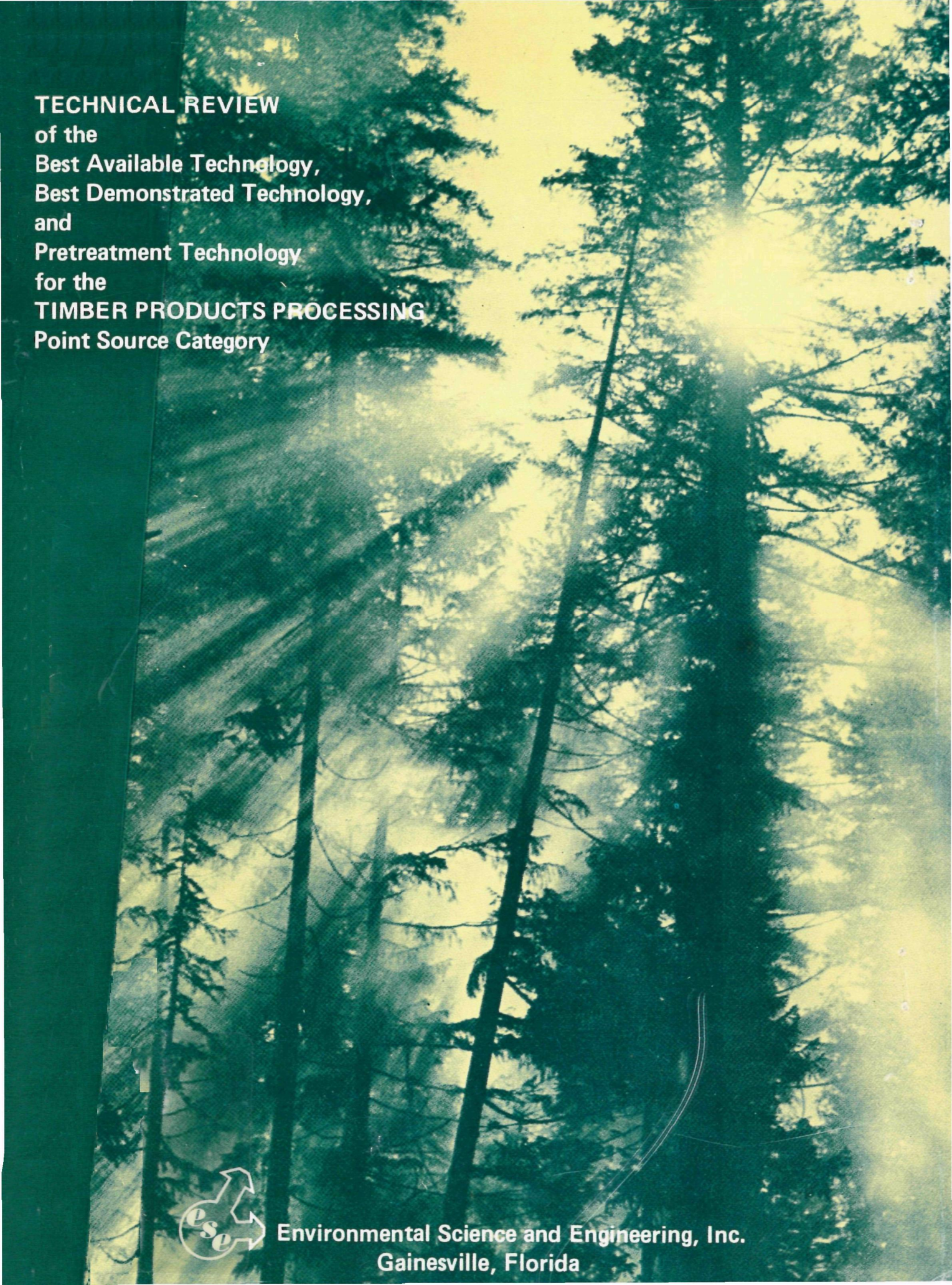
TECHNICAL REVIEW of the Best Available Technology, Best Demonstrated Technology, and Pretreatment Technology for the TIMBER PRODUCTS PROCESSING Point Source Category



Environmental Science and Engineering, Inc.
Gainesville, Florida

NOTICE

This document is a DRAFT CONTRACTOR'S REPORT. It includes technical information submitted by the Contractor to the United States Environmental Protection Agency ("EPA") regarding the subject industry. It is being distributed for review and comment only. The report is not an official EPA publication and it has not been reviewed by the Agency.

The report will be undergoing extensive review by EPA, Federal and State agencies, public interest organizations and other interest groups and persons during the coming weeks.

The regulations to be published by EPA under Sections 301(d), 304(b) and 306 of the Federal Water Pollution Control Act, as amended, will be based in part, on the report and the comments received on it. EPA will also be considering economic, and environmental impact information that is being developed. Upon completion of the review and evaluation of the technical, economic, and environmental information, an EPA report will be issued at the time of proposed rule-making setting forth EPA's preliminary conclusions regarding the subject industry. These proposed rules will include proposed effluent guidelines and standards, standards of performance, and pretreatment standards applicable to the industry. EPA is making this draft contractor's report available to encourage broad, public participation, early in the rule-making process.

The report shall have standing in any EPA proceeding or court proceeding only to the extent that it represents the views of the Contractor who studied the subject industry and prepared the information. It cannot be cited, referenced, or represented in any respect in any such proceedings as a statement of EPA's views regarding the subject industry.

