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Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the

BUILDER'S PAPER & ROOFING FELT

Segment of the Builder's Paper and Board Mills

Point Source Category

MAY 1974

U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

DEVELOPMENT DOCUMENT

for

EFFLUENT LIMITATIONS GUIDELINES

and

NEW SOURCE PERFORMANCE STANDARDS

for the

BUILDERS PAPER AND ROOFING FELT SEGMENT OF THE BUILDERS PAPER AND BOARD MILLS POINT SOURCE CATEGORY

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Abstract

This document presents the findings of a study of the builders paper and roofing felt segment of the builders paper and board industry for the purpose of developing effluent limitations for existing sources and standards of performance for new sources to implement Sections 304(b) and 306 of the Federal Water Pollution Control Act Amendments of 1972 (The "Act").

Effluent limitations are set forth for the degree of effluent reduction attainable through the application of the "Best Practicable Control Technology Currently Available," and the "Best Available Technology Economically Achievable," which must be achieved by existing point sources by July 1, 1977 and July 1, 1983, respectively. "Standards of Performance for New Sources" set forth the degree of effluent reduction which is achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives.

The identified technology for July 1, 1977 is good in-plant waste water management followed by preliminary screening, primary sedimentation, and biological treatment. The 1977 limitations can be met by mills using only biological treatment, but a combination of in-plant controls and biological treatment may prove to be more cost effective.

The identified technology for July 1, 1983 and for new source performance standards is in-plant waste water controls and biological treatment. In addition, coagulation and filtration is identified for TSS reduction. The identified in-plant controls may require some major changes in existing processes and design modifications to existing equipment. The identified in-plant controls and external treatment systems are available for implementation at mills within this subcategory.

Supportive data and rationale for development of the proposed effluent limitations and standards of performance are contained in this report.

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SECTION I

CONCLUSIONS

For the purpose of establishing effluent limitations and standards of performance, the builders paper and builders board industry has been subcategorized. The building paper and roofing felts subcategory is presented in this report. The hard board segment is covered in a separate report on the forest products industry.

Within the building paper and roofing felts subcategory, factors such as age and size of plants, processes employed, climate, and waste treatability confirm and substantiate this subcategorization.

An extensive search for information and data was made for mills within the subcategory. Information and data were gathered from all possible sources including mill records, waste water sampling surveys, technical and trade associations, literature, NPDES permit applications, and interviews with industry authorities. The effluent limitations and performance standards were based upon extensive analysis of the accumulated information and data as described above. Identification of the technology levels of BPCTCA, BATEA, and NSPS were made and effluent qualities which could be achieved by each of the technologies were determined.

Evaluation of all available information and data resulted in the selection of the following significant waste water parameters for which limitations were developed:

- Biochemical Oxygen Demand (five day-20°C) (BOD_5)
- Total Suspended Solids (TSS)
- Settleable Solids
- pH

Limitations have been set forth on BOD_5, TSS, settleable solids, and pH for July 1, 1977. The identified technologies for BPCTCA includes good in-plant waste water management followed by external controls of preliminary screening, primary sedimentation, and biological treatment. The 1977 limitations can be met by mills using only secondary treatment, but a combination of in-plant controls and biological treatment may be more cost effective. It is estimated that increases in production costs to achieve the 1977 effluent limitations will average $7.20 per metric ton ($7.83 per short ton) depending upon specific mill conditions relating to available technologies at the particular mill.

Limitations have been set forth on BOD_5, TSS, settleable solids, and pH for July 1, 1983. The identified technolgies for BATEA include in-plant waste water controls and secondary treatment. The identified in-plant controls may require some major changes in existing processes and design modifications to existing equipment. In addition, coagulation and filtration are identified for TSS reduction. The estimated increases in production costs of upgrading existing mills from BPCTCA to BATEA will average $2.40 per metric ton ($2.67 per short ton) depending upon specific mill conditions.

For new source standards have been set forth on BOD_5, TSS, settleable solids, and pH. The identified technologies for new sources include in-plant waste water controls, secondary treatment, and filtration. The in-plant controls reflect internal improvements which can be achieved through effective design and layout of mill operations. The identified in-plant controls and external treatment systems are available for implementation at mills within this subcategory.

SECTION II

RECOMMENDATIONS

Based upon the information in this report, the effluent limitations and standards of performance shown in Table 1 are for the building paper and roofing felt subcategory.

Table 1

Effluent Limitations and New Source Performance Standards

Values in kg/kkg(lbs/ton)

BOD5		TSS		pH	Settleable
30 Day	Daily Max	30 Day	Daily Max	Range	Solids
BPCTCA					
3.0 (6.0)	5.0 (10.0)	3.0 (6.0)	5.0 (10.0)	6.0-9.0	0.2 ml/l
BATEA					
1.0 (2.0)	1.75 (3.5)	1.0 (2.0)	1.75 (3.5)	6.0-9.0	0.2 ml/l
NSPS					
1.0 (2.0)	1.75 (3.5)	1.0 (2.0)	1.75 (3.5)	6.0-9.0	0.2 ml/l

The maximum average of daily values for any 30 consecutive day period should not exceed the 30 day effluent limitations shown above. The maximum for any one day should not exceed the daily maximum effluent limitations shown above. The limitations are in kilograms of pollutant per metric ton of production (pounds of pollutant per short ton of production) except for the pH range and settleable solids limitations. Mill effluents should always be within the settleable solids concentration and the pH range limitations shown.

The above effluent limitations and new source performance standards for the TSS parameter are measured by the technique utilizing glass fiber filter disks as specified in Standard Methods for the Examination of Water and Waste Water (13 Edition) (1).

Production is defined as the annual average level of production off the machine (air dry tons).

SECTION III

INTRODUCTION

PURPOSE AND AUTHORITY

Section 301(b) of the Federal Water Pollution Control Act, as amended in 1972, requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best practicable control technology currently available as defined by the Administrator pursuant to Section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best available technology economically achievable which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) of the Act. Section 306 of the Act requires the achievement by new sources of a Federal standard of performance providing for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish within one year of enactment of the Act, regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of the best control measures and practices achievable including treatment techniques, process and procedure innovations, operating methods, and other alternatives. The regulations proposed herein set forth effluent limitations guidelines pursuant to Section 304(b) of the Act for the builders paper segment of the builders paper and builders board point source category.

Section 306 of the Act requires the Administrator, within one year after a category of sources is included in a list published pursuant to Section 306(b)(1)(A) of the Act, to propose regulations establishing Federal standards oF performance for new sources within such categories. The Administrator published in the Federal Register of January 16, 1973, (38 F.R. 1624), a list of 27 source categories. Publication of the list constituted announcement of the Administrator's intention of establishing, under Section 306, standards of performance applicable to new sources within the builders paper and builders board point source category, which was included within the list published January 16, 1973.

The limitations in this document identify (in terms of chemical, physical, and biological characteristics of pollutants) the level of pollutant reduction attainable through the application of the best practicable control technology currently available and the best available technology economically achievable. The limitations also specify factors which must be considered in identifying the technology levels and in determining the control measures and practices which are to be applicable within given industrial categories or classes.

In addition to technical factors, the Act requires that a number of other factors be considered, such as the costs or cost-benefit study and the nonwater quality environmental impacts (including energy requirements) resulting from the application of such technologies.

SUMMARY OF METHODS USED FOR DEVELOPMENT OF THE EFFLUENT LIMITATION GUIDELINES AND STANDARDS OF PERFORMANCE

The basic procedures used in developing the effluent limitations and standards of performance are discussed below.

With the objective to identify mills which could be considered as representing the best existing control technology, a list of every mill in the above subcategory was compiled and is shown in Appendix I. All available information regarding the internal processes employed, types of products, waste treatment facilities in operation, and quantity/quality of the waste water discharge was then tabulated for each mill. Evaluation of the results of this search activity made apparent that very few mills provided biological treatment of their effluent. The majority, on the order of 50 - 70 percent of mills in this subcategory, discharge to a public sewer system.

This information was then evaluated to determine which mills should be investigated further by on-site surveys. The main criteria used during the evaluation were the quantity of waste water discharge and quality of the discharge as characterized by BOD_5 and suspended solids. The former indicated the extent of in-plant control measure practices and the latter showed the extent and performance capabilities of their waste treatment facilities.

Previous to sending a full sampling survey team to the above mills, a reconnaissance team was sent to the mills selected from the above list of qualified candidates. At this time the mill personnel were briefed on the objectives of the project, the information that was necessary for the successful completion of the project, and the work program to be carried out by the survey team. A copy of the reconnaissance and mill survey questionnaires is shown in Appendix III. At this time the availability of laboratory facilities, and the feasibility of obtaining verification data by a field survey was determined. A tour of the plant and the treatment facilities, and a review of the available mill records on waste streams, both internal and external, were made. The objective of this effort was to verify that the mill represented the best practicable control technology and that the mill records could be validated by a field survey team. The types of cost records and information required for the project were described at this time so that the mill would have the time to compile this information which was then collected by the mill survey team.

The field survey team consisted of three to seven people. The goal was to obtain analytical and flow data on various in-plant controls and external treatment systems. Samples were collected every hour for 3-7 days, composited on a 24 hour basis, and analyzed on-site by the survey team or by an independent laboratory. All analyses were performed following methods described in Standard Methods for the Examination of Water and Waste Water (13th Edition) (1) or equivalent EPA-accepted methods. (See Appendix III).

During the survey, samples were split between the mill laboratory personnel and the survey team. The objective of this effort was, if necessary, to generate an "analytical procedure factor" to be applied to the 12 month data collected by the mill. This would place all data on the same analytical base. However, development of the "analytical factor" did not prove to be feasible because of the wide variations in testing procedures, and much of the data did not correlate between procedures. Table 2 shows a sample comparison between results of the split samples.

The data, subject to any corrections indicated from the above procedures, was used to generate a broad based data bank. The tons per day of production for each mill were corrected to air-dry tons (ADT) as required. Reported flows by mills were evaluated and corrected if necessary to include all waste water flows which should be reported as contributing pollutant loads.

The summary bloc of data shown in Table 7, Section VII, is the basis for the limitations developed in this report. They were developed from twelve months of daily records from each mill, when available. The data that have been selected are believed to be in accordance with accepted standards of the analytical procedures verified by survey programs described in detail above.

In addition to the above accumulated data and information, the full range of control and treatment technologies existing applicable to builders paper and roofing felt segment was identified. This included an identification of each distinct control and treatment technology, including both in-plant and end-of-process technologies, which are existent or capable of being designed for each subcategory. It also included an identification in terms of the amount of constituents and the chemical, physical, and biological characteristics of pollutants, of the effluent level resulting from the application of each of the treatment and control technologies. The problems, limitations, and reliability of each treatment and control technology and the required implementation time were also identified. In addition, the nonwater quality environmental impact, such as the effects of the application of such technologies upon other pollution problems, including air, solid waste, noise, and radiation was also identified. The energy requirements of each of the control and treatment technologies were identified as well as the cost of the application of such technologies.

The information, as outlined above, was then evaluated to determine what levels of technology constitute the "best practicable control technology currently available," "best available technology economically achievable," and the "best available demonstrated control technology, processes, operating methods, or other alternatives." In identifying such technologies, various factors were considered. These included the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application, the age and size of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques or process changes, non-water quality environmental impact (including energy requirements), and other factors.

Discussion of Data Sources

The data and information base which was used in the development of the effluent limitations was generated by the methods discussed above. The sources of data included the following:

1. Mill records of selected mills

2. Short term survey results of selected mills

3. National Pollutant Discharge Elimination System (NPDES) Applications

4. American Paper Institute (API)

5. Literature

6. Personal interviews with recognized authorities in the industry

Mill Records

Data were accumulated from the selected mills. The records covered 12-13 months operating time. Most of the mill data was a result of daily sampling and analysis. The mill data was carefully screened in order to have an accurate set of data for each mill. In order to evaluate the validity of the mill data, surveys of sampling and analytical techniques were made as discussed previously. Mill waste waters were sampled for a period of 3-7 days with samples being split between the mill laboratory and the contractor's laboratory.

Short Term Survey

As mentioned above, surveys were conducted of the selected mills for 3-7 days with a basic objective of evaluation of mill data. Twenty-four hour composites of hourly samples were taken of the mills' waste water during the surveys. Sampling and analytical techniques were conducted using EPA-accepted procedures.

NPDES Applications

Data from NPDES applications represents an average operating condition for the mills. The data frequently does not compare to data from other sources for the same mills. Thus, the NPDES data were only used as a comparison check to other data.

Literature

Frequently, the mill effluent data in published literature is not correlated with the particular mill which it represents. Also, the reliability of the data is sometimes questionable since sampling and analytical methods are usually not presented and since the time period which the data represents is frequently omitted. Thus, the data in literature was carefully screened before consideration.

Use of Data Sources

All of the above sources were used in developing the effluent limitations. However, it should be pointed out that the data sources are not equal in reliability and thus, they were weighted accordingly. The data from the selected mills' records were used as the major source. In addition, the short term survey data for the selected mills without adequate mill records were used in conjunction with the mills' data in developing the limitations. The short term survey data represents essentially one data point over a year's time and thus should be within the range of the year's operating data. These two sources were used as the basis for the effluent limitations. The data from other sources were used mainly as backup data from which to check the mill and short term survey data.

Table 2

BUILDING PAPER AND ROOFING FELT SUBCATEGORY

COMPARATIVE TEST RESULTS ON SPLIT SAMPLES
BY MILL BP-1 AND BY EPA

Data in mg/l

	FINAL EFFLUENT	
DAY	BOD5	TSS
1	*25/51	78/94
2	75/84	89/72
3	55/64	81/65
4	35/53	68/44
5	38/56	21/31
Averages	46/62	67/61

*mill result/EPA result

GENERAL DESCRIPTION OF INDUSTRY SEGMENT

This report pertains to the builders paper segment of the builders paper and board point source category. The terms "building papers" and "roofing felts" are more commonly applied to the products of this segment and are, of course, aptly descriptive of heavy papers used in the construction industry. As a group, they are identified more by nomemclature appropriate to their use rather than by significant variations in the raw materials or the process used to manufacture them. Both products are composed of varying combinations of wood, waste paper and/or rags, The process used for the production of both types of product is similar in concept, differing basically to accommodate the particular combinations of raw materials used. Each of the raw materials described above requires different equipment to reduce the material to individual fibers. The fibers are then blended in varying proportions and formed on a paper machine which is common to both types of product.

Building papers are generally characterized as saturating papers, flooring paper, and deadening papers which are used in the construction and automotive industries. They differ from unsaturated roofing felts only in thickness and possible chemical additives added to the process in order to achieve a specific property, i.e., strength, density, wet strength, water repellant capability, or similar physical qualities.

The function of dry roofing felt is to provide a strong, highly absorbent material as support and backing for the bituminous coatings necessary for the water-proofing characteristics essential to the finished product (2). One or more saturating coats of melted asphalt are applied to the finished roll of felt in a process which follows the papermaking process. If the product is a roofing roll, the sheet is given a thin coat of mica and talc after the saturating process and is then the finished product. "Mineral-surfaced" products used as roof-flashing rolls or shingles, are surfaced with granules of slate, stone, or ceramic following the saturating and talc processes (3). This coating provides resistance to weathering and to damage caused by roof maintenance activities. Roll roofing does not require this granular coating since it is protected by gravel placed in a heavy coat of bitumen when installed. Roll roofing felts of wood and asbestos fibers are exceptionally strong and weather and heat resistant, making it possible to install them without providing a protective coat of gravel or granular material. The roofing materials described above account for a high percentage of the production of the mills which are the subject of this report.

The objective of this project is to study mills that generate a wasteload that is attendant to the manufacture of building paper and roofing felt. Some of these products are made by mills which also produce other paper and paperboard products, manufacturing building paper and dry felt only on an intermittent basis. These products also derive from mills which produce both building paper and building board, insulating board, or other combinations of products. In keeping with the objective, therefore, this report deals exclusively with those mills which produce building papers and felts as their primary product.

Eighty-one mills in this group are listed in Appendix I. Although there is some overlapping, they are divided generally in accord with their announced production as follows:

Dry Roofing Felt	17 mills
Saturated/Coated Roofing Felt	58 mills
Combination of The Above	6 mills

It was found during the course of this study that these mills quite frequently change their production, discontinuing one or more products and introducing new ones. Thus, this list is illustrative only.

The total daily production capacity of these 81 mills is approximately 4898 metric tons (5400 short tons) per day. The daily capacity of the largest mill is 295 metric tons (325 short tons) and the smallest output is 20 metric tons (22 short tons). The size distribution of the mills is shown below.

kkg/day (short tons/day)	% of mills
Less than 45.3 (50)	30%
55.3-87.7 (50-99)	40%
90.7-135 (100-149)	20%
Greater than 136 (150)	10%

They are geographically distributed over most of the United States as illustrated in Figure 1. The majority of them are located in or near metropolitan areas where the quantity of waste paper required is available. Because they are so located, many of them, 60 to 75 percent is estimated, dispose of their wastes in municipal sewerage systems.

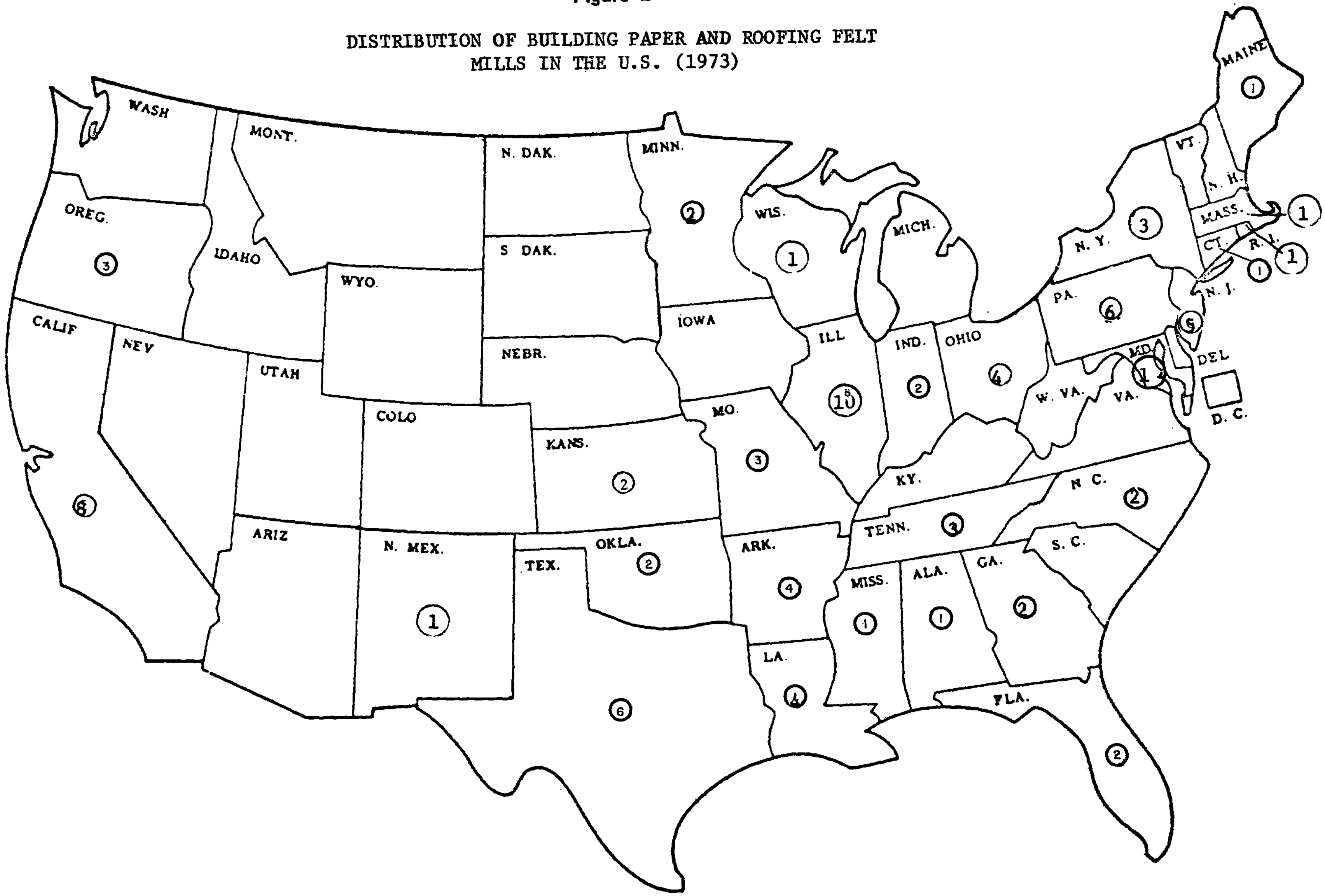
Total annual U.S. production of construction paper, the term utilized by the Bureau of the Census and the American Paper Institute (API), in 1971 was 1,473,000 metric tons (1,623,000 short tons) (4).

Production Processes

In terms of quality, raw material requirements for building paper and felt are not, generally, as demanding as those for finer grade papers. Thus, more flexibility exists in those that can be used and in the way they are prepared. These products generally consist of waste paper and defibrinated wood, wood flour, or pulp mill rejects although some rags or other materials can be employed.

Figure 1

DISTRIBUTION OF BUILDING PAPER AND ROOFING FELT MILLS IN THE U.S. (1973)



Some mills receive wood as logs which are chipped on the premises. Others purchase wood chips, sawdust, or wood flour. Or in the case of many mills, equipment is available to handle these materials alternatively. Rags and waste paper arrive at the mill in bales. Old, low grade rags not suitable for recycling into fine paper may be utilized for building paper and felt. Similarly lower specifications for reclaimed paper result in frequent variations in quality of this raw material.

Various specifications require different preparations of raw materials to impart desired characteristics such as strength, absorptive capacity, heat and flame resistance, and flexibility.

The furnish for roofing felt must be such that the product can meet specifications of weight, tensile strength, and flexibility to enable it to withstand any strain to which it may be later subjected in the roofing plant (3). It must be able to absorb from two to three times its weight in bituminous saturants and six times its weight in saturants and granule coatings.

Stock Preparation

Fibers are prepared for use by various methods which are determined by the fiber source. Wood chips are pulped mechanically in an attrition mill. This is a refiner containing fixed and rotating discs between which the chips pass on a stream of water. In some operations, this is preceded by cooking, or steaming, the chips with water for a short period in a digester, a large metal pressure vessel. This softens the chips and reduces the mechanical energy required. Chemicals are not generally utilized.

The pulp is discharged from the attrition operation as a slurry which goes to a stock chest for storage. It is then blended with other raw materials. Wood flour requires no pretreatment and enters the system in the blending chest.

After they are cut and shredded, rags are placed, along with fresh or process water, in a beater tank at about six percent consistency. Here a rotating cyclindrical bladed element, which operates in conjunction with stationary blades, both impacts the fiber and causes its continuous circulation around the beater and back through the attrition zone. Thus, progressive fiberizing occurs. After a period of several hours, when the charge is sufficiently defibered, the pulp is diluted and removed to a dump chest (4).

Waste paper is similarly treated in beaters or pulpers. In the pulper operation, the paper follows the water circulation in a large open vat and is repeatedly exposed to rotating impeller blades. Over a period of time it is ripped, shredded, and finally defibered (2). Accessory equipment separates and removes metal and other contaminants.

After the stock is blended, it is subjected to refining and screening ahead of the forming process.

Some building papers are highly sized with resins and alum. Felts may be sized with bituminous materials or contain mold-proofing or fungicidal materials.

Papermaking

These products are manufactured principally on single-cylinder paper machines from the raw materials reduced to fiber in the stock preparation area and transported to the machine in a dilute slurry. A rotating wire-covered cylinder retains the fibers which form a sheet on its surface and permits water to drain through. This sheet is then removed from the wire by a cloth felt which carries it through a press section where additional water is removed from the sheet. It is self supporting as it leaves the press sections and passes through the steam-heated multi-drum drier section from which it is cut to width and rolled. At this stage it is considered a dry or unsaturated felt. The above paper forming and drying process is the type used by all manufacturers treated in this study.

A process flow diagram of a building paper and roofing felt mill is shown in Figure 2.

