technology - that technology new in 1967.

5. Capital Cost - Equivalent 1966 cost.

6. Annual Operating and Maintenance Expenditures - Equivalent 1966 cost.

7. Economic Life - the length of time the machine or structure can be expected to compete with advancing technology. Economic obsolescense varies greatly depending upon the nature of the product, the dynamics of industry growth, etc.

TABLE IV-1

SMALL PLANT - OLD TECHNOLOGY

Alternative Subprocesses	Capital Costs (Dollars)	Annual Operating and Maintenance Expenditures (Dollars)	Economic Life (Years)
Long Soak & Wash	10-20,000	6,000-9,000	10
Liming	10-20,000	10,000-15,000	10
Bating-Paddle Machine	8-15,000	5,000-8,000	10
Pickling-Paddle Machine	8-15,000	10,000-12,000	10
Tanning	20-30,000	12,000-15,000	10
Blue Split, Shave & Sort	10-16,000	15,000-20,000	10-20
Color, Retan & Fatliquor	10-20,000	12,000-15,000	10
Rest of Plants	100-200,000	30,000-40,000	10
TOTAL	176-336,000	100,000-134,000	

End of Line Treatment			
Screening	2,000-13,000	150-1,500	10
Sedimentation	10,000-20,000	450-1,500	30
Chemical Precipitation	10,000-80,000	1,500-7,000	15
Trickling Filter	27,000-80,000	1,500-4,500	20
Activated Sludge	34,000-100,000	1,500-8,000	20
Lagooning	2,000-5,000	100-600	10-20
Oxidation Pond	2,700-7,000	600-2,000	20
Sludge Disposal	-	1,500-7,000	-

Special Notes:

1. **All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate engineer construction cost factor may be used).**
2. **Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.**
3. **The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.**

TABLE IV-2

MEDIUM PLANT - OLD TECHNOLOGY

Alternative Subprocesses	Capital Costs (Dollars)	Annual Operating & Maintenance Expenditures (Dollars)	Economic Life (Years)
Long Soak & Wash	20-40,000	20-25,000	10
Liming	20-40,000	20-25,000	10
Bating-Paddle Machine	15-30,000	8-13,000	10
Pickling-Paddle Machine	15-30,000	15-25,000	10
Tanning-Paddle Machine	30-70,000	25-35,000	10-20
Blue Split, Shave, & Sort	20-30,000	30-40,000	10
Color, Retan, & Fatliquor	20-40,000	25-35,000	10
Rest of Plant	200-400,000	50-70,000	10
TOTAL	340-680,000	193,000-268,000	

End of Line Treatment			
Screening	4,000-25,000	300-3,000	10
Sedimentation	20,000-40,000	1,000-3,000	30
Chemical Precipitation	20,000-160,000	3,000-15,000	15
Trickling Filter	50,000-150,000	3,000-10,000	20
Activated Sludge	75,000-200,000	3,000-16,000	20
Lagooning	5,000-10,000	200-1,300	10-20
Oxidation Pond	7,000-15,000	3,000-15,000	20
Sludge Disposal	-	3,000-15,000	-

Special Notes:

1. **All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate engineer construction cost factor may be used).**
2. **Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.**
3. **The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.**

TABLE IV-3

LARGE PLANT - OLD TECHNOLOGY

Alternative Subprocesses	Capital Costs (Dollars)	Annual Operating & Maintenance Expenditures (Dollars)	Economic Life (Years)
Long Soak & Wash	80-100,000	35-50,000	10
Liming	80-100,000	55-70,000	10
Bating-Paddle Machine	70-80,000	25-35,000	10
Pickling-Paddle Machine	70-80,000	55-65,000	10
Tanning	125-175,000	70-80,000	10
Blue Split, Shave, & Sort	65-85,000	80-100,000	10-20
Color, Retan, & Fatliquor	80-100,000	70-80,000	10
Rest of Plant	800-900,000	180-220,000	10
TOTAL	1,370,000 1,620,000	570,000-700,000	