U.S. Environmental Protection Agency
Office of Water and Hazardous Materials
Effluent Guidelines Division
Washington, D.C. 20460

TECHNICAL REVIEW OF THE BEST AVAILABLE TECHNOLOGY, BEST DEMONSTRATED TECHNOLOGY, AND PRETREATMENT TECHNOLOGY FOR THE TIMBER PRODUCTS PROCESSING POINT SOURCE CATEGORY

U.S. ENVIRONMENTAL PROTECTION AGENCY

July 29, 1977

Submitted by:

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Project No. 75-054

ABSTRACT

This document presents the findings of a review by Environmental Science and Engineering, Inc., of the proposed effluent limitations based on the best available technology (BAT) and pretreatment standards for existing sources and new sources, in conformance with a consent decree of the United States District Court for the District of Columbia, June 7, 1976.

The development of information in this document relates to the wood preserving, insulation board, and hardboard segments of the timber products point source category.

The purpose of this document and supporting file records is to develop a profile of the industry segments, assemble and analyze existing information, collect and analyze new information, and evaluate the full range of applicable treatment and control technology in order to provide to the U. S. Environmental Protection Agency a technical base for subsequent development of revised guidelines.

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SECTION I

CONCLUSIONS

The U.S. Environmental Protection Agency will propose effluent limitations for BAT, NSPS, and pretreatment standards for new and existing sources of the wood preserving, insulation board, and wet process hardboard industries upon review and evaluation of technical information contained in this document, comments from reviewers of this document, and other information as appropriate.

Information pertaining to the potential toxicity of discharged wastes to aquatic organisms, animals, and the human population, as well as information concerning the economic impact on the industry if it is required to install additional pollution control technology, will be considered prior to determination of proposed effluent limitations and guidelines.

SECTION II

RECOMMENDATIONS

The U.S. Environmental Protection Agency will propose effluent limitations for BAT, NSPS, and pretreatment standards for new and existing sources of the wood preserving, insulation board, and wet process hardboard industries upon review and evaluation of technical information contained in this document, comments from reviewers of this document, and other information as appropriate.

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SECTION III

INTRODUCTION

Purpose and Authority

The Federal Water Pollution Control Act Amendments of 1972 (the Act) made a number of fundamental changes in the approach to achieving clean water. One of the most significant changes was a shift from reliance on effluent limitations related to water quality to direct control of effluents through the establishment of technology-based effluent limitations which form an additional and minimal basis for issuance of discharge permits.

The Act requires EPA to establish guidelines for technology-based effluent limitations which must be achieved by point sources of discharges into the navigable waters of the United States. Section 301(b) of the Act 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 BPT 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 BAT technology, resulting in 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 new sources to achieve standards of performance providing for the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of NSPS technology, operating methods, or other alternatives, including where practicable a standard permitting no discharge of pollutants.

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:FR:1624) a list of 27 point 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.

Section 307(b) provides that:

1. The Administrator shall, from time to time, publish proposed regulations establishing pretreatment standards for introduction of pollutants into treatment works (as defined in Section 212 of this Act) which are publicly owned, for those pollutants which are determined not to be susceptible to treatment by such treatment works or which would interfere with the operation of such treatment works. Not later than ninety days after such publication and after opportunity for public hearing, the Administrator shall promulgate such pretreatment standards. Pretreatment standards under this subsection shall specify a time for compliance not to exceed three years from the date of promulgation and shall be established to prevent the discharge of any pollutant through treatment works (as defined in Section 212 of this Act) which are publicly owned, which pollutant interferes with, passes through, or otherwise is incompatible with such works.

2. The Administrator shall, from time to time, as control technology, processes, operating methods, or other alternatives change, revise such standards, following the procedure established by this subsection for promulgation of such standards.

3. When proposing or promulgating any pretreatment standard under this section, the Administrator shall designate the category or categories of sources to which such standard shall apply.

4. Nothing in this subsection shall affect any pretreatment requirement establishment by any state or local law not in conflict with any pretreatment standard established under this subsection.

In order to insure that any source introducing pollutants into a publicly owned treatment works, which would be a new source subject to Section 306 if it were to discharge pollutants, will not cause a violation of the effluent limitations established for the treatment works, the Administrator shall promulgate pretreatment standards for the category of such sources simultaneously with the promulgation of standards of performance under Section 306 for the equivalent category of new sources. Such pretreatment standards shall prevent the discharge into the publicly owned treatment works of any pollutant which may interfere with, pass through, or otherwise be incompatible with the works.

The Act defines a new source to mean any source for which the construction is commenced after the publication of proposed regulations prescribing a standard of performance. Construction means any placement, assembly, or installation of facilities or equipment (including contractual obligations to purchase such facilities or equipment) at the premises where such equipment will be used, including preparation work at such premises.

Furthermore, in a consent agreement between EPA and the Natural Resources Defense Council and other plaintiffs (Civil Actions Nos. 2153-73, 75-0172, 75-1699, and 75-1267) dated June 7, 1976, it was stipulated and agreed that EPA would review the June 30, 1983, guidelines, pretreatment standards, and new source performance standards for a number of industry segments, including the Timber Products Processing Point Source Category. The review is to specifically address a number of pollutants, listed in Appendix A of this document and referred to in this document as "priority pollutants." The review is also to recommend technology-based limitations for the priority pollutants, if applicable.

The Administrator published effluent guidelines and standards for the timber products processing point source category in the Federal Register of April 18, 1974, (39:FR:76). These guidelines and standards were subsequently modified in the Federal Register on January 16, 1975 (40:FR:11). Included in these standards are those for the wood preserving and wet process hardboard industries. Regulations for the insulation board industry have not been promulgated. The published effluent limitations and standards are shown in Tables III-1 and III-2.