PRODUCTION CLASSIFICATION

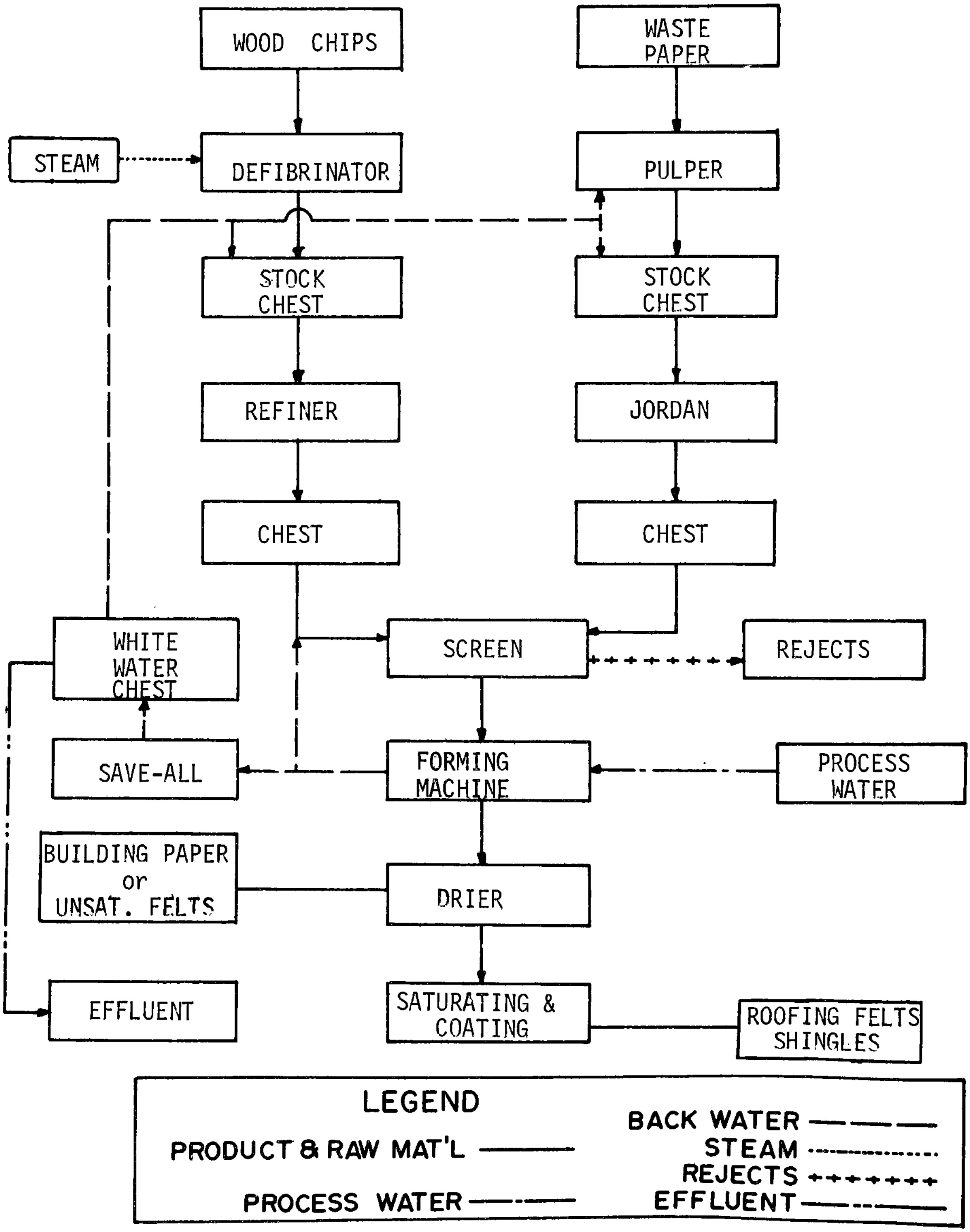
The U.S. Bureau of the Census, Census of Manufactures (4), classifies construction paper (dry basis before saturating) as Product Code No. 26612 under the four-digit category 2661, building paper and board.

CAPACITY PROJECTIONS

Only a very minor increase in construction paper capacity is forecast through 1975 (6). The percentage of waste paper used as a constituent is projected to rise from 27.1 percent in 1969 to 40 percent in 1985 (7). Research, development, and implementation of programs in response to environmental problems associated with the disposal of solid wastes, to which "paper" makes a large contribution, may support this projection.

FIGURE 2

BUILDING PAPER AND ROOFING FELT PROCESS DIAGRAM



SECTION IV

SUBCATEGORIZATION OF THE INDUSTRY

FACTORS OF CONSIDERATION

This study is concerned with the building paper and roofing felt segment of the builders paper and board mills point source category. In order to identify any relevant discrete subcategories within this segment, the following factors were considered:

1. Raw materials
2. Production processes
3. Products produced
4. Size and age of mills
5. Waste water characteristics and treatability
6. Geographical location

After analyzing these factors, it is concluded that this segment constitutes one discrete subcategory defined as BUILDING PAPER AND ROOFING FELT, which is the production of heavy papers used in the construction industry from cellulose and mineral fibers derived from waste paper, wood flour and sawdust, wood chips, asbestos, and rags, without bleaching or chemical pulping.

RATIONALE FOR SELECTION OF SUBCATEGORY

Raw Materials

Cellulose fiber is the principal raw material used. While there are differences in the sources of these fibers, as noted above and in Sections III and V, such differences have only a minor impact on waste water characteristics and treatability. All raw wastes containing cellulose respond to the same treatment techniques for removal of suspended solids and BOD5. The details of these techniques are described in Section VII.

Other raw materials, such as asphalt used in some roofing felt mills, do not contribute significantly to waste water characteristics, as described in Section V.

Production Processes

All mills within the subcategory studied utilize the same basic production processes. Although there are deviations in equipment and production procedures, these deviations do not significantly alter either the characteristics or the treatability of the waste water generated.

Products Produced

As delineated in Section III, there is a wide variety of products produced, ranging from roofing felts to gasket materials. As shown in Section V, waste water characteristics do not vary significantly as a function of product produced.

Size and Age of Mills

While older mills tend to have higher levels of pollutants in the waste water than newer mills, there are "old" mills which have applied available technology, principally in the area of recycle, to reduce such pollutant levels to those obtained by "new" mills. Size of most mills varies only within a relatively narrow range from nearly 45 kkg (50 tons) to about 227 kkg (250 tons) per day.

Geographical Location

Waste water characteristics and treatability do not differ significantly with geographical location, irrespective of the raw materials and process employed and the products produced. However, the local climate can affect biological treatment processes as climatic effects can (1) slow biological oxidation processes through lower biological activity due to extremely cold waste water temperatures, and (2) decrease biological treatment efficiencies during the fall and spring when waste water temperatures are changing and also the biological community. These effects can be minimized in the design of the biological treatment systems as described in Section VII. In addition other factors frequently have a greater effect upon final effluent qualities than climate. Also, the effects of climate can be accounted for in the effluent limitations by inclusion of mills located in all geographical locations in the data base. Thus, the industry segments were not further subcategorized based upon geographical location or climate.

SECTION V

WATER UTILIZATION AND WASTE CHARACTERISTICS

PROCESS WATER UTILIZATION

General Use

A building paper and/or roofing felt mill utilizes water in its process, exclusive of steam generation, for the following purposes:

1. To act as an agent for separating the raw materials into discrete fibers which is essential for: the formation of the end product; the removal of contaminants and undesirable fibers from the stock system; and the control and metering of stock to the paper machine. This water, which is generally recycled, acts as a vehicle for transporting the fiber to the process.

2. To clean those areas, particularly on the wet end of the machine, which tend to develop fiber buildup. These areas are the paper forming section of the machine and the felts used to carry the formed sheet through the machine and press sections. This water enters the system via shower nozzles and represents the largest contribution to the volume of raw waste water generated since it is nearly all excess water in terms of process water needs.

3. To keep production equipment throughout the mill operational or permit the equipment to perform its design function. Typical applications are the seal and cooling waters used on pumps, agitators, drives, bearings, vacuum pumps, and process controls. Also cooling water is required by those mills that include the asphalt saturating process for the production of roofing felts and shingles. This water represents the second largest contributor to the volume of waste water generated by the process.

4. To supply emergency make-up water, under automatic control, to various storage tanks to avoid operational problems resulting in reduced production or complete mill shut down.

5. To provide power boiler condenser, heat exchange condensate, and non-contact cooling water that can be segregated and discharged separately without treatment. However, there are many mills that still permit all or part of this water to enter the waste water sewer system which increases the volume of water requiring treatment.

Specific Process Use

The manufacture of building paper involves three relatively discrete process systems in terms of quantity and quality of water utilization: stock preparation and the wet end and dry end of the machine. An illustrative process flow diagram is shown in Figure 3.

Stock Preparation Area

The stock preparation area uses water for purposes described in Items 1, 3, 4, and 5 of the General Use section. Water in the form of steam may also be used directly to maintain stock temperature which contributes to the volume of waste water generated since it represents excess water in terms of the process water balance.

Process water is mixed with baled waste paper in the pulper or beater and the resulting slurry is then carried through the stock cleaning system where additional process water is introduced. The stock is then thickened to increase consistency for refining or jordaning (fiber control). The process water removed by the thickener or decker is recirculated back to the pulper and cleaning system. A mill utilizing wood flour instead of wood pulp from an attrition mill adds the flour in the above waste paper stock system ahead of the jordans or refiners. However, those that use wood chips and/or rags and/or inorganic materials such as asbestos require a preparation process for each type of furnish used. These are generally low volume water users although each system contributes to the waste load generated. The various stock components are blended and passed through the refiners and discharged to a machine stock chest.

Wet End Area

The stock is pumped to a head box which meters the quantity of stock of the paper machine. At this point process water is added to reduce the stock consistency to 0.25-0.5 percent in the vat which is the forming section of the machine. The stock deposits on a cylinder wire and the excess machine white water passes through the wire. A large portion of this white water is recycled back through the machine stock loop and the excess is pumped to a white water collection chest for reuse in the stock preparation area. It is on the wet end that excess water is created by the use of fresh water showers as described in Item 2 of the General Use Section. The sheet is carried by felts to the press sections where additional quantities of water are removed. Felt cleaning showers add more excess water, but are necessary for the maintenance of the drainability of the felt.

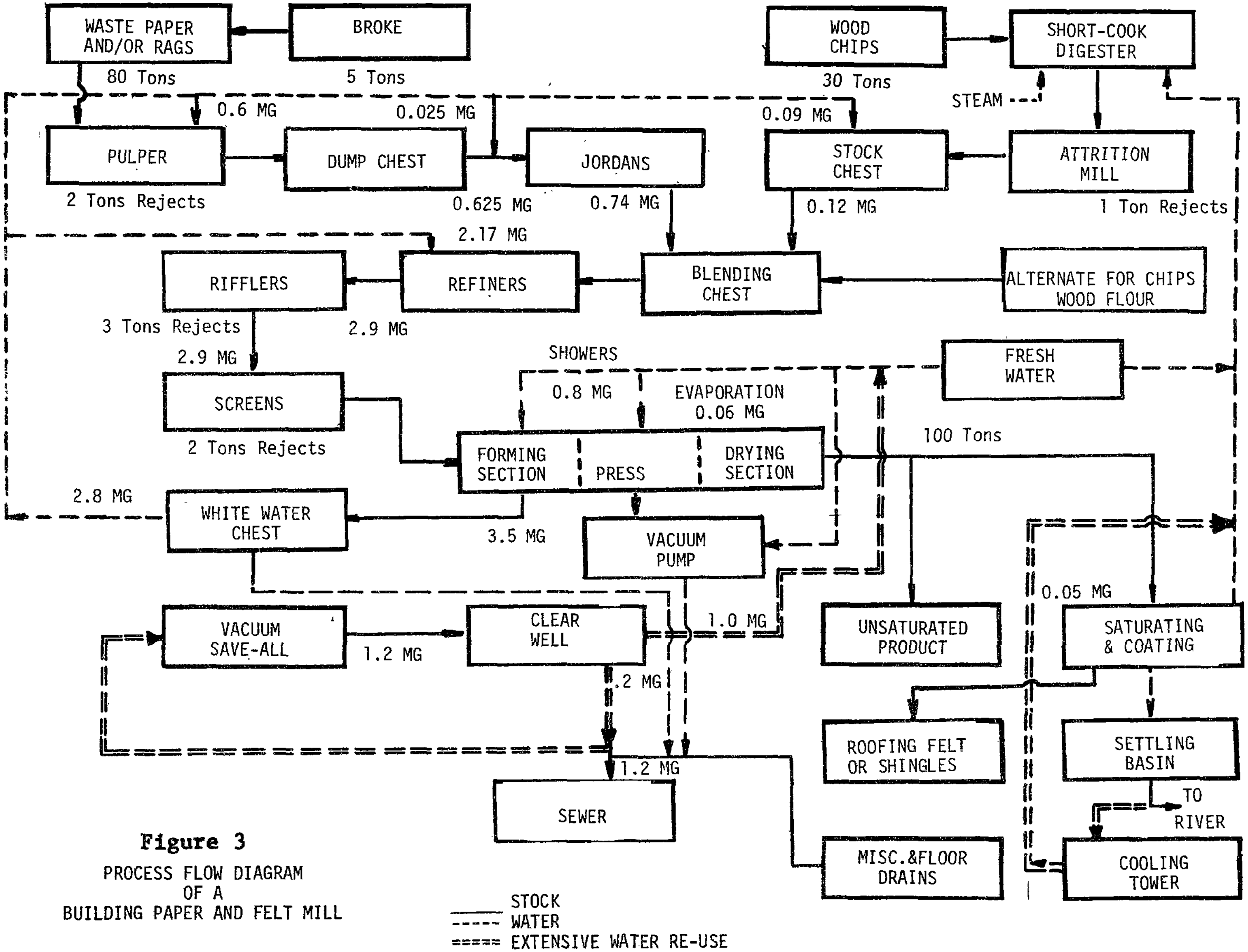


Figure 3

PROCESS FLOW DIAGRAM
OF A
BUILDING PAPER AND FELT MILL

Dry End Area

The sheet passes through the drier section to the dry end where water use is generally low in volume consisting principally of cooling water and sheet moisture control. The product at this point may be the finished product or it may be subject to additional processes in the mill. For some products, the saturating process is the next waste generating step after the papermaking process. However, the production of deadening or flooring felts from the paper produced does not require processing which generates a waste water load.

Asphalt Saturating Process

The paper is carried through one or two stations for asphalt saturation and application of a coat of talc on one side of the sheet. This requires the utilization of cooling water applied by spray nozzles after each saturation which represents the waste load sewered from the area. This process has the capability of making roofing shingles as well as roofing felts; therefore a section for coating the saturated felt with a granular stone and/or mica is part of the operation. These particles fall to the floor and are washed to the sewer and represent the principal source of inert suspended solids in the waste water generated in the area. As explained in Section VII, the volume of water used for this application varies widely, and the resulting waste water is very low in BOD5.

UNIT PROCESS WASTE LOADS

Definitive data on individual waste loads from each of the above process sources do not presently exist, and are difficult to develop: First, many, if not most, mills in this subcategory change raw materials and products manufactured in response to short term pricing, availability, and demand. Figure 3 demonstrates the complexity of process options which may be used in even a single mill in response to these factors. Second, the pronounced tendency in these mills toward increased recycle could erroneously attribute a waste load to one unit process which actually originated in another. Such recycle, as explained below and in Section VII, reduces pollutant levels in the raw waste and in the final discharge.

TOTAL RAW WASTE LOAD

Definition of "total raw waste load" from mills in this subcategory is subject to interpretation dependent upon the particular scheme of recycle used. Three principal schemes have been identified, each being effective insofar as reduction of final discharge pollutants is concerned, and each dependent upon product quality, mill layout, and other factors:

1. An internal device such as a save-all or DSM screen is used to remove suspended solids. Both the solids and the clarified process water may then be recycled, at least in part, resulting in a low "raw waste" level of suspended solids.

2. An external device such as a mechanical clarifier is used to serve the same functions. The influent to the clarifier may technically be called "raw waste," but any effluent not reused would be the definition comparable to scheme #1.

3. The third scheme relies principally upon internal recycle, with internal or external storage facilities to hold surge flows due to grade changes and other process upsets. Most of these surge flows are then returned to the process as production equilibrium is again approached, with only a small and sometimes intermittent final waste flow occurring.

Thus, raw waste loads from mills in this subcategory vary widely, depending upon the definition used. Data developed in 1971 illustrate this point. Of 13 mills in this subcategory, raw waste suspended solids varied typically from 2.5 kilograms per metric ton (5 pounds per short ton) to 30 kilograms per metric ton (60 pounds per short ton).

Raw waste suspended solids for the two selected mills ranged from 4 kg/kkg (8 lbs/ton) to 42 kg/kkg(84 lbs/ton). Raw waste BOD_5 for the two selected mills ranged from 7 kg/kkg (14 lbs/ton) to 15 kg/kkg(30 lbs/ton). The above raw waste characteristics are show in Table 3.

Although no definition of "total raw waste load" fits all cases, the "primary effluent not recycled" probably meets most field conditions as the best definition.

Final effluent flow is a measure of the degree of reuse employed by a given mill. The first surveyed mill employed extensive recycle and used only 4,200 liters per metric ton (1,000 gallons per short ton) during the four days of the survey. The second mill, which did not employ extensive recycle, used 54,000 liters per metric ton (13,000 gallons per short ton) during the survey.

Longer term data from the 13 mills mentioned above show a wide variation in water usage, primarily as a function of recycle. The typical range among these mills was from 8,400 liters per metric ton (2,000 gallons per short ton) to 42,000 liters per metric ton (10,000 gallons per short ton).

Table 3

Raw Waste Characteristics

Mill	BOD5 kg/kkg (lbs/ton)	TSS kg/kkg (lbs/ton)
BP-1*	12.6 (25.2)	41 (82)
BP-1**	9.5 (19)	42 (84)
BP-2**	7.2 (14.3)	4.1 (8.3)

* Mill Records
** Short term survey data (3-7 days)

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

WASTE WATER PARAMETERS OF SIGNIFICANCE

A thorough analysis of the literature, mill records, sampling data which has been derived from this study, and the NPDES applications demonstrates that the following constituents represent pollutants according to the Water Pollution Control Act for the subcategories under study:

Biochemical Oxygen Demand (5-day, 20°C) (BOD_5)
Total Suspended Solids (TSS)
Settleable Solids
pH

RATIONALE FOR SELECTION OF IDENTIFIED PARAMETERS

Biochemical Oxygen Demand (5-day, 20°C)

Biochemical oxygen demand (BOD) is a measure of the oxygen consuming capabilities of organic matter. The BOD_5 in builders paper and roofing felt mill effluents is a result of the raw materials and the manufacturing processes as shown in Sections III and V.

The BOD_5 does not in itself cause direct harm to a water system, but it does exert an indirect effect by depressing the oxygen content of the water. Sewage and other organic effluents during their processes decomposition exert a BOD_5, which can have a catastrophic effect on the ecosystem by depleting the oxygen supply. Conditions are reached frequently where all of the oxygen is used and the continuing decay process causes the production of noxious gases such as hydrogen sulfide and methane. Water with a high BOD_5 indicates the presence of decomposing organic matter and subsequent high bacterial counts that degrade its quality and potential uses.

Dissolved oxygen (DO) is a water quality constituent that, in appropriate concentrations, is essential not only to keep organisms living but also to sustain species reproduction, vigor, and the development of populations. Organisms undergo stress at reduced DO concentrations that make them less competitive and able to sustain their species within the aquatic environment. For example, reduced DO concentrations have been shown to interfere with fish population through delayed hatching of eggs, reduced size and vigor of embryos, production of deformities in young, interference with food digestion, acceleration of blood clotting, decreased tolerance to certain toxicants, reduced food efficiency and growth rate, and reduced maximum sustained swimming speed. Fish food organisms are likewise affected adversely in conditions with suppressed DO. Since all aerobic aquatic organisms need a certain amount of oxygen, the consequences of total lack of dissolved oxygen due to a high BOD5 can kill all inhabitants of the affected area.

If a high BOD5 is present, the quality of the water is usually visually degraded by the presence of decomposing materials and algae blooms due to the uptake of degraded materials that form the foodstuffs of the algal populations.

Total Suspended Solids (TSS)

Total Suspended Solids (or Suspended Solids) is a measure of non-dissolved solids in the waste water which are trapped or "suspended" on a test filter medium. Suspended solids in builders paper and roofing felt mill effluents are generally fibrous materials lost in the manufacturing process. Most of these suspended solids can be removed by primary treatment with most of the remainder removed by secondary treatment. The suspended solids discharged from builders paper and roofing felt mill secondary treatment systems are generally biological organisms generated in the secondary treatment system in the removal of BOD5, and thus are not of the same characteristic as the suspended solids in mill waste waters. These suspended solids have the following detrimental effects upon receiving waters: (1) increases in turbidity of the receiving water resulting in reduced light transmission and accompanying effects, such as reduced photosynthesis, (2) degradation of aesthetic values, (3) settling of suspended solids to the bottom of receiving waters, and (4) exertion of BOD by the biological suspended solids is only partically measured by the BOD5 test as the long term BOD (often expressed BOD20) would be more descriptive of the oxygen consuming effects. A general description of suspended solids and effects upon receiving waters is given below.

Suspended solids include both organic and inorganic materials. The inorganic components include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, animal and vegetable fats, various fibers, sawdust, hair, and various materials from sewers. These solids may settle out rapidly and bottom deposits are often a mixture of both organic and inorganic solids. They adversely affect fisheries by covering the bottom of the stream or lake with a blanket of material that destroys the fish-food bottom fauna or the spawning ground of fish. Deposits containing organic materials may deplete bottom oxygen supplies and produce hydrogen sulfide, carbon dioxide, methane, and other noxious gases.

In raw water sources for domestic use, state and regional agencies generally specify that suspended solids in streams shall not be present in sufficient concentration to be objectionable or to interfere with normal treatment processes. Suspended solids in water may interfere with many industrial processes, and cause foaming in boilers, or encrustations on equipment exposed to water, especially as the temperature rises. Suspended soilds are undersirable in water for textile industries; paper and pulp; beverages; dairy products; laundries; dyeing; photography; cooling systems, and power plants. Suspended particles also serve as a transport mechnism for pesticides and other substances which are readily sorbed into or onto clay particles.

Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These settleable solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration and impair the photosynthetic activity of aquatic plants.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often much more damaging to the life in water, and they retain the capacity to displease the senses. Solids, when transformed to sludge deposits, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic and therefore decomposable nature, solids use a portion oor all of the dissolved oxygen available in the area.

Settleable Solids

The settleable solids test involves the quiescent settling of a liter of wastewater in an "Imhoff cone" for one hour, with appropriate handling (scraping of the sides, etc.). The method is simply a crude measurement of the amount of material one might expect to settle out of the wastewater under quiescent conditions. It is especially applicable to the analysis of wastewaters being treated by such methods as screens, clarifiers and flotation units, for it not only defines the efficacy of the systems, in terms of settleable material, but provides a reasonable estimate of the amount of deposition that might take place under quiescent conditions in the receiving water after discharge of the effluent.

pH, Acidity, and Alkalinity

The effluent from a typical biological treatment process will normally have a pH in the range of 6.0 to 9.0, which is not detrimental to most receiving waters. However, the application of some external technologies can result in major adjustments in pH. The effluent limitations which are cited insure that these adjustments are compensated prior to final discharge of treated wastes in order to avoid harmful effects within the receiving waters. A general description of pH, acidity, and alkalinity and their effects upon receiving waters is given below.

Acidity and alkalinity are reciprocal terms. Acidity is produced by substances that yield hydrogen ions upon hydrolysis and alkalinity is produced by substances that yield hydroxyl ions. The terms "total acidity" and "total alkalinity" are often used to express the buffering capacity of a solution. Acidity in natural waters is caused by carbon dioxide, mineral acids, weakly dissociated acids, and the salts of strong acids and weak bases. Alkalinity is caused by strong bases and the salts of strong alkalies and weak acids.

The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. Lower pH values indicate acidity while higher values indicate alkalinity. The relationship between pH and acidity or alkalinity is not necessarily linear or direct.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add such constituents to drinking water as iron, copper, zinc, cadmium and lead. The hydrogen ion concentration can affect the "taste" of the water. At a low pH water tastes "sour." The bactericidal effect of chlorine is weakened as the pH increases, and it is advantageous to keep the pH close to 7. This is very significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Dead fish, associated algal blooms, and foul stenches are aesthetic liabilities of any waterway. Even moderate changes from "acceptable" criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. Metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. The availability of many nutrient substances varies with the alkalinity and acidity. Ammonia is more lethal with a higher pH.

The lacrimal fluid of the human eye has a pH of approximately 7.0 and a deviation of 0.1 pH unit from the norm may result in eye irritation for the swimmer.

RATIONALE FOR PARAMETERS NOT SELECTED

Oil and Hexane Solubles

The asphalt saturation process associated with the production of roofing felts has a potential for developing an oil and grease (hexane soluble) constituent in the waste water generated by the process. Useful data regarding the concentrations of oil and grease in the treated waste water generated by mills engaged in this activity are almost negligible. However, if the identified treatment systems are operated efficiently, any oil and grease should be effectively removed. Thus, oil and grease is not considered as a separate pollutant parameter. A general description of oil and grease is given below.

Oil and grease exhibit an oxygen demand. Oil emulsions may adhere to the gills of fish or coat and destroy algae or other plankton. Deposition of oil in the bottom sediments can serve to exhibit normal benthic growths, thus interrupting the aquatic food chain. Soluble and emulsified material ingested by fish may taint the flavor of the fish flesh. Water soluble components may exert toxic action on fish. Floating oil may reduce the re-aeration of the water surface and in conjunction with emulsified oil may interfere with photosynthesis. Water insoluble components damage the plumage and costs of water animals and fowls. Oil and grease in a water can result in the formation of objectionable surface slicks preventing the full aesthetic enjoyment of the water.

Oil spills can damage the surface of boats and can destroy the aesthetic characteristics of beaches and shorelines.

Color

Color is defined as either "true" or "apparent" color. In Standard Methods for the Examination of Water and Waste Water (1), the true color of water is defined as "the color of water from which the turbidity has been removed." Apparent color includes "not only the color due to substances in solution, but also due to suspended matter." Color has not been a problem in effluents from builders paper and roofing felt mills. Short term survey data substantiated this as it showed only two kilograms per metric ton (four pounds per short ton) of color. Thus, color was not included as a separate pollutant parameter.

Nutrients

Waste water discharged from builders paper and roofing felt mills is deficient in nitrogen and phosphorus. Frequently, nutrients must be added to mill effluents in amounts sufficient to enhance biological treatment. Thus, nutrients were not included as separate pollutant parameters. A general description of the nutrients, ammonia and phosphorous is given below.