End of Line Treatment			
Screening	10,000-60,000	900-9,000	10
Sedimentation	45,000-100,000	2,000-6,000	30
Chemical Precipitation	45,000-300,000	9,000-45,000	15
Trickling Filter	100,000-300,000	7,000-25,000	20
Activated Sludge	150,000-500,000	7,000-40,000	20
Lagooning	13,000-30,000	500-3,000	10-20
Oxidation Pond	16,000-40,000	6,000-30,000	20
Sludge Disposal	-	8,000-40,000	-

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate engineer construction cost factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

TABLE IV-4

SMALL PLANT - PREVALENT TECHNOLOGY

Alternative Subprocesses	Capital Costs (Dollars)	Annual Operating & Maintenance Expenditures (Dollars)	Economic Life (Years)
Short Soak & Wash	8-10,000	6,000-9,000	10
Liming	15-20,000	10,000-15,000	10
Bating-Drum Machine	15-20,000	5,000-8,000	10
Pickling-Drum Machine	10-15,000	10,000-12,000	10
Tanning	25-35,000	12,000-15,000	10
Blue Split, Shave, & Sort	15-25,000	15,000-20,000	10-20
Color, Retan & Fatliquor	15-25,000	12,000-15,000	10
Rest of Plant	110-220,000	30,000-40,000	10
TOTAL	213-370,000	100-134,000	

End of Line Treatment

Since volume approximately the same as for old technology see "old technology"

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate engineer construction cost factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

TABLE IV-5

MEDIUM PLANT - PREVALENT TECHNOLOGY

Alternative Subprocesses	Capital Costs (Dollars)	Annual Operating & Maintenance Expenditures (Dollars)	Economic Life (Years)
Short Soak & Wash	10-20,000	20-25,000	10
Liming	25-40,000	20-25,000	10
Bating-Drum Machine	20-30,000	8-13,000	10
Pickling-Drum Machine	20-30,000	15-25,000	10
Tanning	40-70,000	15-25,000	10
Blue Split, Shaves, & Sort	25-35,000	25-35,000	10-20
Color, Retan, & Fatliquor	25-40,000	30-40,000	10
Rest of Plant	225-400,000	50-70,000	10
TOTAL	390-665,000	183-258,000	

End of Line Treatment	Capital Costs (Dollars)	Annual Operating & Maintenance Expenditures (Dollars)	Economic Life (Years)
Screening	4,000-25,000	300-3,000	10
Sedimentation	20,000-40,000	1,000-3,000	30
Chemical Precipitation	20,000-160,000	3,000-15,000	15
Trickling Filter	50,000-150,000	3,000-10,000	20
Activated Sludge	75,000-200,000	3,000-16,000	20
Lagooning	5,000-10,000	200-1,300	10-20
Oxidation Pond	7,000-15,000	3,000-15,000	20
Sludge Disposal	-	3,000-15,000	-

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate engineer construction cost factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

TABLE IV-6

LARGE PLANT - PREVALENT TECHNOLOGY

Alternative Subprocesses	Capital Costs (Dollars)	Annual Operating & Maintenance Expenditures (Dollars)	Economic Life (Years)
Short Soak & Wash	45-55,000	35-50,000	10
Liming	80-100,000	55-70,000	10
Bating-Drum Machine	60-70,000	25-35,000	10
Pickling-Drum Machine	60-70,000	55-65,000	10
Tanning	140-170,000	80-90,000	10
Blue Split, Shave, & Sort	75-85,000	80-100,000	10-20
Color, Retan, & Fatliquor	105-125,000	70-80,000	10
Rest of Plant	850-950,000	190-230,000	10
TOTAL	1,415,000 1,625,000	590-720,000	