The purpose of this document is to provide the technical data base for a review by EPA of BAT, NSPS, and pretreatment standards under Section 307(b)(2) and in accordance with the NRDC versus Train consent decree. Information is presented on the processes, procedures, or operating methods which will result in the elimination or reduction in the discharge of pollutants from the industry, including data on the costs of implementing such technology.

Standard Industrial Classifications

The Standard Industrial Classifications list was developed by the United States Department of Commerce and is oriented toward the collection of economic data related to gross production, sales, and unit costs. The list is useful in that it divides American industry into discrete product related segments.

The SIC list is not related to the nature of the industry in terms of actual plant operations, production processes, or considerations associated with water pollution control. The SIC codes investigated during the Timber Products Processing Effluent Limitations Review are:

SIC	2411	Logging Camps and Logging Contractors
SIC	2421	Sawmills and Planing Mills
SIC	2426	Hardwood Dimension and Flooring Mills
SIC	2429	Special Product Sawmills
SIC	2431	Millwork

Table III-1. Current Effluent Guidelines and Standards of Timber Products Processing.

Subcategory	1977 BPT						1983 BAT & NSPS					
	Max Day			30-Day Avg			Max Day			30-Day Avg		
	COD	Phenols	O&G	COD	Phenols	O&G	COD	Phenols	O&G	COD	Phenols	O&G
Wood preserving	NO DISCHARGE						NO DISCHARGE					
Wood preserving Boultonizing	NO DISCHARGE						NO DISCHARGE					
Wood preserving Steam	1,100 (68.5)	2.18 (0.14)	24.0 (1.5)	550 (34.5)	0.65 (0.04)	12.0 (0.75)	220 (13.7)	0.21 (0.014)	6.9 (0.42)	110 (6.9)	0.064 (0.004)	3.4 0.21

NOTE: Units for wood preserving limitations are Kg/1000 cm of product (lb/1000 CF). pH will be in the range of 6.0 to 9.0.

SOURCE: 40 CFR, Part 429.

Table III-2. Current Effluent Guidelines and Standards for Timber Products Processing, Wet Process Hardboard

Subcategory	1977 BPT				1973 BAT & NSPS			
	Max Day		30-Day Avg		Max Day		30-Day Avg	
	BOD	TSS	BOD	TSS	BOD	TSS	BOD	TSS
Wet Process Hardboard	7.8 (15.6)	16.5 (33.0)	2.6 (5.2)	5.5 (11.0)	2.7 (5.4)	3.3 (6.6)	0.9 (1.8)	1.1 (2.2)

NOTE: Units for Wet Process Hardboard are Kg/1000 Kg of product (lb/2000 lb of product). pH will be in the range of 6.0 to 9.0.

SOURCE: 40 CFR, Part 429.

SIC	2434	Wood Kitchen Cabinets
SIC	2435	Hardwood Veneer and Plywood
SIC	2436	Softwood Veneer and Plywood
SIC	2439	Structural Wood Members
SIC	2491	Wood Preserving
SIC	2499	Timber Products not elsewhere classified (Hardboard)
SIC	2661	Building Paper and Building Board Mills (Insulation Board)

The industry segments addressed in this document are wood preserving (SIC 2491), insulation board production (SIC 2661), and hardboard production (SIC 2499).

Methods Used for Development of Candidate Technologies

The first step in the review process was to assemble and evaluate all existing sources of information on the wastewater management practices and production processes of the timber products processing industry.

Sources of information reviewed included:

1. Current literature, EPA demonstration project reports, EPA technology transfer reports.
2. Effluent Limitations Guidelines and New Source Performance Standards, Timber Products Processing Industry, including supplemental information.
3. Draft Development Document for Pretreatment Standards, Wood Preserving Segment, Timber Products Processing Industry, including supplemental information.
4. Summary Report on the Re-evaluation of the Effluent Guidelines for the Wet Process Hardboard Segment of the Timber Products Processing Industry, including supplementary information.
5. Information obtained from regional EPA and state regulatory agencies on timber products plants within their area of jurisdiction.
6. Data submitted by individual plants and industry trade associations in response to publication of EPA proposed regulations.

A preliminary analysis of the above data indicated that additional information would be required, particularly concerning the use and discharge of priority pollutants. Updated information was also needed on production related process raw waste load (RWL) currently practiced or potential in-process waste control techniques, and the identity and effectiveness of end-of-pipe treatment systems.

Recognizing that individual plants within the industry could help provide the necessary information, EPA had a data collection portfolio prepared and sent it directly to manufacturing plants of the wood preserving, insulation board, and hardboard segments of the industry. The portfolio was designed to update the existing data base concerning water consumption, production processes, wastewater characterization, raw waste loads based on historical production and wastewater data, in-process waste control techniques, and the effectiveness of in-place external treatment technology. The portfolio also requested information concerning the extent of use of materials which could contribute priority pollutants to wastewater and any data for priority pollutants in wastewater discharges.

Responses to the data collection portfolio served as the source of updated information for the traditional parameters such as BOD, COD, etc.

Additional sources of information included NPDES, state, and local discharge permits; information provided by industry trade associations; and information obtained from direct interviews and sampling visits to production facilities.

Survey teams composed of project engineers and scientists conducted the actual plant visits. Information on the identity and performance of wastewater treatment systems was obtained through interviews with plant water pollution control or engineering personnel, examination of treatment plant design and historical operating data and sampling of treatment plant influents and effluents.