Ammonia

Ammonia is a common product of the decomposition of organic matter. Dead and decaying animals and plants along with human and animal body wastes account for much of the ammonia entering the aquatic ecosystem. Ammonia exists in its non-ionized form only at higher pH levels and is the most toxic in this state. The lower the pH, the more ionized ammonia is formed and its toxicity decreases. Ammonia, in the presence of dissolved oxygen, is converted to nitrate (NO_3) by nitrifying bacteria. Nitrite (NO_2), which is an intermediate product between ammonia and nitrate, sometimes occurs in quantity when depressed oxygen conditions permit. Ammonia can exist in several other chemical combinations including ammonium chloride and other salts.

Nitrates are considered to be among the poisonous ingredients of mineralized waters, with potassium nitrate being more poisonous than sodium nitrate. Excess nitrates cause irritation of the mucous linings of the gastrointestinal tract and the bladder; the symptoms are diarrhea and diuresis, and drinking one liter of water containing 500 mg/l of nitrate can cause such symptoms.

Infant methemoglobinemia, a disease characterized by certain specific blood changes and cyanosis, may be caused by high nitrate concentrations in the water used for preparing feeding formulae. While it is still impossible to state precise concentration limits, it has been widely recommended that water containing more than 10 mg/l of nitrate nitrogen (NO_3-N) should not be used for infants. Nitrates are also harmful in fermentation processes and can cause disagreeable tastes in beer. In most natural water the pH range is such that ammonium ions (NH_4^+) predominate. In alkaline waters, however, high concentrations of un-ionized ammonia in undissociated ammonium hydroxide increase the toxicity of ammonia solutions. In streams polluted with sewage, up to one half of the nitrogen in the sewage may be in the form of free ammonia, and sewage may carry up to 35 mg/l of total nitrogen. It has been shown that at a level of 1.0 mg/l un-ionized ammonia, the ability of hemoglobin to combine with oxygen is impaired and fish may suffocate. Evidence indicates that ammonia exerts a considerable toxic effect on all aquatic life within a range of less than 1.0 mg/l to 25 mg/l, depending on the pH and dissolved oxygen level present.

Ammonia can add to the problem of eutrophication by supplying nitrogen through its breakdown products. Some lakes in warmer climates, and others that are aging quickly are sometimes limited by the nitrogen available. Any increase will speed up the plant growth and decay process.

Phosphorus

During the past 30 years, a formidable case has developed for the belief that increasing standing crops of aquatic plant growths, which often interfere with water uses and are nuisances to man, frequently are caused by increasing supplies of phosphorus. Such phenomena are associated with a condition of accelerated eutrophication or aging of waters. It is generally recognized that phosphorus is not the sole cause of eutrophication, but there is evidence to substantiate that it is frequently the key element in all of the elements required by fresh water plants and is generally present in the least amount relative to need. Therefore, an increase in phosphorus allows use of other, already present, nutrients for plant growths. Phosphorus is usually described, for this reasons, as a "limiting factor."

When a plant population is stimulated in production and attains a nuisance status, a large number of associated liabilities are immediately apparent. Dense populations of pond weeds make swimming dangerous. Boating and water skiing and sometimes fishing may be eliminated because of the mass of vegetation that serves as an physical impediment to such activities. Plant populations have been associated with stunted fish populations and with poor fishing. Plant nuisances emit vile stenches, impart tastes and odors to water supplies, reduce the efficiency of industrial and municipal water treatment, impair aesthetic beauty, reduce or restrict resort trade, lower waterfront property values, cause skin rashes to man during water contact, and serve as a desired substrate and breeding ground for flies.

Phosphorus in the elemental form is particularly toxic, and subject to bioaccumulation in much the same way as mercury. Colloidal elemental phosphorus will poison marine fish (causing skin tissue breakdown and discoloration). Also, phosphorus is capable of being concentrated and will accumulate in organs and soft tissues. Experiments have shown that marine fish will concentrate phosphorus from water containing as little as 1 ug/l.

Turbidity

Turbidity is an expression of the optical property of the fine suspended matter in a sample of water. The suspended matter may be clay silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. The suspended matter causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. The builders paper and and roofing felt subcategory may have effluents which have high turbidities. However, turbidity is not considered as a pollutant parameter because an adequate data base does not exist for turbidity in builders paper and roofing felt mill effluents and the treatment systems which are installed to reduce BOD_5 should also reduce turbidity.

Polychorinated Biphenyls

Polychlorinated biphenyls (PCB's) are chemically and thermally stable compounds found in waste paper and are known to cause deleterious effects upon biological organisms. They have been shown to concentrate in food chains and few restrictions on their control exist at present. Recycled office papers are the main source at present, although occasionally paperboard extracts show evidence of Monsanto's Aroclor 1254 (PCB) from environmental and other sources. Quantities of PCB in recycled wastepaper are generally low. PCB's are not being added to paper products and are being purged from the system through process waters, volatilization and paper destruction. This parameter is not considered as a separate pollutant parameter because an adequate data base and an adequate means of control technology do not exist at this time.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGIES

Waste waters discharged from mills in the building paper and roofing felt industry to receiving waters can be reduced to required levels by conscientious application of established in-plant process loss control and water recycle measures and by well designed and operated external treatment facilities.

This section describes both the in-plant and external technologies which are either presently available or under intensive development to achieve various levels of pollutant reduction. External technology is used to treat the residual waste concentration levels to achieve the final reduction of pollutants discharged to the environment. Tables 4 and 5 summarize internal and external pollution control technologies, respectively, which are applicable to builder's paper and roofing felt mills. Table 6 shows the estimated distribution of external treatment systems employed at builders paper and roofing felt mills.

TABLE 4
SUMMARY OF INTERNAL TECHNOLOGIES
Building Paper and Roofing Felt Mills

1. Reuse of white water
2. Saveall system
3. Shower water reduction/reuse
4. Gland water reduction/reuse
5. Vacuum pump seal water reduction/reuse
6. Internal spill collection
7. Segregation of non-contact process water
8. Low volume cooling spray shower nozzles

TABLE 5
SUMMARY OF EXTERNAL TECHNOLOGIES
Building Paper and Roofing Felt Mills

BASIC FUNCTION	ALTERNATIVE TECHNOLOGIES
Screening	Traveling, self-cleaning Bar Screen
Suspended Solids Removal	(C) Mechanical Clarifier (L) Earthen Basin (MMF) Mixed (multi)-Media Filtration (Coag) Coagulation
BOD_5 Removal	(ASB) Aerated Stabilization Basin (AS) Activated Sludge (SO) Storage Oxidation Ponds
Temperature Control	Cooling Tower

Table 6

Estimated Distribution of Treatment Systems Employed at Builders Paper and Roofing Felt Mills

Number of Plants	81
Plants Using Municipal Systems	50%
Non-Municipal Plants with Access to Municipal Systems	25%
Plants with No Treatment	7%
Primary Only or Equivalent	10%
Plants Using Activated Sludge	4%
Plants Using Aerated Stabilization Basins	4%
Plants Using Storage Oxidation Ponds	None

INTERNAL CONTROLS

Recovery and Recycle Concepts

Generally, mills that reduce effluent volume through recycle reduce raw waste pollutant loads concommitantly. As discussed in Section V, in some cases a mill may employ extensive suspended solids removal equipment internally, reusing both the clarified water for manufacture and the recovered solids in the product, whereas another mill depends on an extensive primary clarifier for suspended solids removal. This study indicated that similar reductions in pollution loads are achieved by both methods of treatment.

Large quantities of water are necessary to form a sheet of paper. Typically, the fibrous stock is diluted to about 0.5 percent consistency before entering the paper machine itself. Such dilutions are necessary in order to provide uniform dispersion of the fibers in the sheet forming section. Most of this water must be removed in the wet end of the machine since only a small amount of moisture, typically five to eight percent by weight, is retained in the product at the dry end.

After leaving the forming section of the machine, the sheet of paper or board contains about 80 percent moisture. A press section employing squeeze rolls, sometimes utilizing vacuum, is used to further reduce moisture to a level of about 40 percent. The remaining moisture is evaporated by steam-heated drying rolls.

Water leaving the forming and press sections is called white water, and approximates 104,325 liters per metric ton (25,000 gallons per short ton) of product. Due to recycling, only a relatively small portion of the total is wasted. Mills which utilize varying amounts of extensive recycling discharge only 2087 to 20,865 liters of white water per metric ton (500 to 5000 gallons of white water per short ton) from the system.

Recycling of this white water within the stock preparation and wet end of the papermaking machine has long been practiced in the industry. However, in recent years very extensive reuse of treated white water has been achieved. The replacement of fresh water with treated white water is the mechanism by which final waste water volume is reduced. It has been demonstrated that with a closed water system the concentration of solids increases significantly to a high level at which plateau it remains, varying only plus or minus 10 to 15 percent. Thus, a significant result of total or near total recycle of process water is that dissolved solids, derived primarily from raw materials, are removed from the process water system via the product manufactured rather than in the waste stream.

Problems are experienced, however, as near total recycle of process water is approached. It appears, though, that the production process and product quality of mills in the building paper industry, and particularly those manufacturing roofing felt paper, are such that with good system design these problems can be overcome. This posture is supported, to some extent, by a report from one mill in the industry. In this instance both in-plant and external biological treatment facilities, using the activated sludge process and final chlorination, were installed. After a year of operation, the mill is near a decision to eliminate its discharge to the environment and operate a completely closed process water system. In addition, an on-going EPA supported project will demonstrate the elimination of discharge from a roofing felt mill and will also provide information on conversion to closed loop operation, its costs and effect on product quality. The overall costs of closed loop operation are expected to be much less than the costs of end-of-the-pipe treatment technologies.

Saturated roofing felt mills have a water use requirement which is independent of that for the papermaking process. This water is essentially cooling water that becomes contaminated by the granular particles used to coat the saturated felts. The cooling water is applied across the festooned sheet immediately after it passes through the hot liquor asphalt saturation bath. This study indicated that there is no measurable contamination of the water due to its contact with the hot asphalt. The volume required depends entirely on the types of showers used and therefore varies over a wide range, perhaps as low as 209 liters per metric ton (50 gallons per short ton) to as high as 4173 liters per metric ton (1000 gallons per short ton) of paper saturated. There are mills that segregate this water and convey it to a settling pond for the removal of readily settleable suspended solids. However, in order to reuse it as cooling water it is necessary to employ a cooling tower process application. The success of this recycle system, on a year round basis, is not well documented since the reduction in pollution load that can be achieved does not necessarily warrant the capital investment, increased operating costs, and potential loss of production inherent in the operation of such a system. Those systems that have been installed have not been operated on a continuous basis by virtue of the weather-dependent nature of a cooling tower.

Internal Recovery Equipment

Most mills employ a save-all to recover fibrous and other suspended solids from the process water of which there are three principal types. (1) One is the gravity or vacuum drum type which employs a rotating screen-covered drum immersed in a vat containing the waste water. The water passes through the drum, leaving a mat of fiber which is removed continuously for reuse. (2) The vacuum disc filter is another type of save-all which utilizes a series of screen-covered discs on a rotating shaft immersed in the vat. Both types filter the white water through a filter mat; however, the disc type has the advantage of greater filtering area or capacity per unit volume. This filtering medium in each case is provided by a side-stream of "sweetener" stock added to the influent to act as a filtering mat for the removal of suspended solids. The recovered fiber and sweetener stock is returned for reuse directly to the stock system. (3) A third type is a stationary bar screen with very fine slots between the bars which has in recent years been employed by mills in this industry for the recovery of fiber from the process water system. There is a significant economic advantage in this type of system. However, the quality of the effluent is not as good in terms of suspended solids as that generated by vacuum filters.

All or part of the effluent from a save-all may be discharged directly to a sewer, but most mills reuse a significant portion for such services as:

1. Machine Showers

2. Stock clean elutriation

3. Pump and agitator seals

4. Vacuum pump seals

5. Wash-ups

6. Consistency regulation dilution

Machine Showers

Machine and felt showers are used in both the forming and press sections to clean the wire, felts, and other machine elements subject to contact with the stock. Formerly, large volumes of fresh water were used for this purpose, but in recent years, attention has focused on the use of recycled white water. However, a suspended solids content of less than 120 milligrams per liter (one pound per thousand gallons) is generally required to avoid plugging of shower nozzles. Concurrently, the use of high pressure (up to 52 atm. or 750 psig), low volume showers using fresh water has increased. These are employed where product, operability, cleanliness, or other factors mitigate against the use of white water showers. These high pressure showers are operated on a time cycle, so that flow occurs only a small percentage, 10 to 20 percent, of the time.

Whether recycled water or lower volumes of fresh water are used for showers, a reduction in fresh water usage and its concomitant waste water flow results. Significantly, this reduction also decreases the fiber losses to sewer.

Seal Water

Vacuum pumps are essential to the paper forming process as presently practiced to provide a vacuum source to accelerate the removal of water from the sheet as formed, and to dry the felts for each pass through the wet end. Most such pumps are of the ring seal type, which requires water to provide a seal between the moving parts of the pump and avoid backflow of air to the vacuum side. Water used for this purpose must be sufficiently free of suspended solids to avoid plugging of the orifices or other control devices used to meter it to the pump. Further, it must not be corrosive to the mechanical parts of the pump, and it must be relatively cool (typically less than 32 C (90 F) to permit development of high vacuums of o.67-0.74 atm. (20-22 in. Hg.). For lower vacuum requirements 0.17-0.40 atm. (5-12in. hg.), somewhat higher temperatures are permissible.

Seal water is also used on packing glands of process pumps, agitators, and other equipment employing rotating shafts. It cools bearings, lubricates the packing, and minimizes leakage of the process fluid. Even though the amount of water used per packing is small -- generally in the range of 1.86 to 11.34 liters per minute (0.5 to 3 gpm) -- the total usage is quite extensive because of the large number of rotating shafts required in the processes. The total usage may approximate 4173-8346 liters per metric ton (1000-2000 gallons per short ton) of product. Methods used to control and reduce the quantities of water required include proper maintenance of packings and flow control of individual seal water lines.

As more extensive recycle is employed the significance of the quantity of seal water used for all purposes in the mill increases in terms of waste water volume. The use of mechanical seals has reduced the amount of seal water, but they have so far not proven satisfactory in terms of maintenance and reliability for many applications.

The replacement of fresh water with clarified waste water in the building paper industry is dependent largely on maintaining a level of suspended solids in the recycled seal water at 120 mg/l or less. The vacuum required on the paper machines in these mills indicates that a seal water temperature of 49 degrees centigrade can be tolerated. The limits to recycle in the water use area will be more completely documented as more mills develop reuse systems.

Stock Cleaning Systems

A majority of mills in this industry employ a stock cleaning system that dates back many years, the riffler. This is a simple device that removes sand, grit, metals, and other readily settled contaminants from the stock slurry. This system subjects the process water system to insignificant, if any, fresh water requirements and satisfies the cleaning needs of the production quality. The contribution to the waste water load is also small since the solids removed from the stock can be removed at intervals from the bottom of the riffler trough, generally at most, once a week. This material is disposed of by trucking to a plant-owned or municipal land disposal area.

If cleaning at the machine is practiced, flat bed slotted plate vibrating screens are generally employed. This method of cleaning, as with a riffler, has been in use for many years. Again, rejects are removed in a relatively dry state for truck disposal and the impact on the waste water generated by the mill is negligible.

The trend toward replacement of these older cleaning systems with more modern equipment will increase in this industry as labor and maintenance costs exceed the increased power costs associated with the new equipment. With newer cleaning equipment there is potential for increased quantities of rejects and, more importantly, fiber discharged to the sewer. This phenomenon has already been experienced by many mills in the waste paperboard industry. The effect on the waste water load generated can be minimized or eliminated by the inclusion of a well designed rejects handling system along with an improved cleaning system. The effectiveness of these systems becomes more significant to a mill as it approaches near total recycle of process water. In fact, under this condition it becomes of paramount importance since rejects cannot escape from the mill in the waste water, and therefore build up in the system unless removed in a relatively dry state by an adequate rejects handling system.

Cooling Water

Cooling water is used for bearings, particularly in older mills using sleeve bearings instead of the anti-friction bearings employed in new or rebuilt mills. Cooling water is not contaminated and can be collected and reused either directly (after heat removal), or indirectly by discharge into the fresh water system, if heat buildup is not a problem. Similarly, water used to cool brake linings in paper rewind applications may be reused, but because of high heat loads cooling of this water by cooling towers or other means would usually be necessary. None of the mills surveyed in this study cooled this water. However, one mill surveyed returned dryer condensate directly to the feed water heater at the boiler plant under 1.20-1.34 atm. (three-five psig) pressure, thereby reducing the cooling water requirement. This approach could be used more generally where dryers are operated at pressures above 1.34 atm. (five psig).

Asphalt Cooling

The volume of waste water generated in the felt saturating cooling process is entirely dependent on the type of shower nozzles used to spray the sheet. A very high reduction in water requirements with increased cooling efficiency -- i.e., temperature drop per unit time -- has been achieved with special nozzles. The need to settle the waste water generated by this process is established, and the ability to recycle after cooling has been demonstrated. However, because of its low pollutant load, the need to recycle this waste after settling versus discharge to the environment appears to be an issue to be determined on an individual mill basis. Surveyed mill "b," for example, used 209 liters of cooling water per metric ton of production (50 gal/ton). It utilized a cooling tower to cool this water on a seasonal basis for reuse. When the cooling tower was operating, net discharge flow was reduced to an estimated 19 liters (five gallons) per metric ton.

EXTERNAL TREATMENT TECHNOLOGY

Waste treatment requirements do not vary appreciably among mills in the building paper industry. Although there are variations in concentrations and specific waste constituents, the general classes of compounds which can be expected to occur in their wastes derive from the pulping of wood fiber or repulping of waste fiber and are, thus, characteristic of them all. These substances are dissolved organic components of wood and cellulose degradation products. They make up the bulk of the oxygen demanding wastes of this subcategory. The pulping of rags adds to the waste load generated. In addition, other compounds such as adhesives, sizing material, and resinates are used by the industry depending on product. The residual of all of these substances in the waste load or combinations of them, appears to be amenable to the various biological treatment processes used by the industry.

Removal of Suspended Solids

The physical process of removing suspended organic and inorganic materials, commonly termed "primary treatment," is generally accomplished by sedimentation. Screening ahead of treatment units is necessary to remove trash materials which could seriously damage or clog succeeding equipment. Automatically cleaned screens, operating in response to level control, are commonly employed and represent preferred practice.

Primary treatment can be accomplished in mechanical clarifiers or sedimentation lagoons. Although the latter enjoyed widespread use in the past, the large land requirements, coupled with inefficient performance and high cost for cleaning, have made them less popular in recent years (8).

The most widely used method for sedimentation in this industry is the mechanically-cleaned quiescent sedimentation basin (8). Large circular tanks of concrete construction are normally utilized with rotating sludge scraper mechanisms mounted in the center. Flow usually enters the tank through a well which is located at the center of the tank. Settled sludge is raked to a center sump or concentric hopper and is conveyed back to the process system. Floating material is collected by a surface skimmer attached to the rotating mechanism and discharged to a hopper. This material may be brought back to the process or carried to land disposal.

A properly designed and installed mechanical clarifier is capable of removing over 95 percent of the settleable suspended solids from the waste water. The removal efficiency of this fraction of the total suspended solids is the true measure of performance for this device since it cannot be expected to separate those solids which will not settle under the most favorable conditions.

Because of the biodegradable nature of a portion of the settleable solids present in the effluents of these mills, clarification results in some BOD_5 reduction.

Biological Treatment

BOD reduction is generally accomplished by biological means, again because of the relative biodegradability of most of the organic substances in the waste. Advances in reduction of internal losses and recycling of process water have increased BOD concentrations in the waste to be treated. However, this, in general, seems to improve the removal efficiency of the process.

Current biological treatment practice includes the use of very large storage oxidation basins, aerated stabilization basins, or the activated sludge process and modifications thereof. The storage oxidation basin and the aerated stabilization basin because of their large land requirements have not found wide application in this industry. Most of the mills are located in relatively populated areas with minimum land availability. Therefore, the activated sludge process has had wider acceptance.

The land requirements of the oxidation basin are due to the fact that it is a relatively low-rate process. Because of the availability of land, and the warmer climate which helps to maintain consistent biological activity, most natural oxidation basins are found in the Southern states (8). Design loading rates of 56 kilograms BOD_5 per hectare per day (50 pounds BOD_5 per acre per day) for natural oxidation basins to achieve 95-90 percent removal in warm climates have been reported (9).

By installing aeration equipment in a natural basin, its ability to assimilate BOD per unit of surface area is greatly increased. The aerated stabilization basin originally evolved out of the necessity of increasing performance of existing natural basins due to increasing effluent flows and/or more stringent water quality standards. Due to its inherent acceleration of the biological process, the aerated stabilization basin requires much less land than the natural stabilization basin and because of the long reaction period less nutrient addition than that required for activated sludge. Typically, 0.21 hectares per million liters (two acres per MGD) of the aerated stabilization basin compares with 4.8 hectares per million liters (40 acres per MGD) for natural basins for equivalent treatment levels (9).

Detention times in the aerated stabilization basin normally range from five to fifteen days, averaging less than 10 days.

Due to the relatively long aeration time, the buildup of sludge solids is considerably less than for higher rate processes, particularly where primary clarification is employed. Typical rates are 45.4 to 90.8 grams (0.1 to 0.2 pounds) of sludge generated for each 454 grams (1 pound) of BOD removed (8). The sludge is removed as formed by endogenous respiration, sludge loss in the effluent, and sedimentation within the aeration basin. However, discharge of untreated waste to an aerated stabilization basin without prior clarification can result in a buildup of sludge which after a period of time will impede its efficiency.

Most mill wastes are deficient in nitrogen and phosphorus. Therefore, the addition of nutrients to the aeration basin is generally practiced. Reported optimum ratios of BOD to nitrogen are 50:1 with four days aeration, and 100:1 with 10-15 days aeration (9). Aeration is normally accomplished using either gear-driven turbine-type aerators, direct-drive axial flow-pump aerators, and, in a few cases, diffused aerators. Oxygenation efficiencies under actual operating conditions range from 0.61 to 1.52 kilograms of oxygen per kilowatt per hour (one to 2.5 pounds of oxygen per horsepower per hour), depending on the type of equipment used, the amount of aeration power per unit lagoon volume, basin configuration, and the biological characteristics of the system. A dissolved oxygen level of 0.5 mg/l remaining in the lagoon liquid is required to sustain aerobic conditions (10). Approximately 1.1 to 1.3 kilograms of oxygen per kilogram BOD5 (1.1 to 1.3 pounds oxygen per pound BOD5) have been reported to maintain adequate DO for waste oxidation and endogenous respiration of the biological mass produced. Although the activated sludge process has been employed for many years to treat domestic sewage, it was first applied to the building paper industry only very recently. The process is similar to the aerated stabilization basin except that it is much faster, usually designed for four to eight hours of total detention time. The biological mass grown in the aeration tank is settled in a secondary clarifier and returned to the aeration tank, building up a large concentration of active biological material. Since there is approximately 2000-4000 mg/l of active sludge mass in the aeration section of this process, as opposed to 50-200 mg/l in the aerated stabilization basin, dissolved and suspended organic matter are degraded much more rapidly, greatly reducing necessary tank volume as well as required detention time. Since biological organisms are in continuous circulation throughout the process, complete mixing and suspension of solids in the aeration basin is required. The active microbial mass consists mainly of bacteria, protozoa, rotifers, fungi, and cynthonemotodes. Because the process involves intimate contact of organic waste with biological organisms, followed by sedimentation, a high degree of BOD and solids removals is obtained.

The contact stabilization process is a variation of activated sludge wherein two aeration steps are utilized rather than one. First, the incoming waste is contacted for a short period with active organisms prior to sedimentation. Settled solids are then aerated for a longer period to complete waste assimilation. Contact stabilization has not been applied successfully; however, conventional activated sludge has found accepted use in this industry.

The secondary clarifier in the activated sludge process performs the function of sedimentation of the active microbial mass for return to the aeration tank. Loading rates of about 211 liters per day per square meter (600 gallons per day per square foot) have been reported (11).

Due to the fact that the volume of bio-mass in the activated sludge process is greatly reduced because of the hydraulic detention time, endogenous respiration of the concentrated sludge is considerably lessened. Thus, there are additional quantities of excess sludge, three fourths kilogram of excess sludge per kilogram of BOD5 (three fourths pound of excess sludge per pound of BOD5), which must be disposed of.

As in the case of the aerated stabilization basin, aeration can be accomplished by mechanical or diffused aeration. The more efficient and more easily maintained mechanical method is generally preferred by the industry. Oxygen requirements where activated sludge processes are utilized are in the range of one kilogram of oxygen per kilogram of BOD5 (one pound of oxygen per pound of BOD5) removed.

Short detention times and low volumes make the activated sludge process more susceptible to upset due to shock loads. When the process is disrupted, several days are usually required to return the biological activity and high BOD removal rates back to normal. Thus, particular attention is required to avoid such shock loads in mills utilizing this process.

A flow diagram of alternative waste treatment systems at building paper mills is shown in Figure 4.