End of Line Treatment			
Screening	10,000-60,000	900-9,000	10
Sedimentation	45,000-100,000	2,000-6,000	30
Chemical Precipitation	45,000-300,000	9,000-45,000	15
Trickling Filter	100,000-300,000	7,000-25,000	20
Activated Sludge	150,000-500,000	7,000-40,000	20
Lagooning	13,000-30,000	500-3,000	10-20
Oxidation Pond	16,000-40,000	6,000-30,000	20
Sludge Disposal	-	8,000-40,000	-

Special Notes:

1. **All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate engineer construction cost factor may be used).**
2. **Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.**
3. **The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.**

TABLE IV-7

SMALL PLANT - NEW TECHNOLOGY

Alternative Subprocesses	Capital Costs (Dollars)	Annual Operating & Maintenance Expenditures (Dollars)	Economic Life (Years)
Short Soak & Wash	8-10,000	6-9,000	10
Liming with add. Chemicals	15-20,000	10-15,000	10
Bate, Pickle, and Tan Continuous System	70-90,000	25-35,000	10
Blue Split, Shave, & Sort	15-25,000	15-20,000	10-20
Color, Retan, & Fatliquor	15-25,000	12-15,000	10
Rest of Plant	110-220,000	30-40,000	10
TOTAL	233-390,000	98-134,000	

End of Line Treatment

Since volume approximately the same as for old technology see old technology

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate engineer construction cost factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

TABLE IV-8

MEDIUM PLANT - NEW TECHNOLOGY

Alternative Subprocesses	Capital Costs (Dollars)	Annual Operating & Maintenance Expenditures (Dollars)	Economic Life (Years)
Short Soak & Wash	10-20,000	20-25,000	10
Liming with add. Chemicals	25-40,000	20-25,000	10
Bate, Pickle, & Tan	20-30,000		
Continuous System	90-150,000	45-70,000	10
Blue Split, Shave, & Sort	25-35,000	20-40,000	10-20
Color, Retan, & Fatliquor	25-40,000	25-35,000	10
Rest of Plant	235-420,000	55-75,000	10
TOTAL	430-735,000	185-270,000	

End of Line Treatment			
Screening	4,000-25,000	300-3,000	10
Sedimentation	20,000-40,000	1,000-3,000	30
Chemical Precipitation	20,000-160,000	3,000-15,000	15
Trickling Filter	50,000-150,000	3,000-10,000	20
Activated Sludge	75,000-200,000	3,000-16,000	20
Lagooning	5,000-10,000	200-1,300	10-20
Oxidation Pond	7,000-15,000	3,000-15,000	20
Sludge Disposal	-	3,000-15,000	-

Special Notes:

1. All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate engineer construction cost factor may be used).
2. Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.
3. The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.

TABLE IV-9

LARGE PLANT - NEW TECHNOLOGY

Alternative Subprocesses	Capital Costs (Dollars)	Annual Operating & Maintenance Expenditures (Dollars)	Economic Life (Years)
Short Soak & Wash	45-55,000	35-50,000	10
Liming with add. Chemicals	80-100,000	60-75,000	10
Bate, Pickle, and Tan Continuous System	240-300,000	160-180,000	10
Blue Split, Shave, & Sort	75-85,000	80-100,000	10-20
Color, Retan, & Fatliquor	105-120,000	70-80,000	10
Rest of Plant	850-950,000	200-240,000	10
TOTAL	1,395,000-1,610,000	605-725,000	
End of Line Treatment			
Screening	10,000-60,000	900-9,000	10
Sedimentation	45,000-100,000	2,000-6,000	30
Chemical Precipitation	45,000-300,000	9,000-45,000	15
Trickling Filter	100,000-300,000	7,000-25,000	20
Activated Sludge	150,000-500,000	7,000-40,000	20
Lagooning	13,000-30,000	500-3,000	10-20
Oxidation Pond	16,000-40,000	6,000-30,000	20
Sludge Disposal	-	8.000-40.000	-

Special Notes:

1. **All costs are equivalent 1966 costs. (To determine actual costs for an earlier year, an appropriate engineer construction cost factor may be used).**
2. **Percentage of pollution reduction achieved by a particular end of the line treatment process is simplified and assumed to be the same in compared years. For example, it is assumed that the screening process in 1950 would achieve the same efficiency of pollution reduction as screening in 1963 and 1967.**
3. **The end of the line treatment does not include any sewer collection system costs. It is assumed that the waste treatment facility is located adjacent to the industrial waste source.**

TABLE IV-10

SUMMARY OF PRODUCTION LEATHER TANNING AND FINISHING AND WASTE TREATMENT COSTS

Item	Quantity
Total production	31.3 million equivalent hides
Total value added in manufacture*	$272 million
Average unit value added in manufacture	$8.70/equivalent hide
Estimated replacement value of waste reduction facilities**	$11.6 million
Annual amortized cost of waste treatment of facilities at 7% and 10 yr life**	$1.6 million
Estimated annual waste reduction operating and maintenance cost**	$1.3 million
Average industry cost of waste treatment per unit of production	$0.09/equivalent hide
Total waste reduction costs as percent of total production cost	1.07 percent

* From the Business and Defense Services Administration, U. S. Department of Commerce, 1967.

** Estimated replacement value, estimated amortization, and estimated annual operating costs include an estimate of the cost of municipal treatment facilities attributable to this industry's wastes.

APPENDIX I

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APPENDIX II

GLOSSARY

Activated Sludge Process - a process for treating liquid waste by aeration and recirculation of biologically active sludge.

Aeration - the act of supplying with oxygen.

Anaerobic - living or active in the absence of oxygen.

Areolar (adj.) - description of fatty tissue intermingled with other tissue in small, interstitial particles.

Bating - a chemical process for preparing swollen and alkaline hides for tanning, usually using ammonium salts and enzymes.

Beam (v.) - to remove hair.

BOD - biochemical oxygen demand - the weight of oxygen required to biologically oxidize an organic waste over a specified period of time.

Chemical Coagulation - the change from a liquid to a thickened, curd-like state by chemicals.

COD - chemical oxygen demand - a measure of the organic pollution.

Effluent - polluted water discharged from a process.

Emulsification - to convert to an oily mass in suspension in a watery liquid.

Enzyme - any of a class of organic substances that accelerate specific transformations of material, as in digestion and fermentation.

Equalization - the process of combining two or more dissimilar wastes to produce a uniform composite.

Fatliquoring - the process of adding fats and greases to tanned hides to prevent cracking.

Gambier - a yellowish catechu derived from a Malayan rubiaceous woody vine, used for tanning and dyeing.

APPENDIX II (cont'd)

Green Fleshing - removal of flesh from hides before soaking.

Lagooning - the liquid wash treatment process of holding the waste in shallow ponds for a period of several hours to allow absorption of oxygen.

Lime Fleshing - removal of flesh from hides after soaking.

Lot - 30,000 lb of whole hides.

Pectic acid - any of various water insoluble substances formerd by hydrolizing the methyl ester groups of pectins.

Peroxidase - an enzyme that catalyzes the oxidation of various substances by peroxides.

Pickling - a chemical process using sulfuric acid and sodium chloride to make skins acid enough to prevent precipitation of insoluble salts during vegetable tanning.

Potable - drinkable.

Precipitate - to cause to separate from solution or suspension.

Process - a series of actions or operations definitely conducting to an end; continuous operation or treatment, especially as in manufacture.

Rehydration - process of recombining with water.

Screening - separation of solid material from liquid waste by passing the waste through screens.

Sedimentation - gravity settling of solid particles suspended in a liquid.

Sides - half of a skin, the skin having been cut down the back from head to tail.

Subprocess - an alternate method of conducting a process.

Sumac - a material used in tanning and dyeing consisting of the dried and powdered leaves, panicles, etc. of various species of sumac trees, shrubs or woody vines.

Tannin - any of various soluble astringent complex phenolic substances of plant origin used in tanning or dyeing.

Tanning - art or process by which skin is converted to leather.

Trickling Filtration - a liquid waste treatment process involving trickling the waste through a bed of stone or other inert material.

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