Information on process plant operations and the associated RWL was obtained through interviews with plant operating personnel, examination of plant design and operating data (original design specifications, flow sheets, and day-to-day material balances around individual process modules or unit operations where possible), and sampling of individual process wastewater.

Only in rare instances did plants report any knowledge of the presence of priority pollutants in waste discharges. Therefore, priority pollutant data in waste discharges of the industry were obtained by a thorough engineering review of raw materials and production processes used in each industry and by a sampling and analysis program for priority pollutants at selected plants. Every effort was made to choose facilities where meaningful information on both treatment facilities and manufacturing operations could be obtained.

The technical data base served as the basis for a review of existing subcategorization within the industry. Among other factors, subcategorization review took into consideration the raw materials used, products manufactured, production processes employed, and wastewaters generated. The raw waste characteristics for each subcategory were then identified.

This included an analysis of: (1) the source and volume of water used in the process employed and the sources of wastes and wastewaters in the plant; and (2) the constituents of all wastewaters including traditional and priority pollutants. The full range of control and treatment technologies existing within each candidate subcategory was identified. This included an identification of each distinct control and treatment technology, including both in-plant and end-of-pipe technologies, which are existent or capable of being used by the plants in each subcategory. It also included an identification, in terms of the amount of constituents and of the chemical, physical and biological characteristics of pollutants, including priority 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, as well as the required implementation time were identified. In order to derive variability factors based on actual treatment plant performance, statistical analyses were performed on those treatment systems for which sufficient historical data were available.

In addition, non-water quality environmental impacts, such as the effects of the application of such technologies on other pollution problems, were defined. The energy requirements of each of the candidate control and treatment technologies were identified, as well as the cost of the application of such technologies.

The following text describes the details of the scope of study, the coverage of the technical data base, and the technical approach used to select candidate treatment technologies for the wood preserving, insulation board, and hardboard segments of the timber products processing point source category.

Wood Preserving

Scope of Study

The scope of this document includes all wood preserving plants (SIC 2491) regardless of the types of raw materials used, methods of preconditioning stock, types of products produced, or means of ultimate waste disposal.

General Description of Industry

The wood preserving industry applies chemical treatment to round or sawn wood products for the purpose of imparting insecticidal, fungicidal, or fire resistant properties to the wood.

The most common preservatives used in wood preserving are creosote, pentachlorophenol, and various formulations of water-soluble inorganic chemicals, the most common of which are the salts of copper, chromium, and arsenic. Fire retardants are formulations of salts, the principal ones being borates, phosphates, and ammonium compounds. Eighty percent of the plants in the United States use at least two of the three types

of preservatives. Many plants treat with one or two preservatives plus a fire retardant (Thompson, 1973).

Consumption data for the principal preservatives for the five-year period between 1970 and 1974 are given in Table III-3. In terms of amount used, creosote in its various forms is the most important, followed in order by pentachlorophenol and salt-type preservatives. Among the latter, the copper-chromium-arsenic (CCA) formulations account for most of that used.

The general trend in preservative use is a decrease in creosote consumption and increase in the use of pentachlorophenol and salt-type preservatives. This trend is expected to continue, with minor variations. The use of fire retardants has also increased significantly during the five-year period due to to the modification of building codes in many areas permitting the use of fire retardant treated wood in lieu of other flameproof construction materials. Table III-4 presents a summary of the materials treated, by product, for all preservatives during the five-year period between 1969 and 1973.

The wood preserving industry in the United States is composed of approximately 387 plants, of which 312 use pressure retorts. Over three-quarters of the plants are concentrated in two distinct regions. One area extends from east Texas to Maryland and corresponds roughly to the natural range of the southern pines, the major species utilized. The second, smaller area is located along the Pacific Coast, where Douglas fir and western red cedar are the species primarily used. The distribution of plants by type and location is given in Table III-5, and depicted in Figure III-1.

The production of treated wood is very responsive to the general state of the national economy, particularly the health of the construction industry.

Scope Of Coverage for Data Base

The data collection portfolio was sent to 263 wood preserving plants which had been selected to represent the full range of preservatives and products; preconditioning methods; and geographical, size, and age distributions found within the industry. Two hundred and five replies were received. Table III-6 presents the method of ultimate waste disposal utilized by the plants responding to the survey.

In addition to the plants surveyed, nine plants were selected for visits and sampling. Recent data, from the 19 plants which had been visited and sampled during the 1976 pretreatment study, were also included in the data base.

Table III-3. Consumption of Principal Preservatives and Fire Retardants of Reporting Plants in the United States, 1970-1974

Material	(Units)	Year 1970	1971	1972	1973	1974
Creosote	Million Liters	256	241	230	218	250
Creosote-Coal Tar	Million Liters	229	218	220	177	201
Creosote-Petroleum	Million Liters	125	118	108	83.8	96.5
Total Creosote	Million Liters	475	441	418	369	421
Total Petroleum	Million Liters	286	307	324	303	292
Pentachlor-ophenol	Million Kilograms	12.9	14.5	16.6	17.6	19.7
Chromated Zinc Chloride	Million Kilograms	0.2	0.2	0.3	0.3	0.2
CCA	Million Kilograms	2.7	3.9	4.4	5.3	6.9
ACC	Million Kilograms	0.3	0.5	0.6	0.7	0.8
FCAP	Million Kilograms	1.2	1.0	0.9	0.8	0.7
Fire Retardants	Millon Kilograms	8.1	8.1	9.9	9.6	9.7
Other Perser-vative Solids	Million Kilograms	0.4	0.3	0.5	0.6	0.6

NOTE: Data based on information supplied by an average of 331 plants for each year during the five year period.