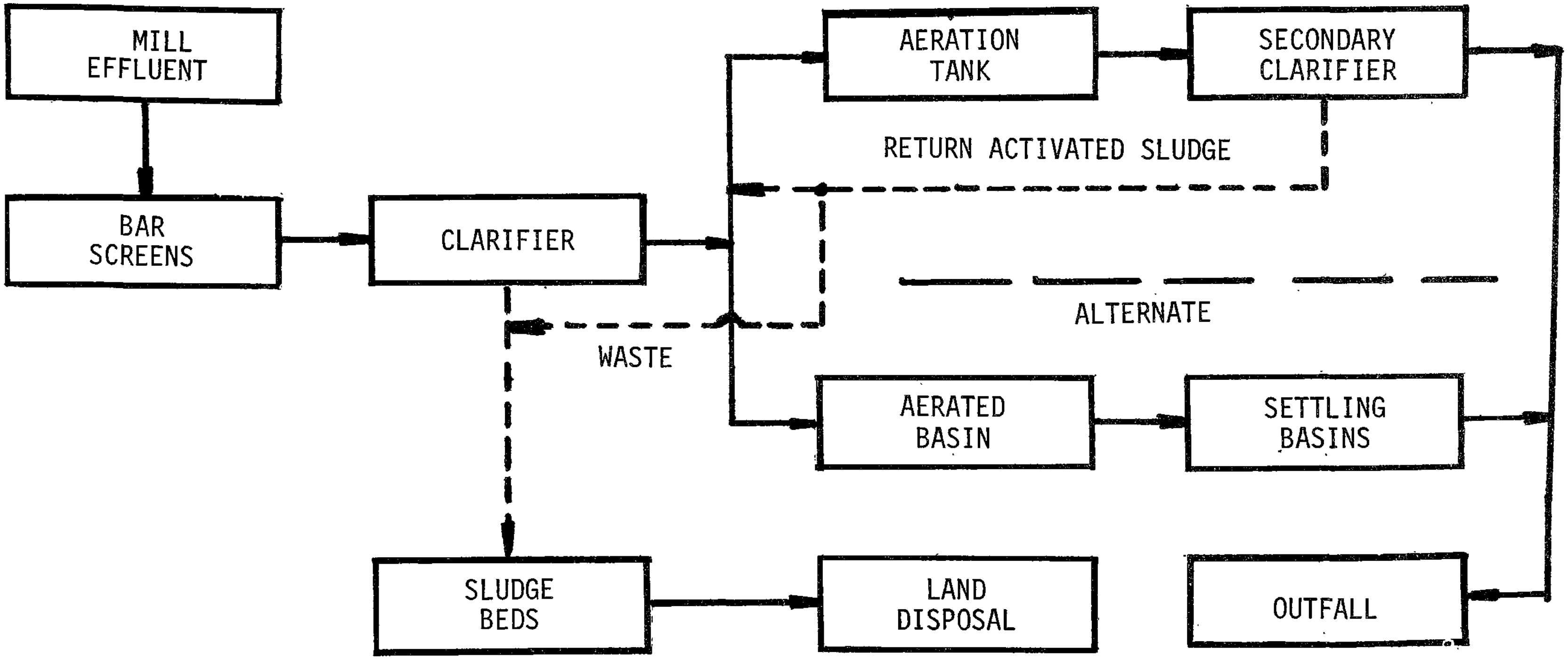


FIGURE 4

EFFLUENT TREATMENT AT

BUILDING PAPER MILLS

Two-Stage Biological Treatment

Two-stage biological treatment is employed to enhance the BOD removal obtained with a single stage. This concept consists of two biological treatments systems, usually arranged in series. In the literature (12) a two stage system is described which employs the activated sludge process in both stages in the treatment of municipal wastes. The authors note that the sludge may be returned or wasted within each stage, or that excess sludge from one stage may be recycled to the other. A principal advantage of this particular arrangement is that the sludge flows may be utilized to maximize BOD_5 removal. Other combinations of biological treatment may be employed in a two-stage arrangement. For example, a trickling filter may precede an aerated stabilization basin or an activated sludge system. This arrangment may be employed where the second stage is required because of insufficient performance of the trickling filter alone. It may also be used in cases where cooling of the waste is required before further biological treatment may proceed. In the latter case, the trickling filter serves as a partial cooling tower, and also accomplishes some BOD_5 reduction.

Two-stage aerated stabilization basins, operated in series, may have particular appeal for this industry. This arrangement usually requires less land than a single unit, and can be expected to provide better treatment on an equal-volume basis. For the first stage, a detention time up to two days or more is usually recommended, and up to 10 days or more for the second stage. If sufficient land is available at reasonable cost, this system is usually a less expensive approach than a two-stage system involving activated sludge. It has the further advantage of providing more detention time which is helpful in treating surges of flow or pollutant load. Under conditions of proper design and operation, including nutrient addition and surge basins located prior to biological treatment, BOD_5 removals of 90-95 percent can ultimately be expected to be achieved with this system.

A two-stage biological system currently employed by some Southern unbleached kraft mills utilizes aerated stabilization basins followed by storage oxidation. Typically, detention time of the former is eight to 14 days and for the latter is eight to 40 days. In these installations, overall BOD_5 removal (compared to raw waste) of 85 percent is being achieved, with 70 percent removal after first stage. These data do not, however, reflect usage of nutrients. It is probable that the addition of surge basins, coupled with nutrient addition, proper aeration and mixing capacity, will ultimately permit BOD_5 reductions of 90-95 percent in this system. For mills with adequate land and other favorable factors, this system may be the most economical approach.

Other combinations of two-stage biological treatment are, of course, possible. These would include use of activated sludge followed by an aerated stabilization basin, storage oxidation, or trickling filters. Such combinations, with rare exceptions, would not usually be the more economical or practicable solution, however.

Temperature Effects

All biological treatment systems are sensitive to temperature. Optimum temperature for these systems is generally in the 16° to 38°C (60° to 100°F) range. Impaired BOD removal efficiency is usually encountered as temperature of the waste water drops significantly below or rises significantly above this range.

Temperatures over 38°C may be encountered in warm climates where heat is also added to the waste stream during processing. Cooling towers or trickling filters have been employed to reduce these higher temperatures prior to biological treatment. In colder climates, waste water temperature is likely to drop below 16°C in the winter, particularly where detention time of the biological unit exceeds 12 to 24 hours. With greater detention times, heat loss to atmosphere from the treatment unit generally becomes significant. Thus activated sludge units, which are usually designed for two to 10 hours detention, are less susceptible to reduction of BOD removal efficiency in cold climates than are aerated stabilization basins or storage oxidation basins. To some degree, this drop-off of BOD removal efficiency can be mitigated in colder climates by improved design of aeration and mixing factors. Two-stage aerated stabilization basins are likely to perform better in cold temperatures than a single stage of greater total detention time. More study also is needed in this area, since other design variables, as well as operating variables, affect BOD removal. For example, mixing efficiency varies as temperature changes in the basin. Other design parameters, such as lagoon geometry, depth, detention time, nutrient addition, BOD loading rate, and aerator spacing, and horsepower, are significant. Other factors which affect heat loss in basin are wind velocity, ambient air temperature and humidity, solar radiation, aeration turbulence, and foam cover.

Tertiary Suspended Solids Reduction Technologies

Mixed-Media Filtration

Mixed-medium filters are similar to conventional single medium deep-bed sand filters, but employ more than one filter media. Typical arrangements employ garnet, sand, or anthracite.

Conventional sand filters have the finer mesh material on top of the bed, with coarser grades below. Flow is downward. Thus most of the suspended solids are trapped in the top inch or two of the bed. Certain types of suspended solids, such as those from biological treatment, rapidly plug the top of the bed, requiring very frequent backwashes.

Multi-media filters have been designed with the objective of overcoming this disadvantage of single-medium filters. Large size medium is employed on the top layer, over a second layer of finer media. Usually anthracite coal is used in the top layer, and sand in the lower layer. Thus larger particles of suspended solids are trapped in the top layer, and finer particles in the lower layer. The result is to extend the filter "run" before backwashing is required. An extension of this principle is to add a third, finer, layer of garnet below the sand continuously decreasing particle size of media as depth increases. The different media are selected so that the top bed has the lowest specific gravity, and successively lower beds have successively higher specific gravities. With this arrangement, the bed layers tend to maintain their respective physical locations during and after the turbulence created by backwashing. Typical arrangements for dual media filters are anthracite (specific gravity 1.6) over sand (specific gravity 2.65). A layer of garnet (specific gravity 4.2) is imposed below the sand for a three-media filter.

Studies on municipal wastes have indicated that multi-media filters outperform single-medium sand filters. Better removal of suspended solids was obtained with longer runs and at higher flow rates per unit area of filter bed.

Flocculation, Coagulation, and Sedimentation for Suspended Solids Removal

To avoid rapid plugging of mixed media filters, an additional step to remove suspended solids contained in biological treatment effluents may be required.

Traditional treatment systems have utilized rapid mix and flocculation basins ahead of sedimentation tanks for chemical clarification. The rapid mix is designed to provide a thorough and complete dispersal of chemical throughout the waste water being treated to insure uniform exposure to pollutants which are to be removed. In-line blenders can be used as well as the traditional high-powered mixers which may require as much as 0.35 kilowatts/MLD (1 horsepower/MGD). In essence, the rapid mix performs two functions, the one previously noted (mixing) and a rapid coagulation. These functions are enhanced by increased turbulence.

Flocculation promotes the contact, coalescence and size increase of coagulated particles. Flocculation devices vary in form, but are generally divided into two categories. These are mechanically-mixed and baffled flocculators. Baffled basins have the advantage of low operating and maintenance costs, but they are not normally used because of their space requirement, inability to be easily modified for changing conditions and high head losses. Most installations utilize horizontal or vertical shaft mechanical flocculators which are easily adjusted to changing requirements.

Solids-contact clarifiers have become popular for advanced waste water treatment in recent years because of their inherent size reduction when compared to separate mixing, flocculation and sedimentation basins in series. Their use in water clarification and softening was carried over to waste treatment when chemical treatment of waste water was initiated. Theoretically, the advantage of reduced size accrues to their ability to maintain a high concentration of previously formed chemical solids for enhanced orthokinetic flocculation or precipitation and their physical design, whereby three unit processes are combined in one unit. In practice this amounts to savings in equipment size and capital cost.

Problems have occurred with the sludge-blanket clarifiers for reasons which include possible anaerobic conditions in the slurry; lack of individual process control for the mixing, flocculation and sedimentation steps; and uncontrolled blanket upsets under varying hydraulic and organic loading conditions. The major allegation is the instability of the blanket, which has presented operational problems in the chemical treatment of waste waters. Possibly the most effective method of control to date, other than close manual control, has been to mimimize the blanket height to allow for upsets. The advantages of higher flow rates and solids-contacting are maintained, but the advantage of the blanket is minimized. Another possiblility which has not been fully evaluated is the use of sludge-blanket sensors for automatic control of solids wasting.

Solids-contact clarifiers have been used for the treatment of secondary and primary effluents, as well as for the treatment of raw, degritted wastewater. Lime as the treatment chemical has been used with overflow rates from 48,900 to 69,300 liters per day per square meter (1200 to 1700 gpd/sq ft) in solidscontact units, while iron compounds and alum have been used at lower values, usually between 20,400 to 40,700 liters per day per square meter (500 and 1000 gpd/sq ft). All of these rates from 48,900 to 69,300 liters per day per square meter (1200 to 1700 gpd/sq ft) in solids-contact units. All of these rates come from pilot studies of less than 3.78 MLD (1 MGD) capacity, and may be subject to change at a larger scale due to differences in hydraulics. Polymer treatment can also influence the choice of overflow rates used for design if their cost can be economically justified when compared to the cost of lower overflow rates. Detention times in these solids-contact basins have ranged from just over one to almost five hours. Sludge removal rate is dependent on the solids concentration of the underflow, which is a function of the unit design as well as the chemical employed. These pilot plants have reported lime sludge drawoffs from 0.5 to 1.5 percent of the waste water flow at concentrations of from 3 to 17 percent solids. Alum and iron sludges have not been monitored extensively, but drawoffs have been reported to be 1 to 6 percent of the flow with 0.2 to 1.5 percent solids.

Much of the design information necessary for solids-contact clarifiers has been obtained from water treatment experience. This is not surprising in that the principles of treatment are identical. The characteristics of the solids that are formed and separated are the source of differences. The organic matter contained in the chemically-created sludges causes the sludge to become lighter and also more susceptible to septicity due to the action of microorganisms. The former condition suggests lower hydraulic loadings, while the latter suggests higher ones, given a set physical design. Since sludge septicity is neither universal nor uncontrollable, a lower design overflow rate may comprise much of the necessary adjustment to waste treatment conditions from those of water treatment. As indicated previously, design overflow rates from 48,900 to 69,300 liters per day per square meter (1200 to 1700 gpd/sq ft) for lime treatment and from 29,400 to 40,700 liters per day per square meter (500 to 1000 gpd/sq ft) for alum or iron treatment have been successful at less than 3.78 MLD (1 MGD) capacity. Cold weather peak flow conditions will probably constitute the limiting condition, as water treatment practice has shown that overflow rates are reduced by as much as 50 percent at near-freezing temperature. Waste water will probably not reach such low temperatures in most areas, but the effects are significant.

Sludge Dewatering and Disposal

Due to their high organic content, the dewatering and disposal of sludges resulting from the waste treatment of mill effluents can pose a major problem and cost more than the treatment itself. In early practice, these sludges were placed in holding basins from which free water from natural compaction and rainfall was decanted. When a basin was full, it was abandoned, or, if sufficient drying took place, the cake was excavated and dumped on waste land. In this case, the basin was returned to service.

Odor problems from drying, as well as land limitations, have demanded the adoption of more advanced practices. These are covered in detail in NCASI Technical Bulletin No. 190 (13) and are described briefly below.

Depending on the performance of dewatering equipment, in some cases it is either necessary or desirable to prethicken sludges. This is accomplished by gravity thickeners of the "picket-fence" type or by providing a high level of sludge storage capacity in mechanical clarifiers. Small mills sometimes employ high conical tanks which serve as both storage tanks and thickeners. These have side wall slopes in excess of 60 degrees but contain no rake mechanism.

Sludges from building paper mills can generally be thickened to a consistency in excess of four percent dry solids by prethickening. If activated sludge from secondary treatment is included, this figure can be somewhat lower.

Vacuum filters are in use for dewatering sludges and produce filter cakes ranging from 20 to 30 percent solids. Observed capacities for this poorly filterable sludges can generally be about doubled by chemical conditioning with ferric chloride, alum, or polyelectrolytes at a cost of from $2.72 to $4.54 per metric ton ($3.00 to $5.00 per short ton) of dry solids. Such treatment is generally necessary when activated sludge is included in the sludge to be dewatered since the addition of 20 percent of this material on a dry solids basis can reduce filtration rates as much as 50 percent.

Complete vacuum filter installations, including all accessories, range from $4,306 to $5,382 per square meter of filter area ($400 to $500 per square foot of filter area). Although a number of different types of filters are in service, coil or belt types are the most popular among recent installations. At one mill using coil filters, average cake content of 23 percent was reported, with an influent sludge concentration of 3.3 percent. Loading rates averaged 27.37 kilograms solids per square meter of filter area per day (5.6 pounds solids per square foot of filter area per day).

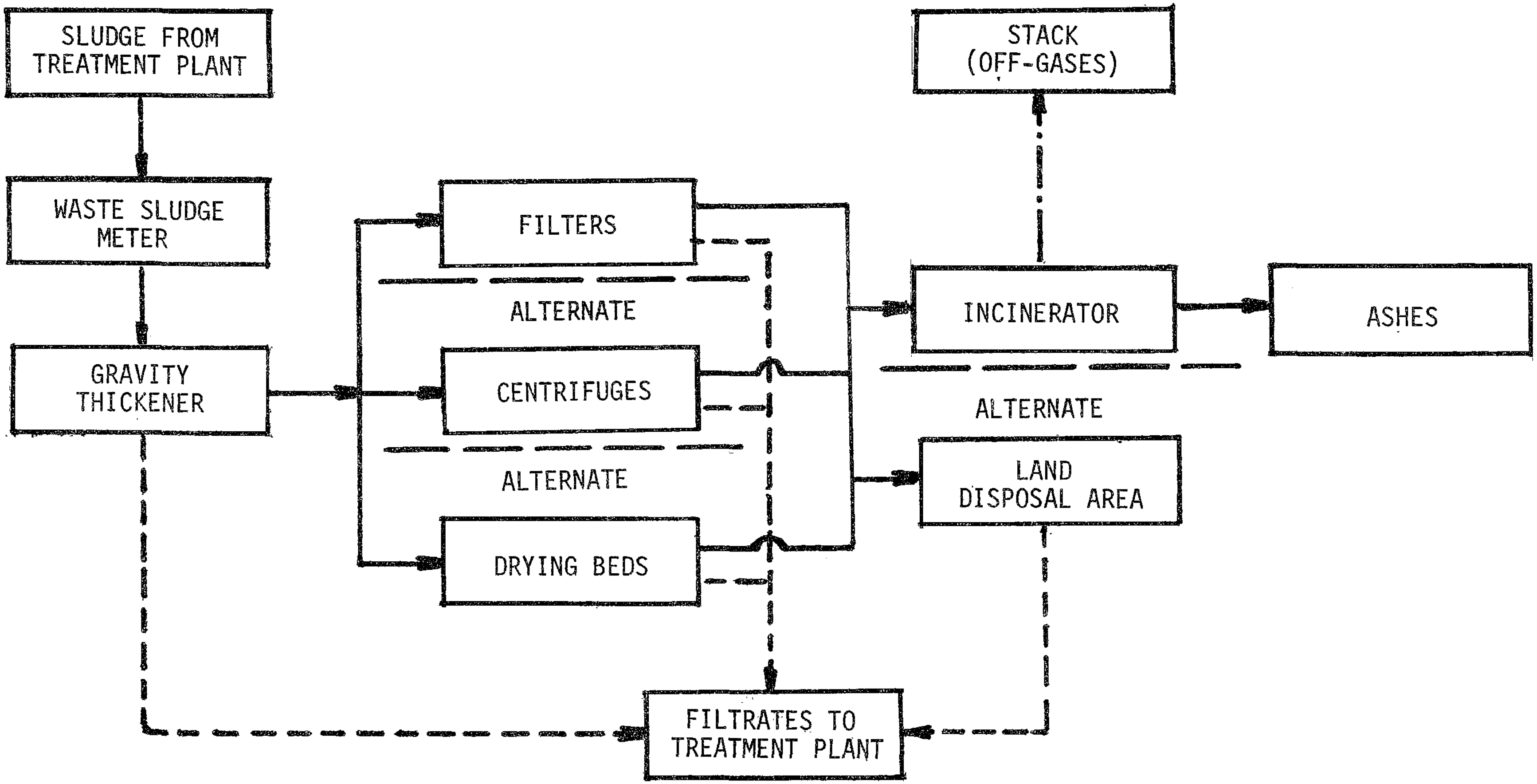
Centrifuges are also used for sludge dewatering. In practice, the higher the consistency of the feed, the more effective they are in terms of solids capture in relation to through-put as well as reduced cake moisture. Moisture is generally lower than in cakes produced by vacuum filters. Cakes range from 25 to 35 percent dry solids content and are in a pelletized easily manageable form. To operate effectively, centrifuges must capture in excess of 85 percent of the solids in the feed stream. Centrifuges cost from $106 to $159 per liter per minute ($400 to $600 per gpm) of feed capacity. At a two percent solids feed consistency, this is equivalent to 97.6 kilograms of dry solids (215 pounds of dry solids) daily at 90 percent capture. Although drying beds are employed for dewatering sludges, they are not constructed as elaborately as are those employed for sanitary sewage. They generally consist only of multiple earthen basins without a complex underdrain system.

Detailed experiments on this method of dewatering sludge set forth parameters of good practice and area requirements (14). The latter vary naturally with the climate, although adjustments as to the depth of sludge deposited and its initial moisture content are also involved. The most effective depth is less than one foot.

Sludge generated by mills in this industry can be removed for disposal on the land as soon as it becomes "spadeable" or handleable with earth moving equipment, which is about 25 percent solids content. Land disposal, via dumping or lagooning, has been a common means of disposing of waste sludges and other solid wastes from many builder's paper and roofing felt mills. Odors formed upon decomposition of these materials, the potential for pollution of nearby surface waters, and the elimination of affected lands from potential future usages, have made such practices generally undersirable: If disposed of using proper sanitary landfill techniques however most solids from this industry should create no environmental problems. In the rare cases in which sludges may contain leachable quantities of taste or odor imparting, toxic, or otherwise undesirable substances, simple sanitary landfilling may not be sufficient to protect groundwater quality. A sludge dewatering and disposal operation is shown in Figure 5.

Effluent Levels Achieved by Existing Treatment Systems at Builders Paper and Roofing Felt Mills

Final effluent levels presently being achieved by existing treatment systems at builder's paper and roofing felt mills are shown in Table 7. BOD5 ranges from 0.055 kg/kkg (0.11 lbs/ton) to 4.3 kg/kkg (8.6 lbs/ton). Total suspended solids ranges from 0.045 kg/kkg (0.09 lbs/ton) to 2.75 kg/kkg (5.5 lbs/ton). It should be noted that the data for mill BP-1 is the most representative data in the table as it represents a year's operating data.



SLUDGE DEWATERING AND DISPOSAL

FIGURE 5

Table 7

Effluent Levels Achieved by Existing Treatment Systems

Mill	Treatment	Production kg/day (tons/day)	Flow kiloliters/kkg (1000gal/ton)	kg/kkg(lbs/ton) BOD5 Inf.	BOD5 Eff.	TSS Inf.	TSS Eff.
Selected Mills							
BP-1 *	DAF-AS	309(341)	75.1(18)	12.6(25.2)	4.3(8.6)	41(82)	2.7(5.5)
BP-1 **	DAF-AS	--	--	9.5(19)	3.9(7.9)	42(84)	4.8(9.6)
BP-2 **	C-ASB-L	304(335)	4.2(1.0)	7.2(14.3)	0.37(0.75)	4.1(8.3)	0.045(0.09)
Mills from NPDES Data							
1	C-TF	150(165)	7.9(1.9)	--	0.3(0.6)	--	0.95(1.9)
2	C-ASB	59(65)	0.37(0.09)	--	--	--	0.4(0.8)
3	C-AS	227(250)	--	--	1.4(2.8)	--	1.0(2.0)
4	C-ASB	73(80)	1.8(0.44)	--	0.05(0.11)	--	0.13(0.26)

* Mill Records
** Short term survey data (3-7 days)
Note: Mill BP-1 is Mill # 3 and Mill BP-2 is Mill # 2.

Section VIII

COST, ENERGY, NON-WATER QUALITY ASPECTS, AND IMPLEMENTATION REQUIREMENTS

COSTS

This section of the report summarizes the costs of internal and external effluent treatment associated with the technologies of BPCTCA, BATEA, and NSPS. The cost functions used are for conventional treatment methods based on industry experience with full scale installations and equipment suppliers' estimates. For more advanced processes, where full scale installations are few or nonexistent, the cost estimates are largely based on experience with pilot installations and on estimates from and discussions with equipment suppliers. Cost estimates for closed-loop operation are based on information obtained from mills presently operating at closed or nearly closed-loop.

It should be recognized that actual treatment costs vary largely from mill to mill depending upon the design and operation of the production facilities and local conditions. Furthermore, effluent treatment costs reported by the industry vary greatly from one installation to another, depending upon bookkeeping procedures. The estimates of effluent volumes and treatment methods described in this section are intended to be descriptive of the segments of the industry that they cover. However, the industry is extremely heterogeneous in that almost every installation has some uniqueness which could be of critical importance in assessing effluent treatment problems and their associated costs.

Costs of effluent treatment which are presented have considered the following (See Appendix IV):

<u>Investment Cost</u>
Design
Land
Mechanical and electrical equipment
Instrumentation
Site preparation
Plant sewers
Construction work
Installation
Testing

Annual Cost

Interest
Depreciation
Operation and maintenance

Costs of effluent treatment are presented as investment and annual costs. The annual costs are further broken down into capital costs and depreciation, and operating and maintenance costs. Investment costs are defined as the capital expenditures required to bring the treatment or control technology into operation. These include the traditional expenditures such as design, purchase of land and all mechanical and electrical equipment, instrumentation, site preparation, plant sewers, all construction work, installation, and testing.

The capital costs are the financial charges on the capital expenditures for pollution control.

The depreciation is the accounting charges which reflect the deterioration of a capital asset over its useful life. Straight line depreciation has been used in all case study cost calculations.

Operation and maintenance costs are those costs required to operate and maintain the pollution abatement equipment. They include such items as labor, parts, chemicals, energy, insurance, taxes, solid waste disposal, quality control, monitoring, and administration. Productivity increases or by-product revenues as a result of improved effluent control are subtracted with the result that the operation and maintenance costs reported are the net costs.

All costs in this report are expressed in terms of August 1971 prices. This is comparable to the following costs indexes:

Indexes	Index @ August 1971
EPA Treatment Plant Construction Cost Index (1957-59 = 100)	164.5
EPA Sewer Line Construction Cost Index (1957-59 = 100)	166.8
Engineering News Record (ENR) Construction Cost Index (1913 = 100)	1614
ENR Labor Cost Index (1949 = 100)	420

Effluent treatment or control technology is grouped into internal and external measures. Available methods for reduction of pollutant discharges by internal measures include effective pulp washing, chemicals and fiber recovery, treatment and reuse of selected waste streams and collection of spills and prevention of "accidental" discharges. Internal measures are essentially reduction of pollutant discharges at the origin and results in recovery of chemicals, byproducts, and in conservation of heat and water.

The treatment unit operations which are discussed are grouped into pre-primary, secondary and tertiary treatment and sludge dewatering and disposal.

Pretreatment are those processes which are used as required to prepare the effluent for the subsequent treatment steps.

Primary treatment is designed to remove suspended solids, and is usually the first major external treatment step.

The primary purpose of secondary treatment is to remove BOD.

The tertiary treatment steps are designed to remove suspended solids and BOD to degrees which are not obtainable through primary and secondary treatment processes, or designed to remove substances which are refractory to the primary and secondary steps. A detailed discussion of external treatment unit operations and processes considered in this study, considered with their costs is summarized in Appendix IV to this report.

The specific internal and external control technologies upon which costs of treatment were based are shown in Table 8.

Table 9 illustrates the costs and resultant pollutant levels for the identified treatment and control technologies for the subject subcategory for a 90.7 metric ton/day (100 short ton/day) mill. Each cost shown reflects the total amount necessary to upgrade a mill which has only minimal internal control of spills, minimal recycling and recovery, and no treatment of waste waters to the specified technology level. It should be recognized that most mills have some existing capability beyond this base line, thus resulting in reduced costs over those shown.

TABLE 8

INTERNAL AND EXTERNAL CONTROL TECHNOLOGIES USED IN THE DEVELOPMENT OF COSTS

Preliminary Upgrading

Internal measures

The internal measures selected can be summarized as follows:

- control of asphalt spills
- installations of low volume, high pressure self-cleaning showers on paper machine
- filtering and reuse of press water

External Treatment

For mills the external treatment consists of raw waste screening by bar screens, primary treatment by mechanical clarifiers, foam control, effluent monitoring and automatic sampling and outfall diffuser.

The screenings are sanitary landfilled.

BPCTCA Technology

Internal Measures

The internal measures selected to bring the mills up to BPCTCA, consist of the preliminary additions already made plus the following:

- segregation and reuse of white waters
- collection and reuse of vacuum pump seal waters
- installation of saveails
- gland water reduction
- press water filtering
- water showers
- save-alls and associated equipment

External Measures

Screening, primary, and secondary treatment are provided to total mill effluents for mills, where the screening is by bar screens and primary sedimentation in mechanical clarifiers as was used when the upgrading was done in the previous upgrading step.

Secondary treatment is provided by biological treatment with nutrient addition. An emergency spill basin is installed prior to the secondary treatment step.

Foam control, flow monitoring and sampling and outfall system are as used under previous upgrading step.

BATEA Technology

Internal measures

The internal measures selected to bring the mills up to BATEA consist of BPCTCA installations plus the following additions:

a. control of spills whereby major pollutional loads bypass the waste water treatment system to a retention basin and are ultimately either reused, gradually discharged into the treatment system, or treated separately;

b. intensive internal reuse of process waters;

c. separation of cooling waters from other waste water streams, and subsequent heat removal and reuse;

d. intensive reduction of gland water spillage.

External measures

All mill effluents are screened by bar screens, and are subjected to primary solids separation in mechanical clarifiers and secondary treatment by biological treatment with nutrient addition. Suspended solids are further reduced by mixed media filtration with, if necessary, chemical addition and coagulation. Emergency spill basins are provided prior to the secondary treatment step.

Effluents receive foam control treatment, monitoring and automatic sampling prior to entering the receiving waters through diffusers.

Screenings are disposed of by sanitary landfilling. Primary sludges and waste activated sludge are thickened in gravity sludge thickeners, and dewatered mechanically by vacuum filters and presses prior to ultimate disposal.

Ultimate sludge disposal is by sanitary landfilling.

NSPS Technology

The same as BATEA.

Effluent Treatment Cost and Quality for 90.7 mtpd (100 tpd) Building Paper Mill

	None			Pre			BPCTCA			BATEA			NSPS		
	I	E	T	I	E	T	I *)	E	T	I **)	E	T	I	E	T
a.	0.	0.	0.	122	344	456	428	487	915	428	1035	1463	NA	725	725
b.	0.	0.	0.	34	84	118	98	137	235	98	217	315	NA	162	162
c.	0.	0.	0.	17	47	64	64	62	126	64	138	202	NA	100	100
d.	0.	0.	0.	17	37	54	34	75	109	34	79	113	NA	62	62

kg/kkg (lbs/ton)	None	Pre	BPCTCA	BATEA	NSPS
TSS	35 (70)	5 (10)	2.5 (5)	1.0 (2.0)	1.0 (2.0)
BOD5	35 (70)	17.5 (35)	2.5 (5)	1.0 (2.0)	1.0 (2.0)

Approximate gallons per ton x 1000

4.17 (10)	8.3 (2)	4.2 (1)	4.2 (1)

Note: In going from *) to **) practical considerations dictate that the internal investment be made at BPCTCA. Therefore, although a decrease in internal water use is expected between BPCTCA and BATEA, the total required investment is given in BPCTCA.

Key for Table

Data are in $1000's unless otherwise indicated.

I = Costs for Internal Controls
E = Costs for External Controls
T = Sum of costs I and E

a = Investment cost
b = Total annual cost (sum of c and d)
c = Interest cost plus Depreciation cost @ 15% per yr.
d = Operating and Maintenance cost (including energy and power) per year.

ENERGY REQUIREMENTS

Specific energy and power prices were based on the following and are reported as annual expenditures.

External treatment

power cost = 1.1¢/KWH
fuel price = $0.24/mill Kg Cal ($0.95/mill BTU)

Internal treatment

steam = $1.86/metric ton ($2.05/short ton)
power = 0.6¢/KWH

The lower power unit price used for internal treatment takes into consideration the lower cost of power generated by the mill, while power from external sources is assumed for external treatment.

For a 91 metric ton (100 short ton) per day mill, energy costs for BPCTCA, BATEA, and NSPS will be $5,400, $5,700 and $3,200, respectively based upon energy requirements of 16 kwh/kkg (18 kwh/ton), 17 kwh/kkg (19 kwh/ton), and 10 kwh/ton (11 kwh/ton), respectively.

NON-WATER QUALITY ASPECTS OF CONTROL AND TREATMENT TECHNOLOGIES

Air Pollution Potential

There is virtually no potential for an air pollution problem arising from the external treatment of effluents from building paper mills, although such problems are encountered in sludge disposal.

The physical processes employed in suspended solids removal do not involve any activity which would create air pollution, since detention times rarely exceed six hours which is not conducive to development of anaerobic or other odors. The subsequent biological processes are aerobic in nature when properly designed and operated, and the products of decomposition consist almost entirely of carbon dioxide, water, sulfates, and a trace of nitrates, all of which are odorless. The absence of objectionable odor has been confirmed by innumerable field observations by contractor personnel and regulatory officials. The only odors detectable were the characteristic odor associated with wood extractants.

Odors can arise from land disposal of liquid sludges as a result of their anaerobic decomposition. These derive primarily from organic acids and hydrogen sulfide produced on reduction of sulfates dissolved in the water content of the sludges. Dewatering prior to disposal on the land arrests such decomposition and represents an adequate odor control measure, as do land fill practices.

Incineration of sludges produced in the effluent treatment processes can, without appropriate control equipment, result in the discharge of particulates to the atmosphere. However, emission control devices are available to meet state regulatory requirements in most instances. Incinerators are either sold with integral emission control appliances or are equipped with them on installation. Gaseous pollutant emissions from such incinerators are negligible.

In-mill controls which effect a reduction in fiber and additive losses such as save-alls and recycling of process waters do not generate an air pollution problem.

Noise Potential

There are no official records of public noise problems arising from the operation of effluent treatment by building paper mills. However, based on many years of contractor association with industry operations, it can be stated that public complaints engendered by such noise are very infrequent. This is due in part to their confinement, in some instances, to manufacturing or utility areas and to the fact that the noise level of most of the devices employed for treatment is generally lower than that of some manufacturing machinery.

The sources of noise are for the most part air compressors or mechanical surface aerators supplying air to treatment processes, vacuum pumps and centrifuges involved in sludge dewatering, and fans serving sludge incinerators. With the exception of surface aerators, these devices are most frequently operated in buildings which serve to muffle their noise. Since many building paper mills are located in populated areas, noise from surface aerators could be a problem. However, these mills are small and employ small aerators which, if not driven through gear boxes, produce little noise. The problem of noise emanating from gear boxes used in these aerators and elsewhere is the subject of an extensive investigation by the Philadelphia Gear Company which manufactures many of these units. It is anticipated that this study will lead to a reduction in noise from these sources.

It can be concluded that noise produced by equipment used for treating building paper mill effluent is not a major public problem at present. Efforts being made to reduce the noise level of mechanical equipment in general, motivated by industrial health protection programs, will lend assistance in preventing it from becoming one.

Solid Wastes and Their Disposal

Solid wastes generated by building paper mills, in addition to sludges produced by effluent treatment, are trash, waste paper, ash, and garbage.

Trash such as metals, glass, and plastics is removed from waste paper and used rags in the beaters and pulpers and in stock cleaning operations. The material and grit from the rifflers are disposed of by land fill on the mill premises or hauled to a suitable location for disposal in this manner.

Wood rejects occur only in small quantities since less than 50 tons of wood a day is generally processed. In most instances, the rejects can be recycled in the process.

Ash from coal-fired boilers can be discharged hydraulically to ash ponds. There the solids settle and compact and the clear supernatant water is discharged to the mill effluent system. If ash is hauled to a disposal area, these materials should be transported wet in order to avoid being blown into the atmosphere.

Waste paper and garbage are either incinerated on the site or hauled away for disposal by contractors engaged in this business. Particulates from incineration must be controlled by effective devices such as bag filters or wet scrubbers.

Research recently has been conducted on solid wastes generated in the pulp and paper industry and their disposal for EPA's Office of Solid Waste Management Programs (EPA Contract No. 68-03-0207).

IMPLEMENTATION REQUIREMENTS

Availability of Equipment

Since 1966, when major Federal water pollution control expenditures began, various Federal and private organizations have analyzed the projected levels of water pollution control activity and their economic impact on the construction and equipment industries. As a result, a plethora of studies has been developed which is related to the levels of municipal and industrial water pollution control construction and the respective markets for waste water treatment equipment. Less information is available concerning the actual and anticipated levels of expenditure by any specific industry.

In recent years, the trend in the waste water equipment industry has seen the larger firms acquiring smaller companies in order to broaden their market coverage.

Figure 6 shows graphically past expenditures and projected future outlays for the construction of industrial waste water treatment facilities, as well as total water pollution control expenditures. Obviously, the level of expenditures by industry is related to the Federal compliance schedule. This will increase until industry is in compliance with Federal standards. Once that occurs, the level of spending will return to a level commensurate with the construction of new facilities, replacement of existing facilities, and the construction of advance waste treatment facilities.

Figure 7 shows past expenditures for and projected future trends in total sales of waste water treatment equipment and the dollar amounts attributable to industrial and municipal sales.

The data in Figures 6 and 7 related to industrial water pollution expenditures include only those costs external to the industrial activity. Internal process changes made to accomplish water pollution control are not included.

Recent market studies have projected the total available production capacity for water and waste water treatment equipment. Most of them have indicated that the level of sales is currently only 30-40 percent contracted to verify these figures and indications are that they are still accurate. A partial reason for this overcapacity is that the demand for equipment has been lower than anticipated. Production capacity was increased assuming Federal expenditures in accord with funds authorized by Congress and conformance to compliance schedules.

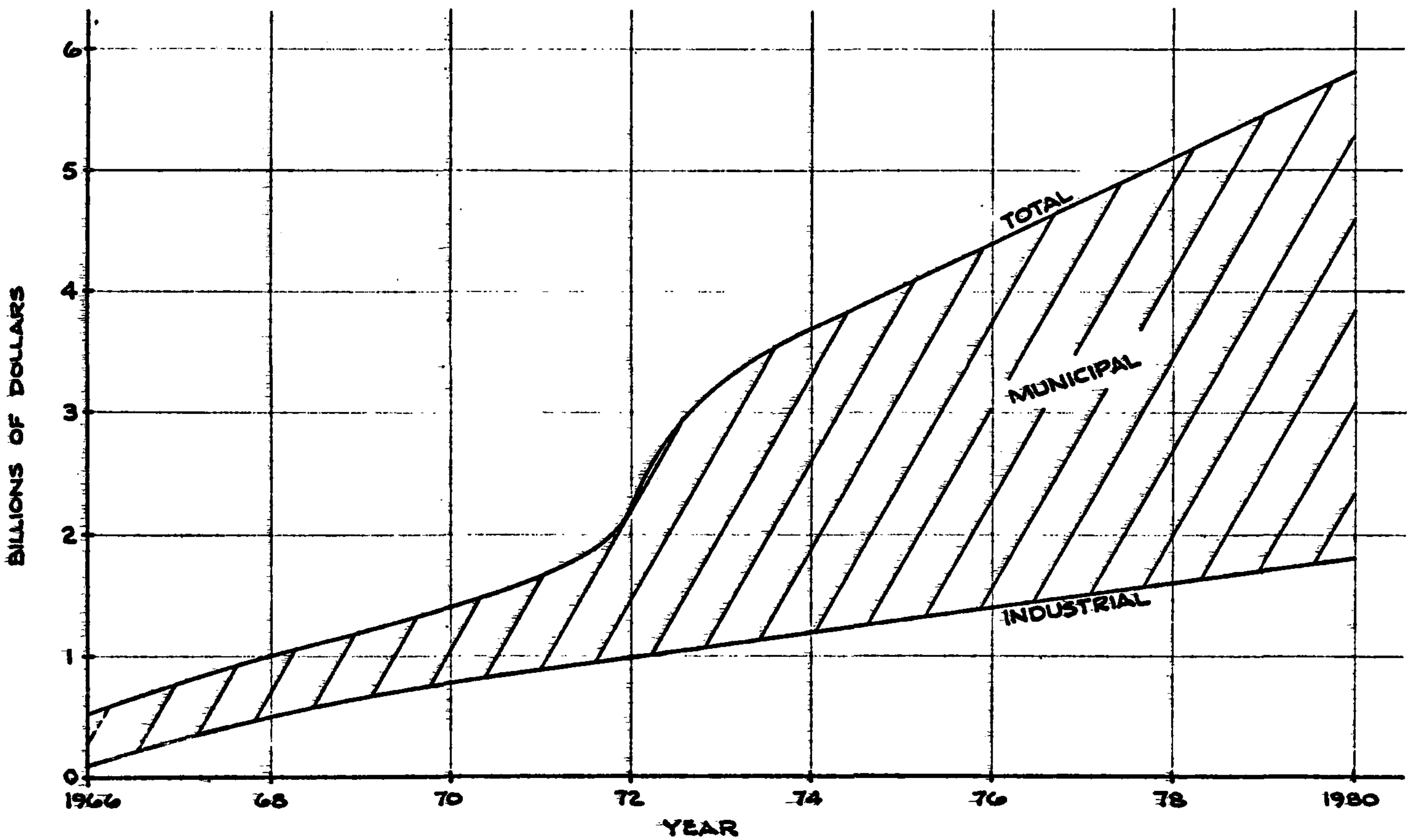


FIGURE 6
TOTAL WATER POLLUTION
CONTROL EXPENDITURES

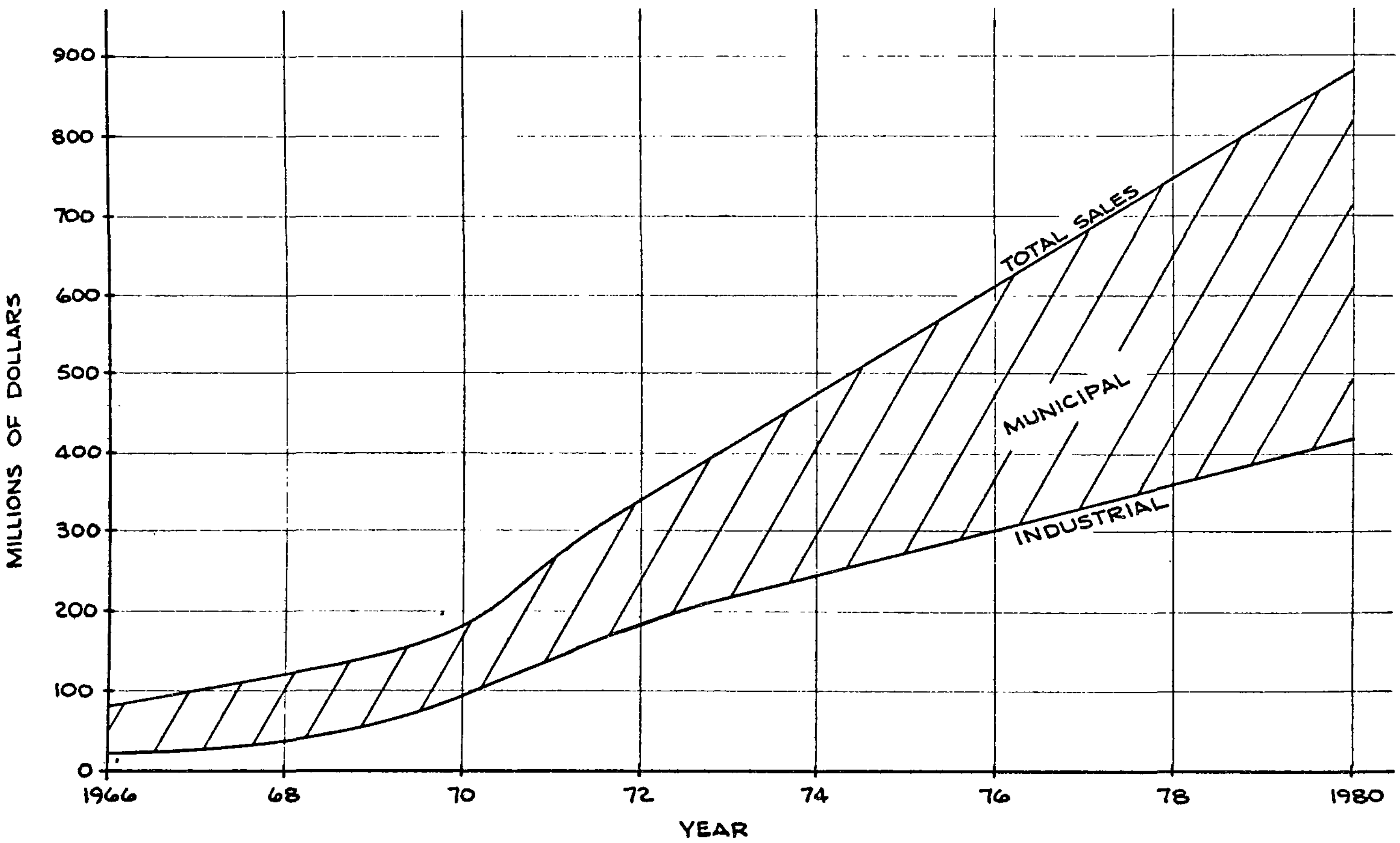


FIGURE 7
WASTEWATER TREATMENT
EQUIPMENT SALES

For the immediate future, increased demands for waste water treatment equipment can be absorbed by the existing overcapacity. Long term requirements will probably necessitate expansion of production capacity in various product lines where the demand is expected to increase dramatically -- specifically, advanced treatment systems and waste solids handling equipment.

It should also be noted that the capacity to produce waste water treatment equipment could be expanded significantly through the use of independent metal fabricators as subcontractors. Even at the present time work loads are heavy and excessive shipping costs make it desirable to use a fabricator close to the delivery site.

There appear to be no substantial geographical limitations to the distribution of waste water treatment equipment to industry. In various areas, certain suppliers may be more successful than others; however, this seems to be more related to the effectiveness of the sales activities than to any geographical limitations. The use of independent metal fabricators as subcontractors to manufacture certain pieces of equipment further reduces geographical limitations.

Equipment delivery schedules may vary substantially depending upon the manufacturer, the current demand, and the specific equipment in question. Obviously, the greater the demand or the more specialized the equipment, the greater the delivery time.

Availability of Construction Manpower

After consultation with the Associated General Contractors of America and other industry groups, it is concluded that sufficient manpower exists to construct any required treatment facilities.

This conclusion has reportedly been substantiated by EPA in an independent study (15) although there is still some concern about localized problems. The Bureau of Labor Statistics has been requested to conduct another study.

Construction Cost Index

The most detailed study and careful analysis of cost trends in prior years still leaves much to be desired in predicting construction cost through the next ten years.

During the years 1955 through 1965 there was a very consistent price rise. The Engineering News Record (ENR) Construction Cost Index in January 1955 was 644. With slight deviations from a straight line, costs rose at a steady rate to an index of 988 in December 1965. This represented an increase in cost of 53.4 percent over an eleven-year period or approximately 5 percent per year.

The first six months of 1966 saw an increase of 6.6 percent which then leveled off abruptly only to rise sharply again in 1967 at a rate of 6.2 percent, then increasing to 9.4 percent in 1968.

The increase in costs continued at about 10.5 percent per year through 1970. During 1971, construction costs rose at the unprecedented rate of 15.7 percent primarily due to larger increases in labor rates.

With the application oF Federal wage and price controls in 1972, the rate of increase dropped to 8.7 percent. The first three months of 1973 saw some escalation of cost due to allowable materials price gains. EPA determined the increase in Treatment Plant Construction Cost during this period to be 3.1 percent. This compares with a rise of only 0.9 percent during the previous three months.

The opinion of some officials of the Associated General Contractors is that rate of cost increase for general construction work, including waste water treatment and industrial construction, should average no more than five to six percent over the next several years. This is, therefore, the basis used for extention of the ENR index curve at an annual six percent increase for construction costs through the year 1983. This is shown in Figure 8.

Land Requirements

Land requirements for a number of external treatment systems have been evaluated and are shown in Figure 9 for a range of plant sizes. Incineration or off-site disposal of dewatered sludge has been assumed. Should sludge lagoons be used on site, additional land would be required.

Time Required to Construct Treatment Facilities

The time required to construct treatment facilities has been determined for a range of plant sizes and for two different project contract possibilities. The treatment sizes evaluated were under 18,925 kiloliters per day (five MGD), 18,925-189,250 kiloliters per day (five to 10 MGD), and over 189,250 kiloliters per day (10 MGD). The contract bases evaluated were 1) separate engineering and construction and 2) turnkey performance. The components considered for both approaches included preliminary engineering, final design engineering, bid and construction award, and construction.

It is concluded from reviewing the data shown in Figure 10 that it should be possible in all cases to meet the implementation requirements of the July 1977 deadlines.