SOURCE: AWPA, 1975.

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Other Perser-vative Solids	Million Kilograms	0.4	0.3	0.5	0.6	0.6

NOTE: Data based on information supplied by an average of 331 plants for each year during the five year period.

SOURCE: AWPA, 1975.

Table III-4. Materials Treated in the United States by Product

Material	(Thousand Cubic Meters) Year 1969	1970	1971	1972	1973
Cross-ties	2020	2248	2465	2432	1915
Switch-ties	180	223	176	169	142
Piling	417	428	388	406	368
Poles	2107	2174	2106	2111	2135
Cross-arms	91.9	97.8	87.1	70.4	73.4
Lumber & Timbers	1689	1577	1695	1811	1950
Fence posts	443	428	472	515	430
Other	231	195	218	205	194
Total	7179	7371	7607	7719	7207

NOTE: Components may not add due to rounding.

SOURCE: AWPA, 1975.

Table III-5. Wood-Preserving Plants in the United States by State and Type, 1974.

	Commercial			Railroad and Other		
	Pressure	Non-Pressure	Pressure and Non-Pressure	Pressure	Non-Pressure	Total Number Plants
Northeast						
Connecticut	0	0	0	0	0	0
Delaware	0	0	0	0	0	0
District of Columbia	0	0	0	0	0	0
Maine	0	1	0	0	0	1
Maryland	6	0	0	0	0	6
Massachusetts	2	0	0	0	0	2
New Hampshire	1	0	0	0	0	1
New Jersey	3	2	0	0	0	5
New York	4	0	0	0	1	5
Pennsylvania	8	0	0	1	0	9
Rhode Island	1	0	0	0	0	1
Vermont	0	0	0	0	0	0
West Virginia	6	0	0	0	0	6
Total	31	3	0	1	1	36
North Central						
Illinois	6	0	0	0	1	7
Indiana	4	0	0	0	0	4
Iowa	0	0	0	0	1	1
Kansas	0	0	0	0	0	0
Kentucky	7	0	0	1	0	8
Michigan	5	1	0	0	0	6
Minnesota	3	3	3	1	0	10
Missouri	8	3	0	0	0	11
Nebraska	0	0	1	0	0	1
North Dakota	0	0	0	0	0	0
Ohio	7	0	0	0	0	7
Wisconsin	3	0	1	1	1	6
Total	43	7	5	3	3	61
Southeast						
Florida	24	1	0	0	0	25
Georgia	24	0	2	0	0	26
North Carolina	17	0	0	0	1	18

Table III-5. Wood-Preserving Plants in the United States by State and Type, 1974 (continued).

	Commercial			Railroad and Other		
	Pressure	Non-Pressure	Pressure and Non-Pressure	Pressure	Non-Pressure	Total Number Plants
South Carolina	11	0	0	0	0	11
Virginia	14	1	1	0	0	16
Puerto Rico	1	0	0	0	0	1
Total	91	2	3	0	1	97
South Central						
Alabama	25	1	1	0	0	27
Arkansas	9	0	3	0	0	12
Louisiana	21	0	0	0	0	21
Mississippi	18	1	4	0	0	23
Oklahoma	5	0	0	0	0	5
Tennessee	5	1	0	0	0	6
Texas	25	2	3	1	0	31
Total	108	5	11	1	0	125
Rocky Mountain						
Arizona	1	0	0	0	0	1
Colorado	3	0	0	0	0	3
Idaho	4	1	0	0	1	6
Montana	2	3	1	1	0	7
Nevada	0	0	0	0	0	0
New Mexico	2	0	0	0	0	2
South Dakota	1	0	1	0	0	2
Utah	0	1	1	0	0	2
Wyoming	1	0	1	0	0	2
Total	14	5	4	1	1	25
Pacific						
Alaska	0	0	0	0	0	0
California	8	0	2	0	1	11
Hawaii	4	0	1	0	0	5
Oregon	5	0	4	0	0	9
Washington	8	5	4	0	1	18
Total	25	5	11	0	2	43
United States Total	312	27	34	6	8	387

SOURCE: AWPA, 1975.