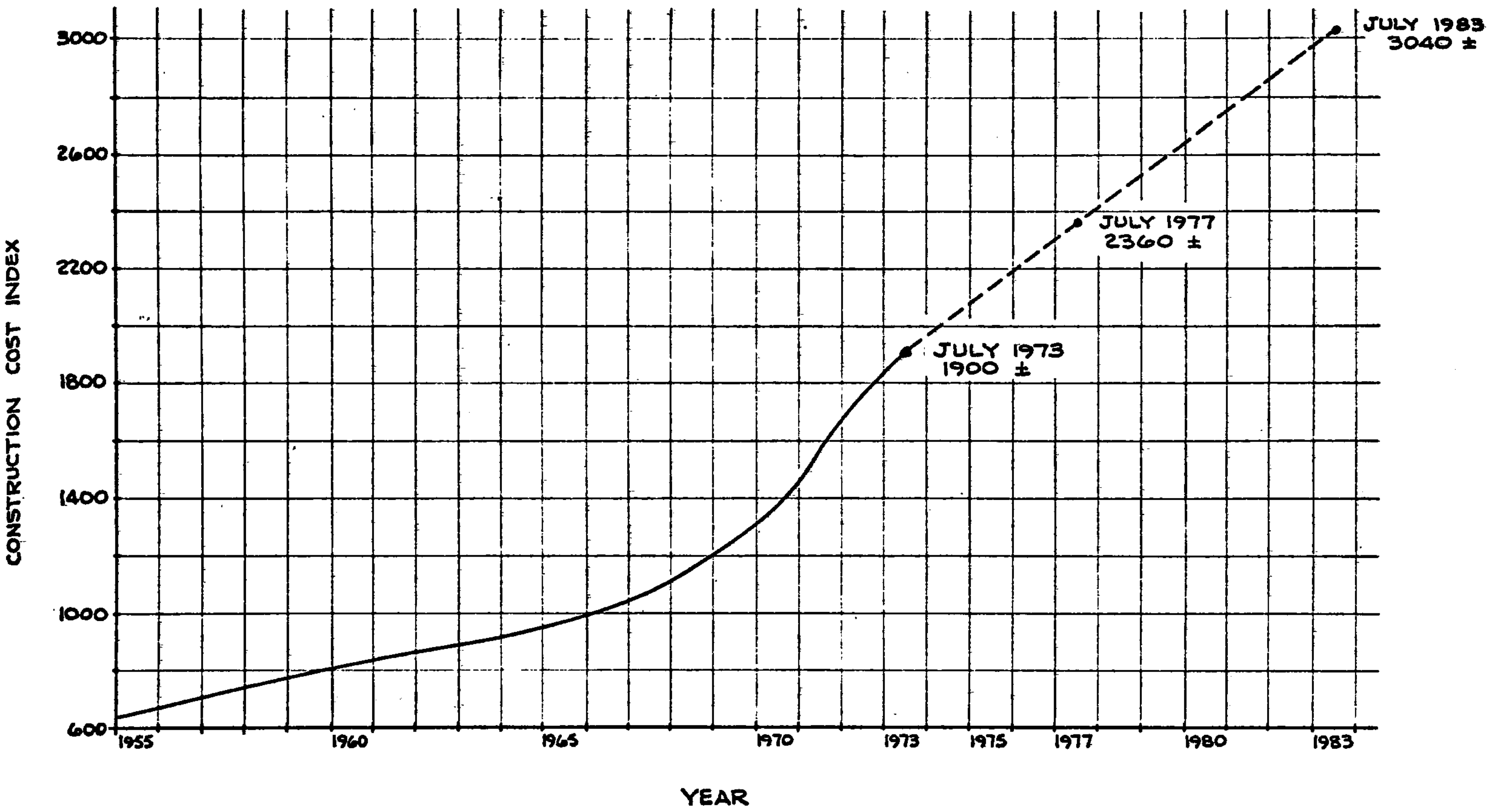


FIGURE 8
ENGINEERING NEWS RECORD
CONSTRUCTION COST INDEX

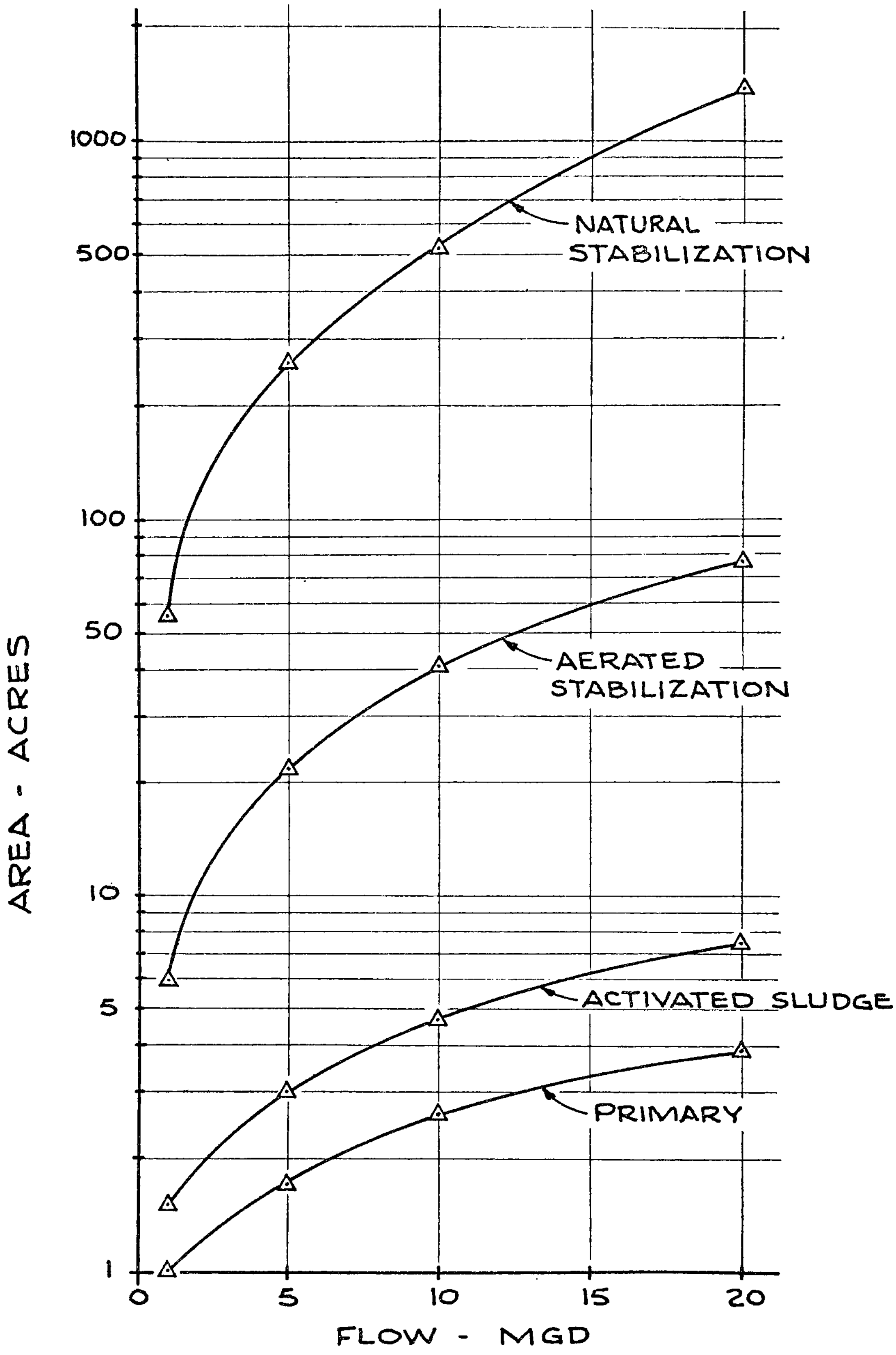
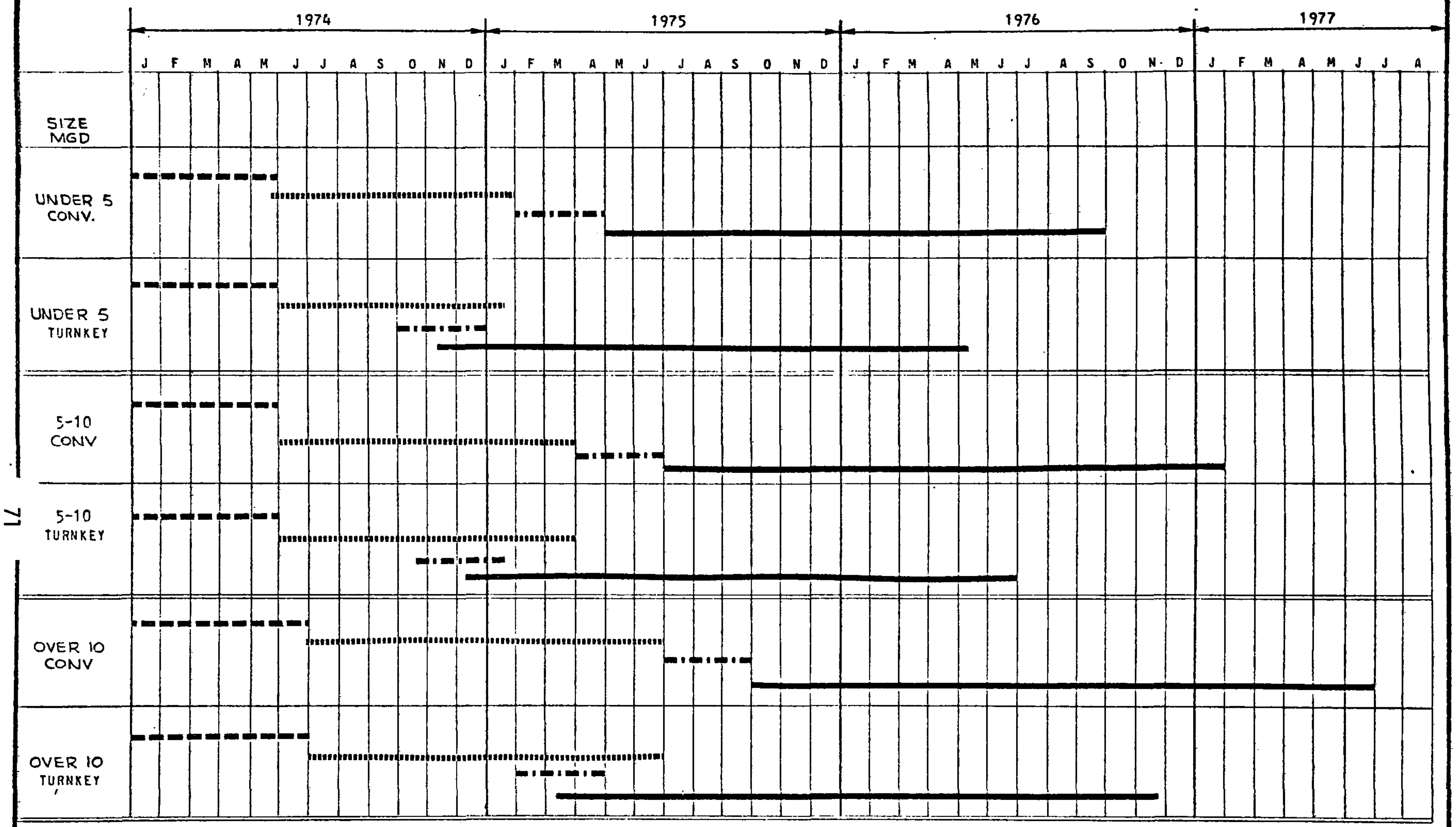


FIGURE 9
LAND REQUIRED FOR WASTEWATER TREATMENT



PRELIMINARY ENGINEERING
FINAL DESIGN ENGINEERING
BID AND CONSTRUCTION AWARD
CONSTRUCTION

FIGURE 10

TIME REQUIRED TO
CONSTRUCT WASTEWATER FACILITIES
CONVENTIONAL & TURNKEY CONTRACTS

SECTION IX

BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

INTRODUCTION

The effluent limitations which must be achieved by July 1, 1977 are to specify the degree of effluent reduction attainable through the application of the best practicable control technology currently available. Best practicable control technology currently available is generally based upon the average of the best existing performance by plants of various sizes, ages, and unit processes within the industrial subcategory.

Consideration was also given to:

a. the total cost of application of technology in relation to the effluent reduction benefits to be the achieved from such application;

b. the size and age of equipment and facilities involved;

c. the processes employed;

d. the engineering aspects of the application of various types of control techniques;

e. process changes;

f. non-water quality environmental impact (including energy requirements);

g. waste water characteristics and treatability.

Also, best practicable control technology currently available emphasizes treatment facilities at the end of a manufacturing process but includes the control technologies within the process itself when the latter are considered to be normal practice within an industry.

A further consideration is the degree of economic feasibility and engineering reliability which must be established for the technology to be "currently available." As a result of demonstration projects, pilot plants, and general use, there must exist a high degree of confidence in the engineering feasibility and economic practicability of the technology at the time of commencement of construction of installation of the control facilities.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Based upon the information contained in Sections III through VIII and the appendices of this report, a determination has been made that the point source discharge limitations for each identified pollutant shown in Table 10 can be obtained through the application of the best practicable pollution control technology currently available.

Table 10

BPCTCA Effluent Limitations

Values in kg/kkg(lbs/ton)

BOD5		TSS		pH	Settleabl
30 Day	Daily Max	30 Day	Daily Max	Range	Solids
3.0 (6.0)	5.0 (10.0)	3.0 (6.0)	5.0 (10.0)	6.0-9.0	0.2 ml/

The maximum average of daily values for any 30 consecutive day period should not exceed the 30 day effluent limitations shown above. The maximum for any one day should not exceed the daily maximum effluent limitations shown above. The limitations are in kilograms of pollutant per metric ton of production except for the pH and settleable solids limitations. Mill effluents should always be within the settleable solids concentration and the pH range shown.

The TSS parameter is measured by the technique utilizing glass fiber filter disks as specified in Standard Methods for the Examination of Water and Waste water (13 Edition) (1).

Production is defined as the annual average level of production off the machine (air dry tons).

IDENTIFICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Best practicable control technology currently available is identified below. The identified in-plant controls are in common use in plants within the subcategory. It should be emphasized that it is not expected that all of the internal controls listed are needed for mills to meet the limitations. Also, the internal controls, as well as the external controls, are identifications (not requirements) of pollution control technologies which can be utilized to meet the 1977 limitations. In addition, mills have the option for pollutant reduction by well designed and operated external treatment systems or by a combination of both internal and external controls.

Internal Control

a. Water Showers

Fresh water showers used to clean wire, felt, and other machine elements (of both fourdrinier and cylinder machines) should be low-volume and high-pressure; white water showers should be low-pressure, high volume, and self-cleaning.

b. Segregation of White Water Systems

The segregation of white water systems should be designed to permit maximum reuse within the stock preparation/ machine systems and to permit only low fiber content white water to enter the sewer.

c. Press Water Filtering

A vibrating or centrifugal screen should be employed to remove felt hairs prior to press water reuse.

d. Collection Systems for Vacuum Pump Seal Water

Seal water should be collected for partial reuse and/or cascade to or from other water users.

e. Save-all with Associated Equipment

An effective save-all should be employed to recover fibrous and other suspended material which escapes from the paper machine.

f. Gland Water Reduction

Flow control of individual seal water lines to equipment packing glands, or equivalent measures, should be exercised.

g. Control of Asphalt Spills

Floor drains are connected to a spill basin which is equipped with asphalt removal facilities.

External Treatment

a. Suspended Solids Reduction

This step involves removal of suspended solids from the raw waste stream. It can incorporate either 1) an earthen stilling basin; or 2) mechanical clarification and sludge removal. Solids dewatering screens can also be incorporated prior to solids settling as a means of removing coarse solids.

b. BOD Reduction

The treatment system for reduction of BOD_5 is biological oxidation with nutrient addition. The treatment system may consist of activated sludge process (AS), aerated basins (ASB), and/or storage oxidation ponds (SO).

c. Secondary Solids Reduction

The system should provide for the removal of biological solids by either mechanical clarifiers, stilling ponds (or a SO following an ASB), or a quiescent zone in an aerated basin which is beyond the influence of the aeration equipment.

d. Sludge Disposal

When compatible with other unit processes, sludge disposal can often be carried out in a stilling pond. However, this necessitates periodic dredging, removal, and disposal of solids. Where activated sludge and mechanical clarification are utilized, ultimate sludge disposal can be accomplished through sludge thickening by vacuum filtration or centrifugation, followed by sludge dewatering and ultimate solids disposal. Disposal can be accomplished by either land disposal or incineration. Combustion of sludges can be carried out either in a sludge incinerator or a power boiler.

RATIONALE FOR THE SELECTION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Age and Size of Equipment and Facilities

There is a wide range, in both size and age among mills in the subcategory studied. However, internal operations of most older mills have been upgraded, and some of these mills currently operate very efficiently. The technology for upgrading of older mills is well established, and does not vary significantly from mill to mill within the subcategory. Studies have also shown that waste treatment plant performance does not relate to mill size. Most mills are constructed on a "modular" concept, where key process elements are duplicated as mill size expands. Consequently, there is no significant variation in either the waste water characteristics or in the waste water loading rates between mills of varying sizes.

Process Change

Application of best technology currently available does not require major changes in existing industrial processes. The identified in-plant systems representing BPCTCA have previously been installed at most mills and are thus in common use. Incorporation of additional systems, treatment processes, and control measures can be accomplished in most cases through changes in piping, and through design modifications to existing equipment. Such alterations can be carried out in all mills within the subcategory.

The in-plant technology to achieve these effluent limitations is practiced and generally in common use within the subcategory under study. The concepts are proven, available for implementation, and applicable to the wastes in question. The waste treatment techniques are also broadly applied within many other industries. The technology identified will necessitate improved monitoring of waste discharges and of waste treatment components on the part of many mills, as well as more extensive training of personnel in operation and maintenance of waste treatment facilities. However, these procedures are commonly practiced in many builders paper and roofing felt mills and are common practice in many other industries.

Engineering Aspects of Control Technique Applications

The technology to achieve these effluent limitations is practiced within the subcategory under study. The concepts are proven, available for implementation, and applicable to the wastes in question. The waste treatment techniques are also broadly applied within many other industries. The technology required will necessitate improved monitoring of waste discharges and of waste treatment components on the part of many mills, as well as more extensive training of personnel in operation and maintenance of waste treatment facilities. However, these procedures are currently practiced in some mills and are common practice in many other industries.

Non-water Quality Environmental Impact

Application of the activated sludge waste treatment process offers a potential for adverse impact upon air quality if dewatered sludges are incinerated. However, proper selection and operation of particulate emission control equipment can minimize this impact. Dredged or dewatered sludges disposed of on land can present an odor problem if a solid waste disposal program is not properly implemented.

The technology cited will not create any significant increase in noise levels beyond those observed in well designed municipal waste water treatment systems which currently are being approved by the Federal government for construction in populated areas. Further, no hazardous chemicals are required as part of this technology.

The greatest proportion of energy consumed will be for pumping and for biological treatment. The total energy requirements for implementation of best available technology are not substantial (less than one percent) and should not be enough to warrant concern on either a national or regional basis.

Cost of Application in Relation to Effluent Reduction Benefits

For a 90.7 metric ton (100 short ton) per day mill, the total annual cost of this level of technology is estimated at $235,000, including energy requirements. This results in an increase in production costs of approximately $7.20 per metric ton ($7.93 per short ton).

This increase reflects both all internal mill and external waste treatment improvements. It is based on 300 days of production/year. It should be emphasized, however, that most mills have already carried out many of these improvements. Subsequently, their increased costs would be less than those shown above.

Processes Employed

All mills within the subcategory studied utilize the same basic production processes. Although there are deviations in equipment and production procedures, these deviations do not significantly alter either the characteristics or the treatability of the waste water generated.

RATIONALE FOR SELECTION OF BPCTCA EFFLUENT LIMITATIONS

The effluent limitations were based upon the two selected mills, Mill BP-1 and Mill BP-2. Mill BP-2 was determined to be achieving effluent qualities representative of BATEA. Thus, the effluent limitations were primarily based on Mill BP-1.

As shown in Table 7 in Section VII, Mill BP-1 was achieving less than 70% BOD_5 reduction with the activated sludge process. Since Mill BP-2 demonstrated that nearly 95% BOD_5 reduction is achievable by secondary treatment, it was determined that Mill BP-1 was not achieving effluent qualities equivalent to the application of BPCTCA. Using the raw waste BOD_5 load from Mill BP-1 and minimally acceptable levels of BOD_5 reduction of 85-90% on an annual average basis, the effluent limitations were determined. Conservative factors of 1.9 and 3.2 for ratios of effluent quality of maximum month to annual average and maximum day to annual average, respectively, were applied to determine the 30-day and daily maximum limitations.

The TSS effluent limitations were based upon Mill BP-1 effluent qualities and effluent flows. Since BPCTCA was not being demonstrated at mill BP-1 as discussed above, the annual average TSS levels in the final effluent of 50 mg/l were used as the maximum month in determining the limitations. The above factors of 1.9 and 3.2 were used to determine the 30-day and daily maximum effluent limitations, respectively, based on an annual average of 26 mg/l.

Since many mills, such as Mill BP-2, may choose to close up their water systems instead of installing external waste water treatment in order to meet the effluent limitations, it was determined that a settleable solids limitations equivalent to primary treatment was needed. These mills may be able to meet the limitations without external treatment and still cause a sludge bed problem in receiving waters by discharging their unsettled bleed-off waste waters containing heavy loads of settleable solids.

pH Range Limitations

The pH range of 6.0-9.0 in receiving waters is satisfactory for aquatic life as specified in the draft document by the National Academy of Sciences (NAS) on Water Quality Criteria. Thus, the effluent limitations of pH range 6.0-9.0 were chosen for all subcategories.

SECTION X

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

INTRODUCTION

Best available technology economically achievable is to be achieved not later than July 1, 1983. It is not based upon an average of the best performance within the subcategory under study, but has been determined by identifying the very best control and treatment technology employed by a specific point source within the subcategory, or by applying technology from other industry areas where it is transferable.

Consideration was also given to:

a. the age of equipment and facilities involved;

b. the process employed;

c. the engineering aspects of the application of various types of control techniques;

d. process changes;

e. cost of achieving the effluent reduction resulting from application of the technology;

f. non-water quality environmental impact, including energy requirements;

g. waste water characteristics and treatability.

This level of technology emphasizes both internal process improvements and external treatment of waste waters. It will, therefore, require existing mills to implement significant internal process changes in water reuse and recycle as well as to apply more advanced waste treatment processes and other improved internal and external controls in order to meet the effluent limitations. In some cases, the industry may be required to conduct applied research and demonstration studies in order to firmly establish the most economical approach toward meeting the limitations. In some cases, closed loop operation may be an economically and environmentally favorable alterative.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

Based upon the information contained in Sections III through VIII and in the appendices of this report, a determination has been made that the point source discharge limitations for each identified pollutant shown in Table 11 can be obtained through the application of best available technology.

Table 11

BATEA Effluent Limitations

Values in kg/kkg (lbs/ton)

BOD5		TSS		pH	Settleable
30 Day	Daily Max	30 Day	Daily Max	Range	Solids
1.0 (2.0)	1.75 (3.5)	1.0 (2.0)	1.75 (3.5)	6.0-9.0	0.2 ml/l

The maximum average of daily values for any 30 consecutive day period should not exceed the 30 day effluent limitations shown above. The maximum for any one day should not exceed the daily maximum effluent limitations shown above. The limitations are in kilograms of pollutant per metric ton of production except for the pH and settleable solids limitations. Mill effluents should always be within the settleable solids concentrations and the pH range shown.

The TSS parameter is measured by the techniques utilizing glass fiber filter disks as specified in Standard Methods For The Examination of Water and Waste Water (13th Edition) (1).

Production is defined as the level of production off the machine (air dry tons).

IDENTIFICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

The best available technology economically achievable consists of the best practicable control technology currently available as defined in Section IX of this report. It also includes the following additional internal mill improvements and external advanced waste water treatment practices.

Internal Controls

Building paper operations will be able to implement modifications and operating procedures for:

a. control of spills whereby major pollutional loads bypass the waste water treatment system to a retention basin and are ultimately either reused, gradually discharged into the treatment system, or treated separately;

b. intensive internal reuse of process waters;

c. separation of cooling waters from other waste water streams, and subsequent heat removal and reuse;

d. intensive reduction of gland water spillage.

External Treatment

Section IX of the report describes best practicable external control technology currently available. Application of that technology in conjunction with several additional recognized and potential technologies described in section VII constitutes best available technology economically achievable. The additional external processes applicable to this more advanced technology are as follows:

a. BOD_5 Reduction
The treatment system is biological oxidation with nutrient addition.

b. Suspended Solids Reduction
The treatment to further reduce suspended solids is mixed media filtration with , if necessary, chemical addition and coagulation.

RATIONALE FOR THE SELECTION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

Age and Size of Equipment and Facilities

There is a wide range, in both size and age, among mills in the subcategory studied. However, internal operations of most older mills have been upgraded, and some of these mills currently operate very efficiently. The technology for upgrading of older mills is well established, and does not vary significantly from mill to mill. Studies have also shown that waste treatment plant performance does not relate to mill size. Most mills are constructed on a "modular" concept, where key process elements are duplicated as mill size expands. Consequently, there is no significant variation in either the waste water characteristics or in the waste water loading rates between mills of varying sizes.

Process Changes

Application of best available technology economically achievable may require some major changes in existing industrial processes. Incorporation of additional systems, treatment processes, and control measures can be accomplished in most cases through changes in piping, through design modifications to existing equipment, and through installation of additional equipment. Such alterations can be carried out on all mills within the subcategory.

Several mills within the builders paper and roofing felt subcategory have closed or nearly closed loop recycling systems. An EPA project investigating recycling possibilities in builders paper and roofing felt mills is scheduled for completion late in 1973. The project is determining the cost-effectiveness of various recycling concepts. Results of the project in conjunction with information on the several mills already practicing closed loop technologies indicate that closed loop operations which are at or nearly at zero discharge may be economically and environmentally advantageous over external treatment systems as identified in BATEA. Thus, the technologies of biological and physical-chemical treatment systems may be changed at a later time after further demonstration of closed loop systems to a BATEA technology of closed loop systems which would result in no discharge of pollutants.

Engineering Aspects of Control Technique Applications

The technology to achieve most of these effluent limitations is either practiced by an outstanding mill in the subcategory, or is demonstrated in other industries and is transferable. The technology required for all best available treatment and control systems will necessitate sophisticated monitoring, sampling, and control programs, as well as properly trained personnel.

Non-water Quality Environmental Impact

Application of the activated sludge waste treatment process offers a potential for adverse impact upon air quality if dewatered sludges are incinerated. However, proper selection and operation of particulate emission control equipment can minimize this impact. Dredged or dewatered sludges disposed of on land can present an odor problem if a solid waste disposal program is not properly implemented.

The technology cited will not create any significant increase in noise levels beyond those observed in well designed municipal waste water treatment systems which currently are being approved by the Federal government for construction in populated areas. Further, no hazardous chemicals are required as part of this technology.

The greatest proportion of energy consumed will be for pumping and for biological treatment. The total energy requirements for implementation of best available technology for the categories under study are not substantial (less than one percent) and should not be enough to warrant concern on either a national or regional basis.

Cost of Application in Relation to Effluent Reduction Benefits

Based upon the information contained in Section VIII and the appendices of this report, total projected cost of upgrading a 90.7 metric ton (100 short ton) per day mill incorporating best practicable control technology currently available to the level of best available technology economically achievable reflects an increase in production expenses of $2.40 per metric ton ($2.67 per short ton). This is based upon total annual cost of $80,000, including energy requirements.

This increase reflects both all internal mill and external waste treatment improvements and is based on 300 days of production per year.

Processes Employed

All mills within the subcategory studied utilize the same basic production processes. Although there are deviations in equipment and production procedures, these deviations do not significantly alter either the characteristics or the treatability of the waste water generated.

RATIONALE FOR SELECTION OF BATEA EFFLUENT LIMITATIONS

The rationale used in developing the BATEA effluent limitations for BOD5, TSS, and pH is discussed below.

BOD5 and TSS Limitations

The BOD5 effluent limtiations were based upon the effluent qualities being achieved by Mill BP-2 as shown in Table 7 in Section VII. Mill BP-2 discharges only 4,170 liters/kkg (1,000 gal/ton) whereas Mill BP-1 discharges 57,100 liters/kkg (13,700 gal/ton). In addition to having low water use, the external treatment was achieving 95% BOD5 reduction. However, because of the short duration of the sampling survey which was made at Mill BP-2, the effluent limitations were determined using the Mill BP-1 raw waste BOD5 load and applying 95% reduction. The identified in-plant controls and external treatment system should achieve at least 95% reduction in BOD5. Since variabilities in effluent qualities should be less utilizing BATEA than BPCTCA, factors of 1.5 and 2.75 were applied to determine the 30-day and daily maximum limitations, respectively.

The TSS effluent limitations were determined using the 1977 limitations as a base and applying 65% reduction which can be achieved by application of in-plant controls and external treatment. It appears that the identified external controls of coagulation and filtration may not be needed by all mills to meet the limitations as Mill BP-2 is already well within the limitations without coagulation and filtration.

The settleable solids limitations was discussed in Section IX.

pH Range Limitations Guideline

The pH range of 6.0-9.0 in receiving waters is satisfactory for aquatic life as specified in the draft document by the National Academy of Sciences (NAS) on Water Quality Criteria. Thus, the effluent limitations guideline of 6.0-9.0 were chosen.

SECTION XI

NEW SOURCE PERFORMANCE STANDARDS

INTRODUCTION

This level of technology is to be achieved by new sources. The term "new source" is defined in the Act to mean "any source, the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance." Such commencement of construction can occur within the near future, certainly before either the 1977 or 1983 compliance dates for either best practicable or best achievable technologies. Therefore, new source performance standards utilize best practicable control technology currently available as a base, but also encompass additional treatment and control technologies through the application of improved production processes which are designed to reduce pollutant loads.

Consideration has also been given to:

a. The type of process employed and process changes;

b. Operating methods;

c. Batch as opposed to continuous operations;

d. Use of alternative raw materials and mixes of raw materials;

e. Use of dry rather than wet processes (including substitution of recoverable solvents for water);

f. Recovery of pollutants as byproducts;

g. Waste water characteristics and treatability.

RECOMMENDED NEW SOURCE PERFORMANCE STANDARDS

The NSPS are the same as limitations to be achieved by July 1, 1983, as presented in Section X.

IDENTIFICATION OF TECHNOLOGY TO ACHIEVE NEW SOURCE PERFORMANCE STANDARDS

The technology for NSPS consists of the best available pollution control technology economically achievable as identified in Section X of this report.

RATIONALE FOR SELECTION OF TECHNOLOGY FOR NEW SOURCE PERFORMANCE STANDARDS

Type of Process Employed and Process Changes

No radical new in-plant processes are proposed as a means of achieving new source performance standards for this subcategory. The internal control technologies which are identified have all been demonstrated by mills within the subcategory under study.

Operating Methods

Significant revisions in operating methods, both in-plant and at the waste water treatment facility, will be necessary. However, these improvements are not beyond the scope of well-trained personnel, and are currently being practiced in other industries. The primary areas of operational change will pertain to required activities for recycle, reuse, and spill control, as well as for optimal performance of waste water treatment facilities.

Batch as Opposed to Continuous Operations

For the subcategory studied, it was determined that batch as opposed to continuous operations is not a significant factor in waste load characteristics and no additional control of pollutants could be achieved through the use of one type process over the other.

Use of Alternative Raw Materials and Mixes of Raw Materials

The raw materials requirements for a given mill do vary, depending upon supply and demand, desired end product, and other conditions. However, alteration of raw materials as a means of reducing pollutants is not considered feasible over the long term even though such a change could possibly realize benefits of short duration in a given instance.

Use of Dry Rather Than Wet Processes (Including Substitution of Recoverable Solvents for Water

For this subcategory, it was determined that technology for dry pulping beyond that already practiced or papermaking processes does not exist nor is it in a sufficiently viable experimental stage to be considered here.

Recovery of Pollutants as Byproducts

It is anticipated that these performance standards will motivate increased research on recovering materials for byproduct sale the recovery of which is not presently economically feasible.

Pretreatment Requirements for Discharges to Municipal Systems

None of the pollutant parameters identified in Section VI of this report, with the possible exception of pH, can be expected to disrupt or interfere with the normal operation of a municipal waste water treatment system which is designed to accommodate the industrial pollutant load discharged to it from any mill within the subcategory studied. In the case of pH, some pre-treatment may be required if it can be shown that the normal pH range in the waste discharged from a given mill exceeds 6.0-9.0.

Cost of Application in Relation to Effluent Reduction Benefits

Based upon the information contained in Section VIII and the Appendices of this report, the total projected cost of the external technologies identified for NSPS for a 90.7 metric ton (100 short ton) per day mill reflects an increase in production expenses of $4.90 per metric ton ($5.40 per short ton). This is based upon a total annual cost of $162,000, including energy requirements and 300 days of production per year. Costs for internal technologies are not available.

SECTION XII

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SECTION XIII

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SECTION XIV

GLOSSARY

Act

Federal Water Pollution Control Act, as amended in 1972.

Air Dry Ton

Measurement of production including moisture content, which usually varies between four and ten percent.

Broke

Partly or completely manufactured paper that does not leave the machine room as salable paper or board; also paper damaged in finishing operations such as rewinding rolls, cutting, and trimming.

Cellulose

The fibrous constituent of trees.

Chest

A tank used for storage of wet fiber or furnish.

Chips

Small pieces of wood used to make pulp.

Coatings

Materials such as clay, starch, alum, synthetic adhesives, etc., applied to the surface of paper to impart special characteristics.

Consistency

The weight percent of solids in a solids-water mixture used in the manufacture of pulp or paper.

Cylinder Machine

A papermaking machine in which the sheet is formed on a wire-covered cylinder rotating in a vat of furnish.

Decker or Thickener

A mechanical device used to remove water from pulp.

External Treatment

Technology applied to raw waste streams to reduce pollutant levels.

Fiber

The cellulosic portion of the tree used to make paper.

Furnish

The mixture of fibers used to manufacture paper.

Gland

A device utilizing a soft wear resistant material used to minimize leakage between a rotating shaft and the stationary portion of a vessel such as a pump.

Gland Water

Water used to lubricate a gland. Sometimes called "packing water."

Grade

The type of building paper or felt manufactured.

In-Plant Measures

Technology applied within the manufacturing process to reduce or eliminate pollutant in the raw waste water. Sometimes called "internal measures."

Machine Felt

An endless belt of wool or plastic used to convey and dewater the sheet during the papermaking process.

Press

A device using two rolls for pressing water from the sheet and/or the felts carrying the sheet, prior to drying.

Pulp

Cellulosic fibers from wood chips, waste paper, or other fiber sources.

Pulper or Beater

A mechanical device used to separate fiber bundles in the presence of water prior to papermaking.

Rejects

Material unsuitable for papermaking which has been separated in the manufacturing process.

Sanitary Landfill

A sanitary landfill is a land disposal site employing an engineered method of disposing of solid waste on land in a manner that minimizes environmental hazards by spreading the wastes in thin layers, compacting the solid wastes to the smallest practical volume, and applying cover material at the end of each operating day.

Save-all

A mechanical device used to recover papermaking fibers and other suspended solids from a waste water or process stream.

Sheet

The web of paper as manufactured on a paper machine.

Stock

Wet pulp with or without chemical additions.

Suction Box

A rectangular box with holes or slots on its top surface, used to suck water out of a felt or paper sheet by the application of vacuum.

Virgin Wood Pulp (or fiber)

Pulp made from wood, as contrasted to waste paper sources of fiber.

White Water

Water which drains through the wires of a paper machine which contains fiber, filler, and chemicals.

APPENDICES

APPENDIX I

BUILDING PAPER AND ROOFING FELT MILLS IN THE U.S.

Saturated/Coated Roofing Felt

GAF Corp
Mobile, Alabama

Bear Brand Roofing, Inc.
Bearden, Arkansas

Celotex Corp.
Camden, Arkansas

A-R Felt Mills, Inc.
Little Rock, Arkansas

Elk Roofing Co.
Stephens, Arkansas

Fry Roofing Co.
Compton, California

Celotex Corp.
Los Angeles, California

Johns-Manville Product Corp.
Pittsburg, California

Certain-Teed Products Corp.
Richmond, California

Anchor Paper Mills, Inc.
South Gate, California

U. S. Gypsum Co.
South Gate, California

Flintkote Company
Vernon, California

Tilo Company, Inc.
Stratford, Connecticut

Fry Roofing Co.
Jacksonville, Florida

GAF Corp.
Savannah, Georgia

Lloyd A. Fry Roofing Corp.
Chicago, Illinois

Logan-Long Co.
Chicago, Illinois

Flintkote Co.
Mt. Carmel, Illinois

Johns-Manville Corp.
Waukegan, Illinois

Carey Co.
Wilmington, Illinois

Celotex Corp.
Wilmington, Illinois

Fry Roofing Co.
Brookville, Indiana

Delta Roofing Mills, Inc.
Slidell, Louisiana

Bird & Son, Inc.
Shreveport, Louisiana

Celotex Corp.
Marrero, Louisiana

Congolium-Nairn, Inc.
Finksburg, Maryland

Bird & Son, Inc.
East Walpole, Massachusetts

Certain-Teed Products Corp.
Minneapolis, Minnesota

Certain-Teed Products Corp.
Shankopee, Minnesota

Atlas Roofing Mfg. Co., Inc.
Meridian, Mississippi

Tamko Asphalt Products Inc.
Joplin, Missouri

GAF Corp.
Kansas City, Missouri

Fry Roofing Co.
N. Kansas City, Missouri

U.S. Gypsum Co.
Jersey City, New Jersey

Johns-Manville Corp.
Manville, New Jersey

Allied Materials Corp.
Albuquerque, New Mexico

Armstrong Cork Co.
Fulton, New York

Penn Yan Paper Products
Penn Yan, New York

Fry Roofing Co.
Morehead City, North Carolina

Certain-Teed Products Corp.
Avery, Ohio

Celotex Corp.
Cincinatti, Ohio

Nicolett Industries
Hamilton, Ohio

Big Chief Roofing Co.
Ardmore, Oklahoma

Allied Materials Corp.
Stroud, Oklahoma

Bird & Son Inc. of Mass.
Portland, Oregon

Fry Roofing Co.
Portland, Oregon

Celotex Corp.
Philadelphia, Pennsylvania

GAF Corp.
Whitehall, Pennsylvania

Certain Teed Products Corp.
York, Pennsylvania

Phillip Carey Mfg. Co.
Memphis, Tennessee

Fry Roofing Co.
Memphis, Tennessee

Celotex Corp.
Memphis, Tennessee

GAF Corp.
Dallas, Texas

Southern Johns-Manville Corp.
Ft. Worth, Texas

Celotex Corp.
Houston, Texas

Fry Roofing Co.
Houston, Texas

Fry Roofing Co.
Irving, Texas

Celotex Corp.
San Antonio, Texas

Dry Roofing Felt

Fontana Paper Mills Inc.
Fontana, California

Lloyd A. Fry Roofing Co.
Miami, Florida

Certain-Teed Products Corp.
Savannah, Georgia

Bird & Son, Inc.
Chicago, Illinois

Certain-Teed Products Corp.
East St. Louis, Illinois

Celotex Corp.
Peoria, Illinois

Lloyd A. Fry Roofing Co.
Mishawaks, Indiana

Royal Brand Roofing, Inc. (Tamko)
Phillipsburg, Kansas

Southern Johns-Manville Corp.

New Orleans, Louisiana

GAF Corp.
Gloucester City, New Jersey

Celotex Corp.
Perth Amboy, New Jersey

Conwed Corp.
Riverside, New York

Celotex Corp.
Goldsboro, North Carolina

Lloyd A. Fry Roofing Co.
Emmaus, Pennsylvania

GAF Corp.
Erie, Pennsylvania

Bird & Son Inc.
Phillipsdale, Rhode Island

The Flintkote Company
Cornell, Wisconson

Combination of the Above

GAF Corp.
Joliet, Illinois

Grace & Co.
Owensburg, Kansas

Celotex Corp.
Linden, New Jersey

Logan-Long Co.
Franklin, Ohio

Malarkey Paper Co.
Portland, Oregon

Nicolet Industries
Ambler, Pennsylvania

Appendix II

Table 1

RAPP DATA - BUILDING PAPER MILLS

Mill	Tons/ Day	Treatment			Flow	Discharge		Comments
		C	ASB	AS	G/Ton x1000	TSS #/Ton	BOD #/Ton	
1	165	X	trickling filter		1.9	1.9	0.58	Felt
2	65	X	X		0.09	0.8	0.001	Roofing felt
3	240				2.5	11.0	30.5	Construction felt
4	250			X	Poor operation reported by state			Roofing felts
5	250	X		X	NA	2.0	2.8	Flooring felt
6	80	X	X		0.44	0.26	0.11	Roofing felt

Key to treatment codes:

C = Clarifier
ASB = Stabilization Basin
AS = Activated Sludge

APPENDIX III

Exhibit 1

PRELIMINARY MILL SURVEY FORMAT

Information to be determined prior to mill survey.

1. PRE-VISIT INFORMATION - Obtain information describing the plant prior to the reconnaissance survey. This could include magazine articles describing the facilities, data or drawings furnished by the mill, RAPP data, or any other pertinent information available. This will enable us to get familiar with the mill before we meet with the mill personnel.

2. EVALUATION OF EXISTING DATA - Check the availability of existing data that the mill will make available for our inspection.

Included in this should be any drawings of the inplant or external treatment facilities such as:

a. Layouts and sewer locations
b. Flow diagrams of treatment facilities
c. Flow diagrams of mill process areas
d. Water balance
e. Material balances

3. INITIAL MEETING - Establish what procedures will be required of us during the sampling survey. For example, are there any areas of the mill off limits or will the mill want someone with us at all times?

What safety requirements must we follow? Do we need safety shoes, life preservers, hard hats, respirators, etc.? Can the mill supply these?

4. INSPECTION OF MILL - In inspecting the various process areas of the mill, we should identify the following:

a. Location of individual discharges to the process sewers.

b. Relative quality and type of individual discharges, i.e., clean, cooling water, contaminated, etc.

c. Types of sewers, i.e., open, closed; and direction of flow.

d. Location of existing flow measurement and sampling points and type of equipment in use.

e. Tentative locations of additional sampling and gauging points. Where possible, an estimation of the average flow and possible peak conditions will be indicated. Upstream conditions and sewer characteristics will be inspected to ascertain that no flooding or other problems will be encountered during measurement.

f. Methods and procedures in use to prevent or intercept strong spills.

g. Relative amount of process water reuse and adequacy of existing information such as flow diagrams to explain and document the extent, methods, and equipment required for reuse.

5. INSPECTION OF EFFLUENT TREATMENT FACILITIES - In addition to location of existing flow measurement and sampling points we should evaluate the need for additional points and any special equipment needed. Sampling points should be available at the following locations:

a. Primary influent
b. Primary effluent
c. Primary sludge
d. Secondary effluent
e. Secondary sludge (if any)
f. Chemical feed systems
g. Sludge disposal
h. Additional treatment facilities

6. LABORATORY FACILITIES - A complete check of the procedures used by the mill in running its chemical and biological tests should be made by the plant chemist or other responsible party.

Determine whether the mill will allow us to use its lab and/or personnel during the survey. If the mill will allow us to use its facilities, a complete list of equipment available should be made and a list of supplies needed to perform the various tests.

If we cannot use the mill's lab, we must determine where we intend to have the samples tested and make the appropriate arrangements.

7. REVIEW INFORMATION AVAILABLE ON FRESH WATER USED AND WHERE USED -

a. Process
b. Sanitary
c. Cooling water
d. Other

Review records showing quantity and quality of fresh water and flow measurement device used.

8. REVIEW INFORMATION AVAILABLE ON THE WASTE WATER DISCHARGE FROM THE POWER PLANT -

a. Determine water treatment facilities employed
b. Facilities used on water discharge
c. Frequency of waste discharges
d. Quality of discharge

9. COST INFORMATION - Determine or have the mill get for us (if they will) any information on the cost of the internal and external treatment facilities. This should include both capital and operating cost for the facilities, preferably for a number of years. The method used by the mill to finance the facilities and the number of years used to write the expense off would be useful.

If possible the cost data should be gotten by area, such as internal treatment, primary, secondary, etc. Operating costs should include labor, maintenance, chemicals, utilities, hauling, supplies, and any other costs available from the mill.

10. TIME CONSIDERATIONS - Obtain any available information on the following:

a. Time required to design the facility including the preliminary study and final design.

b. Time to construct the facility.

c. Was construction bid after completion of engineering or done turn-key?

d. What were delivery times for major pieces of equipment, both internal and external?

e. What delays were encountered in getting approval by the various regulatory agencies?

Determine the availability of any schedules, CPM or Pert charts for the engineering or construction.

Exhibit 2

MILL SURVEY FORMAT

Building Paper and Roofing Felt Mills

GENERAL INFORMATION

I. Geographic and Physical

1. Describe mill by SIC # and name

2. Location: state, city

3. Age of mill - startup date

4. Water Source - river, well, lake, other

Name Flow Characteristics - cfs

Maximum	Average	Minimum

5. Production, annual tonnage (*-projected) 1965 1968 1971 1973* 1977* 1983*

6. Current design capacity of mill, tons/yr.

II. Obtain the following information from daily mill records over 13-month period, where available.

1. Production, tons/day

2. Principal grades run (use raw materials changes as criterion)

3. Raw materials used; % of total tons/day

4. Waste water characteristics

   a. Total raw waste water
   b. Primary treatment effluent
   c. Primary sludge
   d. Secondary treatment effluent
   e. Secondary settling effluent
   f. Secondary sludge
   g. Characteristics of influent and effluent of any additional waste treatment facilities

5. In-plant water/waste water characteristics

   a. Stock preparation area
   b. Paper machine area - wet end
   c. Paper machine area - dry end

d. Power plant - demineralizer
e. Other waste water discharges
f. Asphalt saturation process

III. Determine type of equipment, design parameters, capital and operating costs of all out-of-plant waste treatment facilities and of those in-plant processes contributing to a significant reduction in waste loads generated.

1. Primary treatment

   a. sump pumps controls and screen
   b. surge tank and controls
   c. removal of suspended solids
   d. chemical treatment (cost/day or yr)
   e. system for removal of floating contaminants

2. Primary sludge handling facilities

   a. pump and control station
   b. storage tank and controls
   c. chemical treatment (cost/day or yr)
   d. dewatering facilities
   e. disposal facilities (cost/day or yr)

3. Secondary treatment - biological process

   a. land area required
   b. power required - hp, $/hp
   c. nutrients required - $/d, gpd,
   d. other system components

4. Secondary solids handling facilities

   a. sludge pumping station and controls
   b. sludge storage tank and controls
   c. other system components

5. Other out-of-plant treatment facilities

6. In-plant facilities

IV. Obtain the following information on Process Equipment.

1. Paper mill in-plant treatment, water re-use and clear water segregation systems

   a. overall volume used (provide best estimate)
   b. where occurring (indicate yes, no or unknown)

      1. stock preparation area

         a) top, under, back and filler pulpers
         b) white water chest make-up

c) cleaning system, dilution-elutriation water
d) pump and/or agitator seal water
e) decker or thickener shower water
f) wash-up hoses

2. machine room

a) wire showers
b) headbox showers and dilution water
c) felt showers
d) couch roll, breast roll, suction drum, couch pit showers
e) vacuum pump seal water
f) pumps and agitator seal and gland water
g) wash-up hoses

c. Cooling water segregation of pulper drives, refiner drives, vacuum pump separators, saturating process, other areas.

V. Obtain sufficient information to complete the following:

1. Schematic diagram of plant, including all significant in-plant and waste water treatment processes.

2. block flow diagram showing:

a. water source(s)

b. in-plant effluent discharge(s)

1) location
2) gpm

d. existing sampling stations

1) location
2) types samples
3) frequency

e. water recycling

1) location
2) gpm

f. Contractor sampling stations

3. description of shut-down operations, frequency and effect on water quality.

4. comprehensive report on:

a. mill laboratory procedures and effectiveness
b. housekeeping procedures
c. in-plant and/or waste treatment process improvements

contemplated or under laboratory/pilot study

d. evaluation of operation and maintenance procedures, both in-plant and waste treatment
e. reliability of existing waste treatment facilities at average and maximum efficiency levels
f. availability of back-up systems in waste treatment process (i.e., dual power, by-pass storage and re-cycle, standby equipment and parts, etc.)
g. sensitivity of waste treatment process to shock loads; shock load frequency
h. extent of impact of existing waste treatment system on air quality, noise, etc.
i. treatment and disposal of solid wastes
j. source, use and ultimate disposal of cooling water
k. recovery/reuse of waste water constituents
l. potential for significant upgrading of waste treatment process performance through

    1) modifications in operation and maintenance procedures
    2) minor additions of equipment (i.e. additional aerators, monitoring equipment, etc.)
    3) major additions of equipment (i.e. clarifier, holding basin, etc.)

m. desirability of additional waste stream segregation or integration for improvement of final effluent quality
n. description of in-plant operating procedures and design features for processes demonstrating above-average performance re water and materials usage.

VI. Conduct on-site sampling program, if required, according to the Analytical Verification Program outline dated March 16, 1973. Sampling will be conducted whenever, in the opinion of the on-site contractor teams, there is sufficient reason to question the validity of existing mill data. If sampling is not conducted, justification and documentation of the rationale used in arriving at this decision should be provided.

DEVELOPMENT OF COST EFFLUENT LIMITATION GUIDELINES AND STANDARDS

SUPPORTING DATA

External Treatment

Pretreatment

Pretreatment consists of screening only for all alternatives considered in this report.

Total effluents from all mills considered in this study usually lose coarse material in the form of chips, bark, wet strength paper, etc., in quantities that require screening to avoid plugging of sludge lines and escape of floating objects over overflow weirs.

Although vibrating screens have proven satisfactory when the flows are small (2-4 MGD), travelling screens with 1" openings have been recommended (2) and are used for all mills included in this study.

Design Criteria:

Type: Travelling bar screens
Design Flow: Average daily
Bar Spacing: 1 inch

Capital Cost in $1,000 =
11 + .27 x Q + 7.64 x Q**.625
(see note below)

where: Q = average daily flow in MGD
(cost information from numerous individual installations was also considered in all cases).

Annual operation and maintenance costs are 8.0 and 5.0% of cost, respectively.

Capital cost and annual operation and maintenance costs for raw waste screening are shown graphically in Figure 1, Appendix IV.

Note: The symbol ** indicates quantity squared; i.e., Q** =Q^2.

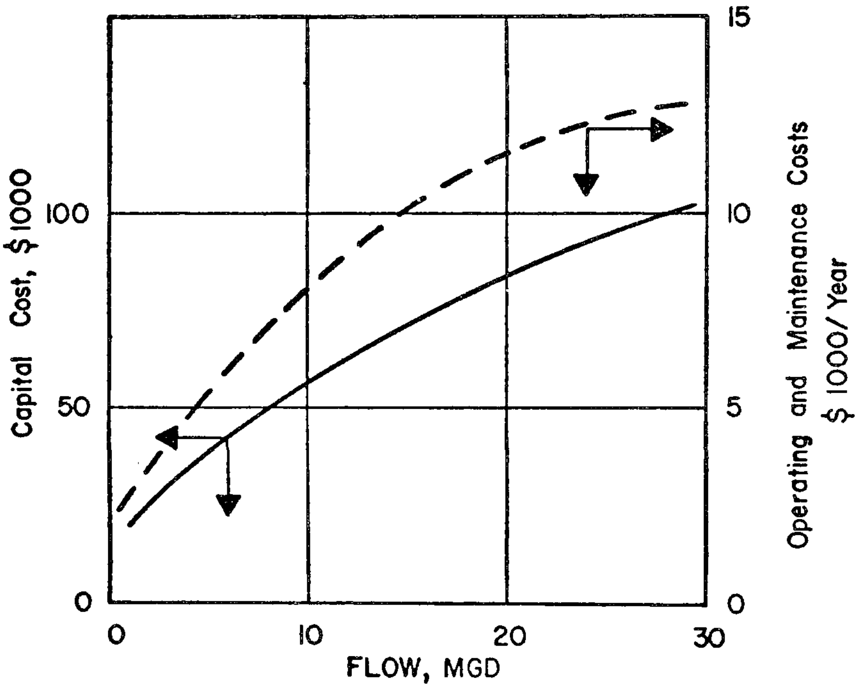

Figure 1 Capital And Operation Cost For Raw Waste Screening

Primary Treatment

Primary treatment is most economically done when all fiber containing wastes are mixed before treatment. Besides the fact that large units give lesser treatment costs than a series of smaller units, mixed effluents generally also have improved settling characteristics, thus decreasing the total treatment units requirements. Internal fiber recovery is assumed done to the maximum economic justifiable degree, with the result that no external fiber recovery for reuse is considered in the treatment process design.

Three unit operations for suspended solids separation have been considered. These are:

a) settling ponds
b) mechanical clarifiers
c) dissolved air flotation

Settling Ponds - Design Criteria:

Construction: earthen construction, concrete inlet and outlet structures
Detention time: 24 hours
Water depth: 12 feet
Sludge removal: manual
Cost Functions:
Capital cost in \$1000 = 27.3 x V **0.75
V = pond volume in million gallons

This construction cost function is based on work in Reference (3). The construction cost, which includes plan sewers, and all diversion - inflow -, and outflow- structures, but excludes land costs, is shown graphically in Figure 2, Appendix IV. The function is "verified" by plotting data from the field survey phase of the same figure.

Operations Costs:

The operation cost of sedimentation ponds consists mainly of sludge dredging and disposal which was estimated to cost \$6.50 per ton of dry solids removed.

Annual maintenance was estimated to be 1% of capital cost.