GEOGRAPHICAL DISTRIBUTION OF WOOD PRESERVING PLANTS IN THE UNITED STATES

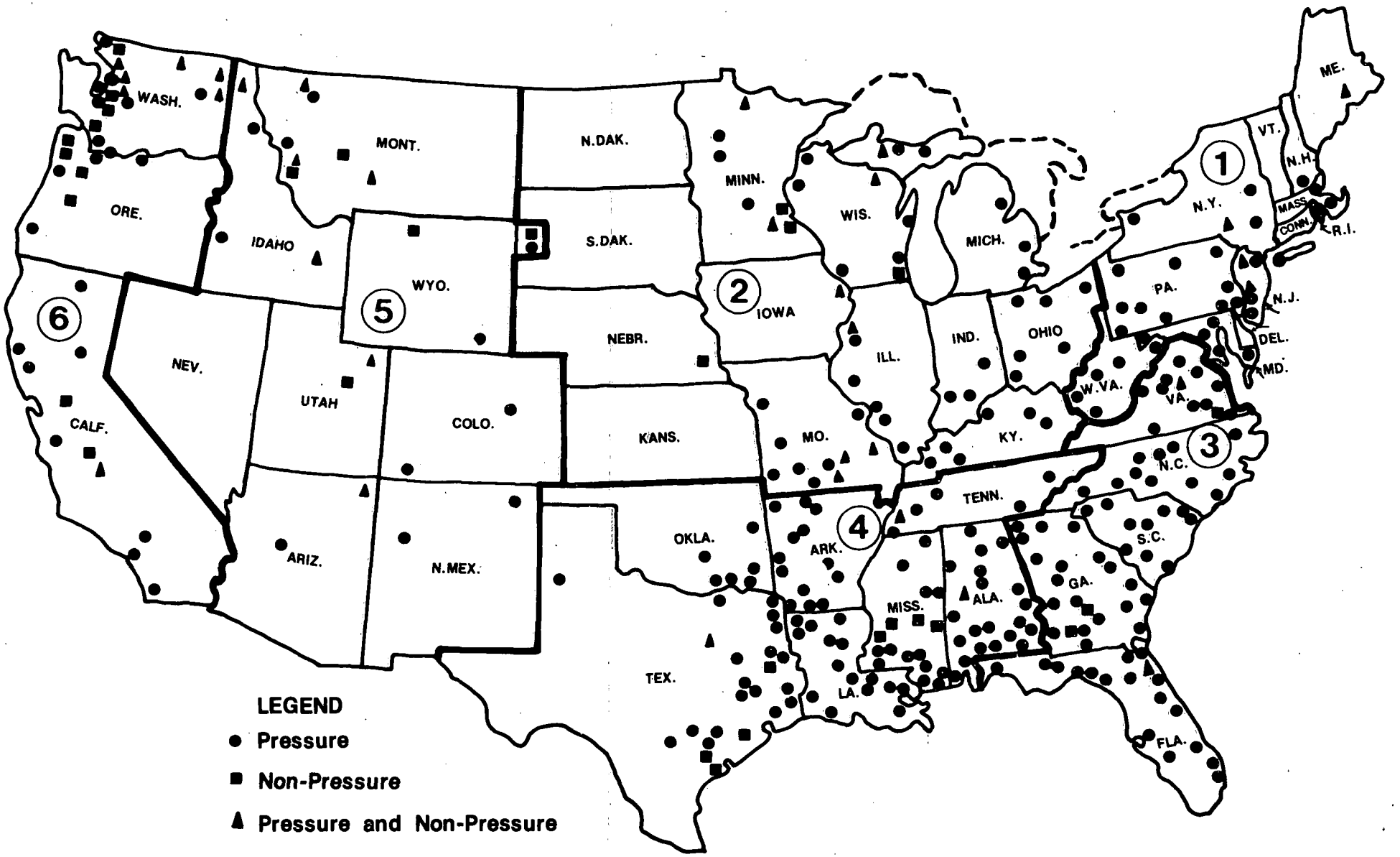


Figure III - 1

Table III-6. Method of Ultimate Waste Disposal by Wood Preserving Plants Responding to Data Collection Portfolio

Ultimate Disposal Method	Number of Plants
Direct Discharge	9
Discharge to POTW	42
Self-contained Dischargers	
Containment and Evaporation	66
Soil Irrigation	14
Subsurface Injection	1
No Discharge (Plants generating no wastewater or recycling all wastewater)	62

NOTE: Nine plants responding to the data collection portfolio have gone out of business.

SOURCE: Data collection portfolios.

Units of Expression

Units of production in the wood preserving industry are shown in cubic meters (cu m). In-plant liquid flows are shown in liters per day (l/day). The wood preserving industry is not yet metricized and uses English units to express production, cubic feet (cu ft); and in-plant flow, gallons (gal) or million gallons per day (MGD). Conversion factors from English units to metric units are shown in Appendix C.

Process Descriptions

Wood Preserving

The wood preserving process consists of two basic steps: (1) preconditioning the wood to reduce its natural moisture content, and (2) impregnating the wood with the desired preservatives.

The preconditioning step may be carried out by one of several methods including (1) seasoning or drying wood in large, open yards, (2) kiln drying, (3) steaming the wood at elevated pressure in a retort followed by application of a vacuum, (4) heating the stock in a preservative bath under reduced pressure in a retort (Boulton process), or (5) vapor drying. All of these preconditioning methods have as their objective the reduction of moisture content of the unseasoned stock to a point where the requisite amount of preservative can be retained in the wood. Preconditioning also results in a more permeable stock allowing penetration of the preservative into the wood as required by American Wood Preservers Association (AWPA) standards.

Conventional steam conditioning (open steaming) is a process in which unseasoned or partially seasoned stock is subjected to direct steam impingement at an elevated pressure in a retort. The maximum permissible temperature is set by industry standards at 118°C and the duration of the steaming cycle is limited by these standards up to 20 hours. Steam condensate that forms in the retort exits through traps and is conducted to oil-water separators for removal of free oils. Removal of emulsified oils requires further treatment.

In closed steaming, a widely used variation of conventional steam conditioning, the steam needed for conditioning is generated *in situ* by covering the coils in the retort with water from a reservoir and heating the water by passing process steam through the coils. The water is returned to the reservoir after oil separation and reused during the next steaming cycle.

Modified closed steaming is a variation of the steam conditioning process in which steam condensate is allowed to accummulate in the retort during the steaming operation until it covers the heating coils. At that point, direct steaming is discontinued and the remaining steam required for the cycle is generated within the retort by utilizing the heating coils. Upon completing the steaming cycle, the water in the cylinder is discarded, upon recovery of oils.

Preconditioning is accomplished in the Boulton process by heating the stock in a preservative bath under reduced pressure in the retort. The preservative serves as a heat transfer medium. Water removed in vapor form from the wood during the Boulton process passes through a condenser to an oil-water separator where low-boiling fractions of the preservative are removed. The Boulton cycle may have a duration of 48 hours or longer for large poles and piling, a fact that accounts for the lower production per retort day as compared to plants that steam condition.

The treatment step may be accomplished by either pressure or non-pressure processes.

Non-pressure processes (thermal) utilize open tanks which contain the preservative chemicals. Stock to be treated is immersed in the treatment chemicals, which may be at ambient temperature, heated, or a combination thereof. Stock treated in nonpressure processes is normally preconditioned by air seasoning or kiln drying.

Treatment methods employing pressure processes consist of three basic types, independent of preconditioning method. Two of the pressure methods, referred to in the industry as "empty-cell" processes, are based on the principle that part of the preservative forced into the wood is expelled by entrapped air upon the release of pressure at the conclusion of the treating cycle, thus leaving the cell walls coated with preservative. The pressure cycle is followed by a vacuum to remove additional preservative. Retentions of 96 to 192 kilograms per cubic meter are generally sought in these processes. The retention attained is controlled in part by the initial air pressure employed at the beginning of the cycle.

The third method, which is known as the "full-cell" process, differs from the other two in that the treating cycle is begun by evacuating the retort and breaking the vacuum with the preservative. The preservative is then forced into the wood under pressure, as in the other processes. Most of the preservative remains in the wood when the pressure is released. Retentions of 320 kilograms per cubic meter or higher are usually the goal for this process.

Stock treated by any of the three methods may be given a short steam treatment to "clean" the surface of poles and pilings and to reduce exudation of oil after the products are placed in service.

Insulation Board

Scope of Study

The scope of this report includes those insulation board plants in SIC 2661 (Building Paper and Building Board Mills) which produce insulation board using wood furnish as the basic raw material.

General Description of the Industry

Insulation board is a form of fiberboard, which in turn is a broad generic term applied to sheet materials constructed from ligno-cellulosic fibers. Insulation board is a "non-compressed" fiberboard, which is differentiated from "compressed" fiberboards, such as hardboard, on the basis of density. Insulation boards have a density less than 0.50 g/cu cm (31 lb/cu ft). Insulation boards are usually manufactured in thicknesses between 5 and 25 mm (nominal 3/8 to one inch). On a basis of density, insulation board may be subdivided into semi-rigid insulation board and rigid insulation board with densities of up to 0.15 g/cu cm (9.5 lb/cu ft) and 0.15 to 0.50 g/cu cm (9.5 to 31 lb/cu ft) respectively. Semi-rigid insulation board is normally used only for insulation and sound deadening purposes, while rigid insulation board may be used for sheathing, interior panelling, and as a base for plaster or siding.

The principle types of insulation board include:

1. Building board--A general purpose product for interior construction.
2. Insulating roof deck--A three-in-one component which provides roof deck, insulation, and finished inside ceiling. (Insulation board sheets are laminated together with waterproof adhesives, with a vapor barrier in between the sheets.)
3. Roof insulation--Insulation board designed for flat roof decks.
4. Ceiling tile--Insulation board embossed and decorated for interior use. It is also useful for acoustical qualities.
5. Lay-in panels--A ceiling tile used for suspended ceilings.
6. Sheathing--Insulation board used extensively in construction due to its insulative, bracing strength and noise control qualities.
7. Sound-deadening insulation board--A special product designed explicitly for use in buildings to control noise level.

The American Society for Testing and Materials sets standard specifications for the categories of insulation boards. Decorative type board products, such as ceiling tiles, lay-in-panels, etc., receive a higher degree of finishing than do structural type boards such as sheathing and building board. Consequently, stricter control during fiber preparation and formation is required in production of decorative-type board to insure that the product can be ironed, edge fabricated, sanded, coated, and painted resulting in a smooth, beveled, finished surface. Decorative board products cannot absorb high amounts of dissolved solids in the production process for this reason.

There are 18 insulation board plants in the United States, with a combined production capacity of over 330 million square meters (3,600 million square feet) on a 13 mm (one-half inch) basis. Sixteen of the

plants use wood as a raw material for some or all of their production. One plant uses bagasse exclusively, and one plant uses waste paper exclusively for raw material. Four plants use mineral wool as a raw material for part of their insulation board production. Five plants produce hardboard products at the same facility. A list of the 16 plants which produce insulation board using wood as raw material is presented in Table III-7. The geographical distribution of these plants is depicted in Figure III-2.

Production of insulation board in the U.S. during 1968-1974 is presented in Figure III-3.

Scope of Coverage for Data Base

The data collection portfolio was sent to all 16 of the insulation board plants which use wood as a raw material. Each of the plants responded to the survey. Table III-8 presents the method of ultimate waste disposal utilized by the plants responding to the survey. In addition to the plants surveyed, six plants were selected for visits and sampling.

Units of Expression

Units of production in the insulation board industry are reported in square meters (sq m) on a 13 mm thick basis. Density figures obtained from the surveyed plants are used to convert this production to metric tons. The insulation board industry is not yet metricized and uses English units to express production, square feet (sq ft) on a one-half inch (in) basis. Liquid flows from the industry are reported in kiloliters per day (Kl/day) and million gallons per day (MGD). Conversion factors from English units to metric units are shown in Appendix C.