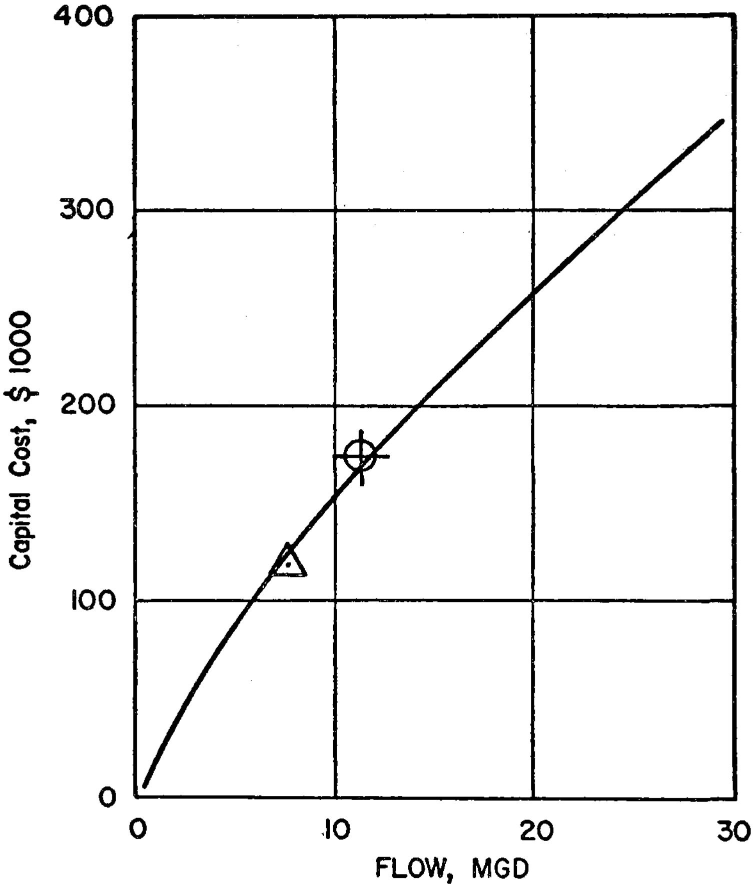

Figure 2 Construction Cost of Earthen Settling Ponds

△ Project Cost Files
○

Secondary Treatment

Primary Clarifiers

Design Criteria:

Construction: Circular heavy duty plow type rotary sludge scraper, scum collection and removal facilities.

Overflow rate: 700 gpd/ft**2 (4)

Sidewater depth: 15 feet

Capital cost in $1000 (3) = 62 x ((1.5 - 0.001Q)Qx1000./OR)**0.60

where: Q = flow in MGD
OR = overflow rate in gpd/ft**2

The construction cost includes all mechanical and electrical equipment, all construction costs, instrumentation, installation, and sludge pumps and plant sewers. Land costs are not included. This cost function is shown graphically in Figure 3, Appendix IV and includes data from the field survey phase of the project.

BOD removal, i.e. secondary treatment, in the builders paper and board industry is usually done by a biological process: Biological filters, natural oxidation ponds, aerated lagoons (or aerated stabilization basins) or activated sludge. Activated sludge treatment was considered in this report since a majority of the mills are close to population centers, where alternate biological treatment systems would not apply because of the high cost of land. A two stage aerated lagoon treatment system is shown in Figure 4 as an alternative to activated sludge.

Activated Sludge

All costs for activated sludge treatment considered in this study are for completely mixed systems, and with biological reaction and oxygen utilization rates representative of the particular effluents undergoing treatment. The completely mixed system was selected because of its ability to handle surges of organic loads and slugs of biological growth inhibitors. The activated sludge plant used for the costing basis is shown in Figure 5, Appendix IV.

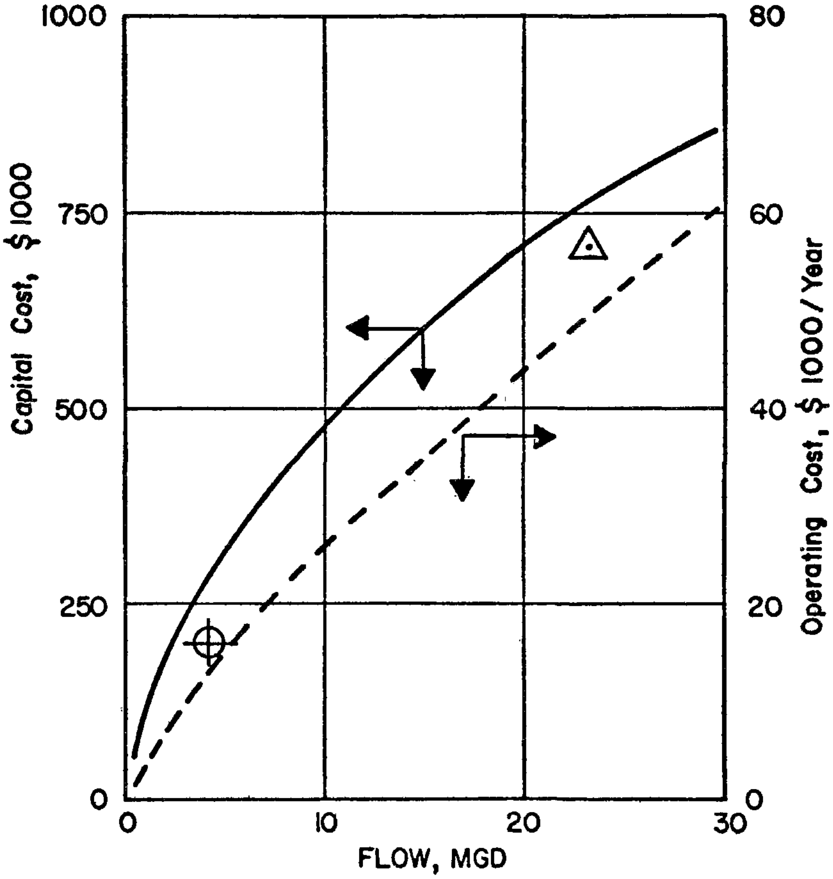

Figure 3 Capital and Operating Costs For Mechical Clarifiers

Capital Cost Case Studies:

△ Project Cost Files
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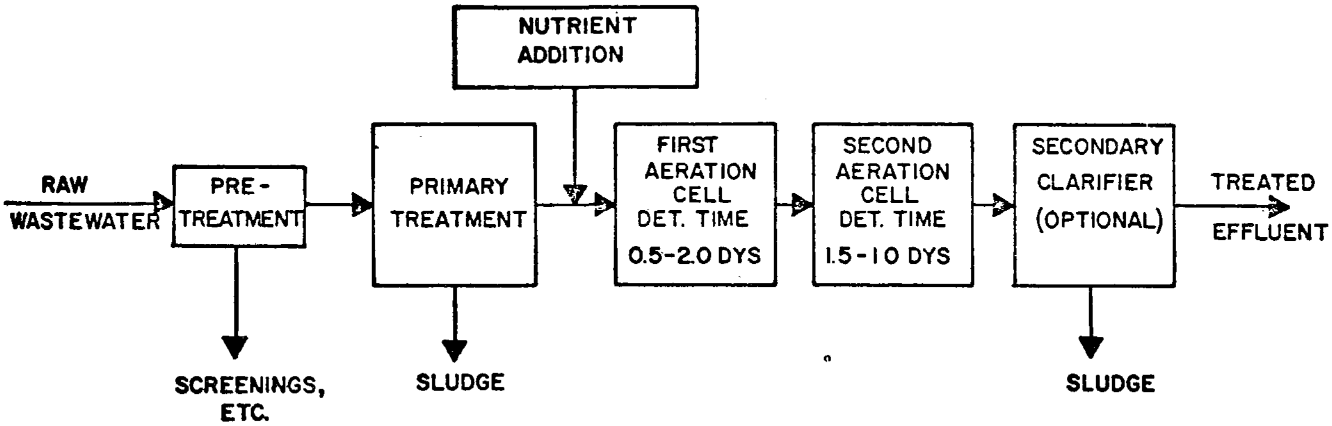


Figure 4 Aerated Lagoon Treatment Plant

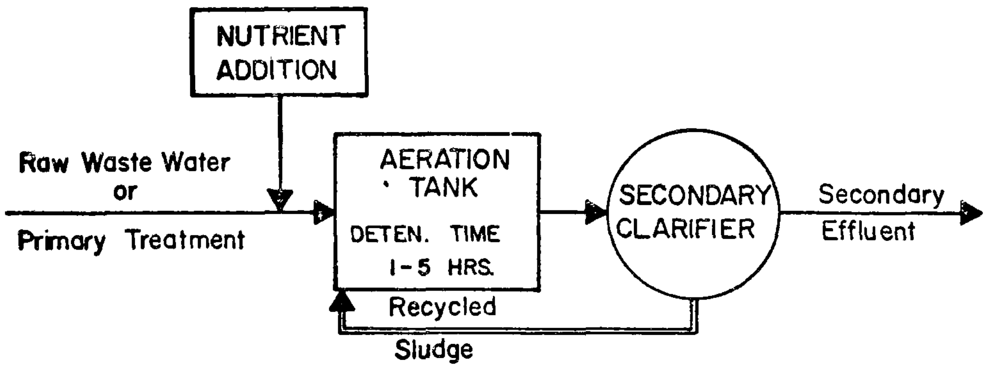


Figure 5 Completely Mixed Activated Sludge System

Design Criteria:

Aeration Tank:

Construction: reinforced concrete with pier mounted surface aerators.

Liquid Depth: 15 feet

Nutrient addition: 4 pounds of nitrogen and 0.6 pounds of phosphorus per every 100 pounds of BOD removed. Influent nutrients are subtracted from these values.

Process design criteria:

Aerators: Type: mechanical surface aerators

Secondary Clarifiers:

Construction: circular concrete tanks with rotary suction type sludge collector

Sidewater depth: 15 feet

Cost Functions: Capital costs in $1000

Aeration tank (3) = 225 x V**0.71
where V = tank volume in million gallons

Aerators (3) = 1.75 x HP**0.81
where HP = total horse power installed

Secondary clarifiers (3) = 62.*((1.5-0.002Q)Q*1000./OR)**0.6
where Q = flow in MGD, including recycle
OR = overflow rate in gpd/ft**2

Sludge recycle pumps (3) = 5.36 + 1.66 x Q
where Q = average daily flow in MG

Operation and Maintenance costs

Cost of operation and maintenance of activated sludge system has been calculated using a cost function developed in Reference (5). This cost function includes operation and maintenance of aeration basin, aerators, final sedimentation tanks and sludge return pumps:

Operation cost (¢/1000 gal) = R x (3.40 + 4.95/v**0.5
where v= basin volume in million gallons
R= retention time in days

The breakdown between operation and maintenance is 60% and 40%, respectively (10).

Power cost is calculated from the net horsepower requirements at 1.1 ¢/kwh.

Nutrient costs are calculated on the basis of $250 per ton of nitrogen and $380 per ton of phosphorus.

Sludge Dewatering

The sludges drawn from the primary and secondary clarifiers require dewatering prior to final disposal. A large number of unit operations are available for this purpose, from which the specific selection depends upon local conditions like sludge characteristics, proportion of primary and secondary sludges, distance to ultimate disposal site, and ultimate disposal considerations. The units operations considered in this study are sludge settlings ponds, gravity thickeners, vacuum filters, centrifuges and sludge presses. The selected sludge dewatering process might consist of one or more sludge dewatering unit operations.

The dewatered sludge solids are usually disposed of either by landfilling or incineration, according to local conditions and the level of technology required. Sludge disposal by landfilling might give very satisfactory solutions provided a suitable site can be found within a reasonable distance from the mill.

Possible harmful effects from landfilling are groundwater pollution by leaching of chemical constituents or decomposition products and erosion by precipitation. Thus, both soil conditions and climate must be suitable to make sludge disposal by landfilling successful, or the required site work might result in a very expensive solution.

Provided air pollution requirements are met, sludge incineration is, from an environmental point of view, a very satisfactory solution since only inert ashes need to be disposed of. Although the solution is usually quite expensive, especially for small installations lack of other solutions might make it the only alternative.

Cost of sludge dewatering and disposal commonly accounts for 30-50% of the total treatment cost.

Cost Functions:

Sludge dewatering ponds: Capital cost in $1000 (3) = 125 x V**0.70
where V = volume in MG

The operation cost of sludge ponds consists mainly of sludge dredging and disposal which was estimated to cost $6.50 per ton of dry solids removed.

Annual maintenance cost was estimated to be 1% of capital cost.

Gravity Thickeners: capital cost in $1000 (3)
= (SA) (34. + 16.5/exp (SA/13.3)
where SA = surface area in thousands of square feet

Annual operation and maintenance costs of gravity sludge thickeners was estimated to 8% of the capital cost.

Vacuum Filters: capital costs in $1000 (12) = 4.70 x A**.58
where A = filter area in square feet

Operating and maintenance cost for vacuum filtration was based on the following (3):

Labor: 0.5 man-hours per filter hour @ $5.25 per hour
Power cost: 0.15 HP per square foot of filter @1.10 ¢/kwh
Chemicals: $10.00 per dry ton for waste activated sludge, and $4.00 per dry ton for primary sludges
Maintenance: 5% of capital cost, annually

Centrifuges: capital costs $1000 (12) = 15.65 * (HP)**0.4
where HP = total installed horsepower of the centrifuge.

Operation and maintenance costs have been calculated as follows:

Labor: 0.25 man-hours per hour of centrifuge operation @5.25 per hour (3).
Power cost: 1.10 ¢/kwh
Chemicals: None required for primary sludges increasing linearly with the fraction of secondary sludges to 8 pounds of polymer per dry ton of solids @$1.25 per pound of polymer.
Maintenance: 10% of capital cost, annually.

Sludge Presses: capital cost in $1000 = 5.75 x (S/F)**0.95
where S = dry weight of sludge, ton/day
F = press load, as a fraction of nominal load

Operation Cost:
Labor: 0.25 hours per hour of press operation @$5.25 per hour of press operation.
Power: 1.1 ¢/kwh

Maintenance: 10% of operation cost, annually.

Landfilling: Transport cost: 20¢/ton mile
Transport distance: 10 miles

Incineration: capital cost $1000 (3) = (S/9.6)
(170 + 735 x S**0.61)

S = total solids in tons/day

Incineration: capital cost $1000 (3) = (S/9.6)
(170 + 735 x S**0.61)
where S = total solids in tons/day

Operation cost in $1000/yr (3)
(0.001 + 0.004 SE/P) S + S**0.85 x 0.001
where SE = secondary sludge in lbs/day
P = primary sludge in lb/day
S = total pounds of sludge/day

Mixed Media Filtration

Builders Paper 100T/D

capital: $75,000 + 35% =		$101,000
operating:		$ 6,200
add: 15% of 101,000	=	15,000
total annual cost	=	$ 21,200
less: 35% of 6,200 energy	=	2,200
annual cost less energy	=	$ 19,000

$\frac{19,000}{100x300}$ = $0.63/ton less energy

$\frac{2,200}{100x300}$ = 0.07/ton energy
$ .70/ton total

Internal Treatment

The following unit prices have been used for the internal measures:

Power 0.60 ¢/kwh
Heat 3.50 $/10**9 cal
Maintenance: 2.5% of capital cost, annually

Costs of heat exchangers, storage tanks, pumps and pipes are estimated according to Chemical Engineering, March 24, 1969 issue and updated to August 1971 price levels.

It should be recognized that costs of internal process modifications may vary greatly from mill to mill, and that cost of internal improvements should be evaluated upon consideration of local conditions.

Land Disposal of Junk Materials

The cost has been calculated on the basis of an external transportation contract, and no capital cost has been assumed. The cost of transportation has been estimated to 20 cents/ton-mile, and cost of disposal to $1.5/ton. Transportation distance has been taken to 10 miles. The amount of junk materials for a building paper mill is the following:

2 ton/day (350¢/ton) = 2800 ¢/d

Control of Asphalt Wastes and Spills

Floor drains are collected to a sedimentation basin equipped with asphalt removal system. The cost of sedimentation basin according to formulas given in the part discussing the external treatment is $43,000. Maintenance at 2.5% equals $0.34/tp. Cost of operation will be $1.64/tp.

Paper Machine Controls

High pressure self cleaning, low volume showers for paper machine, and press water filter for removing felt hairs will be provided.

The following paper machine widths have been assumed:

building paper machine 14 feet

Capital cost has been calculated to 14 feet width.

Cost for each unit:

-4 shower pipes	14 feet	2,000
-2 pumps (10 kw)		2,000
-1 smith screen		1,000
-4 water saveall pans		3,000
-2 hair screens, smith		1,000
-tank, piping, hoses		4,000
-spares		1,000
-design, instrumentation, electricity, installation, etc.		11,000
TOTAL		$35,000

For building paper machine:

Wire part	$ 35,000
Press part	35,000
	$ 70,000

Spill Control

By spills are meant releases of wood fibers and/or process additions to those which are "normal" for the process. The release of the "normal" pollutant load for a process depends upon the process design and equipment used, and is therefore reasonably well defined or deterministic in nature. The spills are caused by "accidents" or mechanical failures in the production facilities and are as such probabilistic in nature.

The accidental spills are in general of short duration and usually have a fiber and/or concentration of chemical substances which are several times those of the normal mill effluents (1). Another undesirable property associated with accidental spills is that they might not be intercepted by the waste water collection system, and they find their way into the storm sewers and therefore bypass all treatment systems.

The main sources of accidental losses are:

a) leaks and overflows from storage tanks, b) leaks and spills resulting from repairs, system changes and mistakes in departments handling strong liquor, and c) overflows from screens and filters in departments handling fiber.

Controls of spills can be done by connecting overflow lines to holding tanks equipped with pumps which return chemicals to storage or to the recovery system, and fibers to the stock chest.

Cost of spill control is based on systems shown schematically in Figure 6, Appendix IV.

Costs of spill controls are lump sums as shown in the cost summary. These costs include construction costs and mechanical and electrical equipment as shown in Figure 6, Appendix IV.

Large Spills

Large accidental losses caused by mechanical failures can be prevented by an effective control system, e.g. conductivity measurements in the waste water lines. As these losses might render the effluent unsuitable for treatment, an emergency spill basin is constructed to intercept these wastes. The spill basin content is pumped back to the treatment process at a rate which does not "upset" the treatment process.

Construction cost of the spill basin is based on a system which is shown schematically in Figure 7, Appendix IV.

Design Criteria for Spill Basin:

Volume: 12 hours of average flow
Pump Capacity: Basin volume returned to treatment process in 12 hours at 30 feet head.
Basin: Earthen construction with 12 foot depth

Sewers

Plant Sewers

Plant sewers are defined as the gravity flow type conveyance facilities within the boundaries of the treatment plant. These may be both closed conduits and open channels. The capital costs of these items are included under the respective treatment plant components.

Annual operation and maintenance costs of in-plant sewers have been taken at a flat 0.50% of the estimated construction cost with no differentiation between materials of construction, except as reflected in the construction cost.

Interceptor Sewers

Interceptor sewers are defined as the conveyance facilities which connect the mill to the treatment plant and the treatment plant to the outfall system. Thus, they may vary from being insignificant in a situation where land is available adjacent to the mill, whereas they may amount to a large percentage of the treatment plant cost where long interceptor sewers are required. For this reason no interceptor sewers are included in this study.

Land Requirements and Costs

Land Requirements: A site suitable for an effluent treatment facility should have the following properties:

- should be within a reasonable distance from the production facilities so that long and expensive interceptor sewers are eliminated.

- should be far enough from the production facilities so that their expansion possibilities are not hampered.

- should be at a suitable elevation relative to the production facilities so that pumping costs are minimized, and ideally allow for gravity flow through all treatment units.

- should allow for orderly future treatment plant expansion on land which can be purchased at a reasonable price and with adequate soil properties.

The two major factors affecting the area requirements for external waste water treatment are the type of secondary treatment and type of sludge disposal. The approximate land requirements for activated sludge systems are 0.04 acres/mgd.

Land required for ultimate solids disposal depends on the sludge quantities generated, moisture content, ash content, and method of placement.

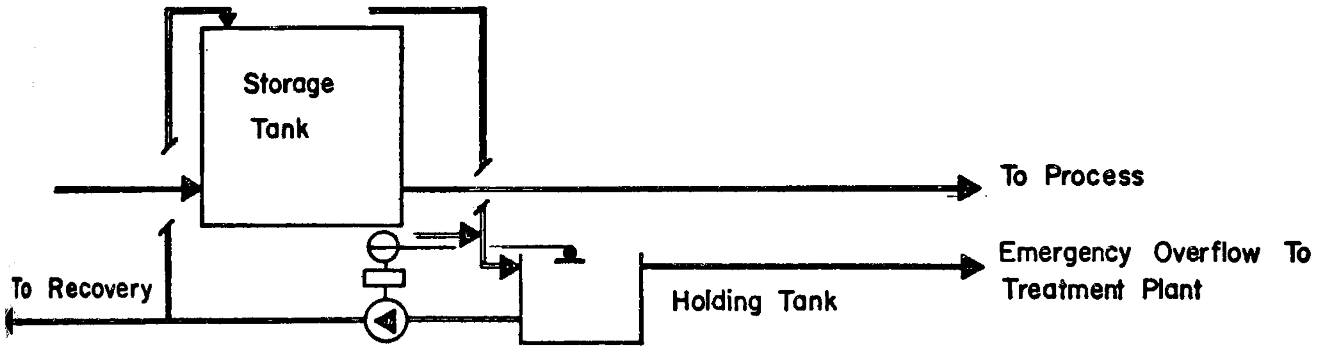
Land requirement for different ultimate sludge disposal methods (Disposed effluent at 12 feet depth)

Disposal Condition	Land Requirements sq ft / ton dry solids
Thickened clarifier underflow, 5% solids	53.0
Centrifuge cake, 20% solids	16.5
Pressed cake, 35% solids	11.6
Incineration, 3% ash	0.15
Incineration, 12% ash	0.60

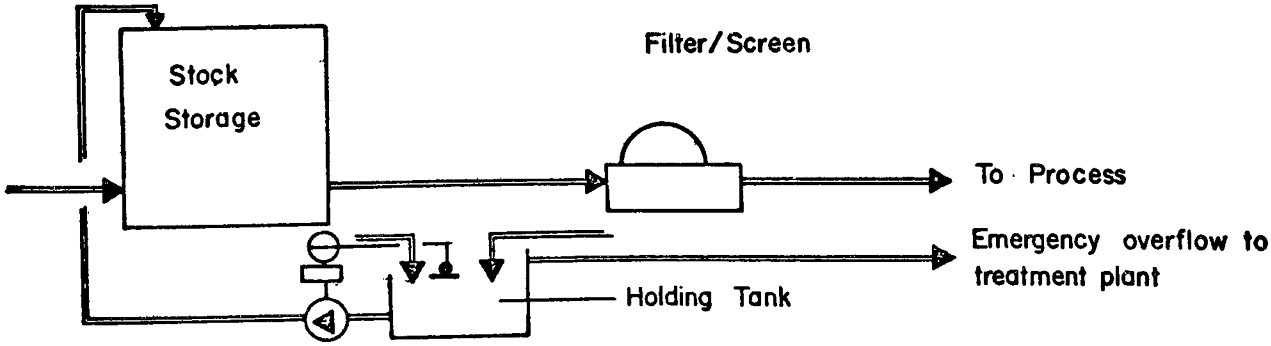
Land Costs

The value of land is often difficult to establish. Depending upon land availability and alternate land use, the land cost might vary from $1.00 per square foot or more down to only a few cents per square foot.

For the purpose of this study a land cost selected was $4,000 per acre.



a) Control Of Chemical Spills And Losses



b) Control Of Fiber Containing Spills

Figure 6 Spill Control Installations

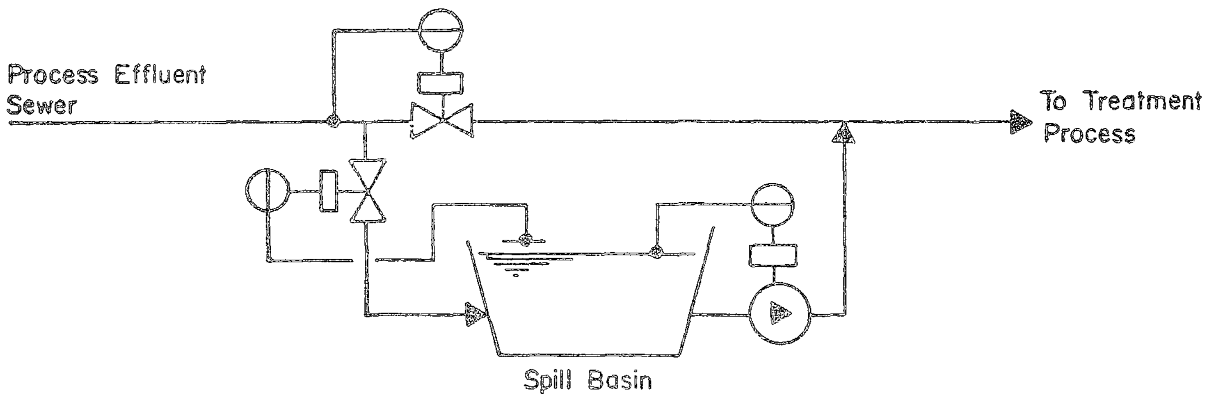


Figure 7 Spill Basin and Controls

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APPENDIX V

METRIC UNITS

CONVERSION TABLE

MULTIPLY (ENGLISH UNITS) by TO OBTAIN (METRIC UNITS)

ENGLISH UNIT	ABBREVIATION	CONVERSION	ABBREVIATION	METRIC UNIT
acre	ac	0.405	ha	hectares
acre - feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram - calories
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg	kilogram calories/kilogram
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	F°	0.555(°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	killowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
million gallons/day	mgd	3,785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (gauge)	psig	(0.06805 psig +1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
tons (short)	t	0.907	kkg	metric tons (1000 kilograms)
yard	y	0.9144	m	meters

* Actual conversion, not a multiplier