Process Description

Insulation board can be formed from a variety of raw materials including wood from a softwood and hardwood species, mineral fiber, waste paper, bagasse, and other fibrous materials. In this study, only those processes employing wood as raw materials are considered. Plants utilizing wood may receive it as roundwood, fractionated wood, and/or whole tree chips. Fractionated wood can be in the form of chips, sawdust, or planer shavings. Figure III-4 provides an illustration of a representative insulation board process.

Table III-7. Inventory of Insulation Board Plants Using Wood as Raw Material.

Abitibi Corporation Blounstown, Florida	Kaiser Gypsum Company, Inc. St. Helens, Oregon
Armstrong Cork Company Macon, Georgia	National Gypsum Company Mobile, Alabama
Boise Cascade Corporation International Falls, Minnesota	Georgia-Pacific Jarratt, Virginia
The Celotex Corporation Dubuque, Iowa	Temple-Eastex Diboll, Texas
The Celotex Corporation L'Anse, Michigan	United States Gypsum Company Lisbon Falls, Maine
The Celotex Corporation Sunbury, Pennsylvania	United States Gypsum Company Greenville, Mississippi
Flintkote Company Meridian, Mississippi	United States Gypsum Company Pilot Rock, Oregon
Huebert Fiberboard, Inc. Boonville, Missouri	Weyerhauser Company (Craig) Broken Bow, Okalhoma

SOURCE: 1977 Directory of the Forest Products Industry.

GEOGRAPHICAL DISTRIBUTION OF INSULATION BOARD MANUFACTURING FACILITIES IN THE UNITED STATES

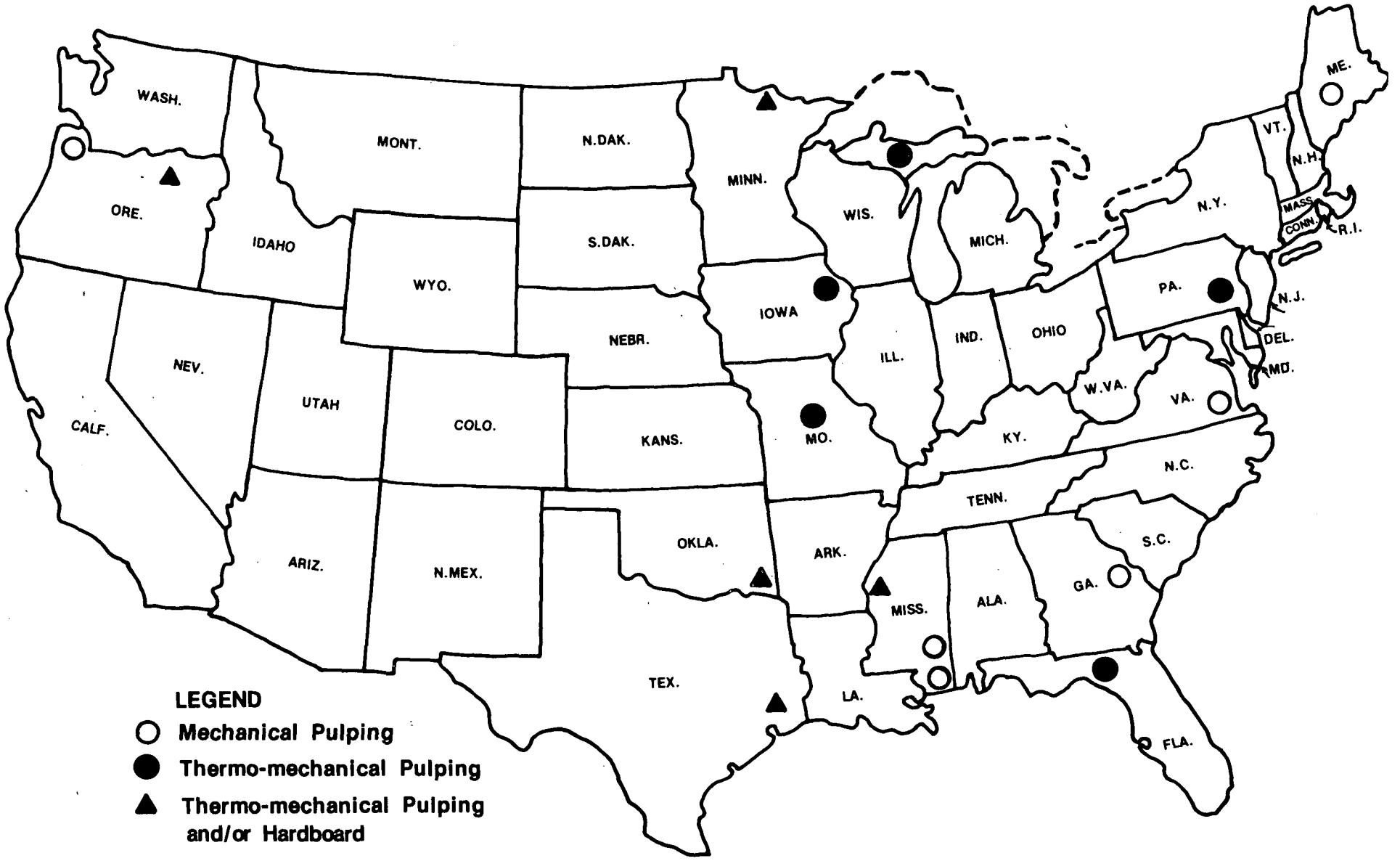


Figure III - 2

TOTAL BOARD PRODUCTION FIGURES: HARDBOARD

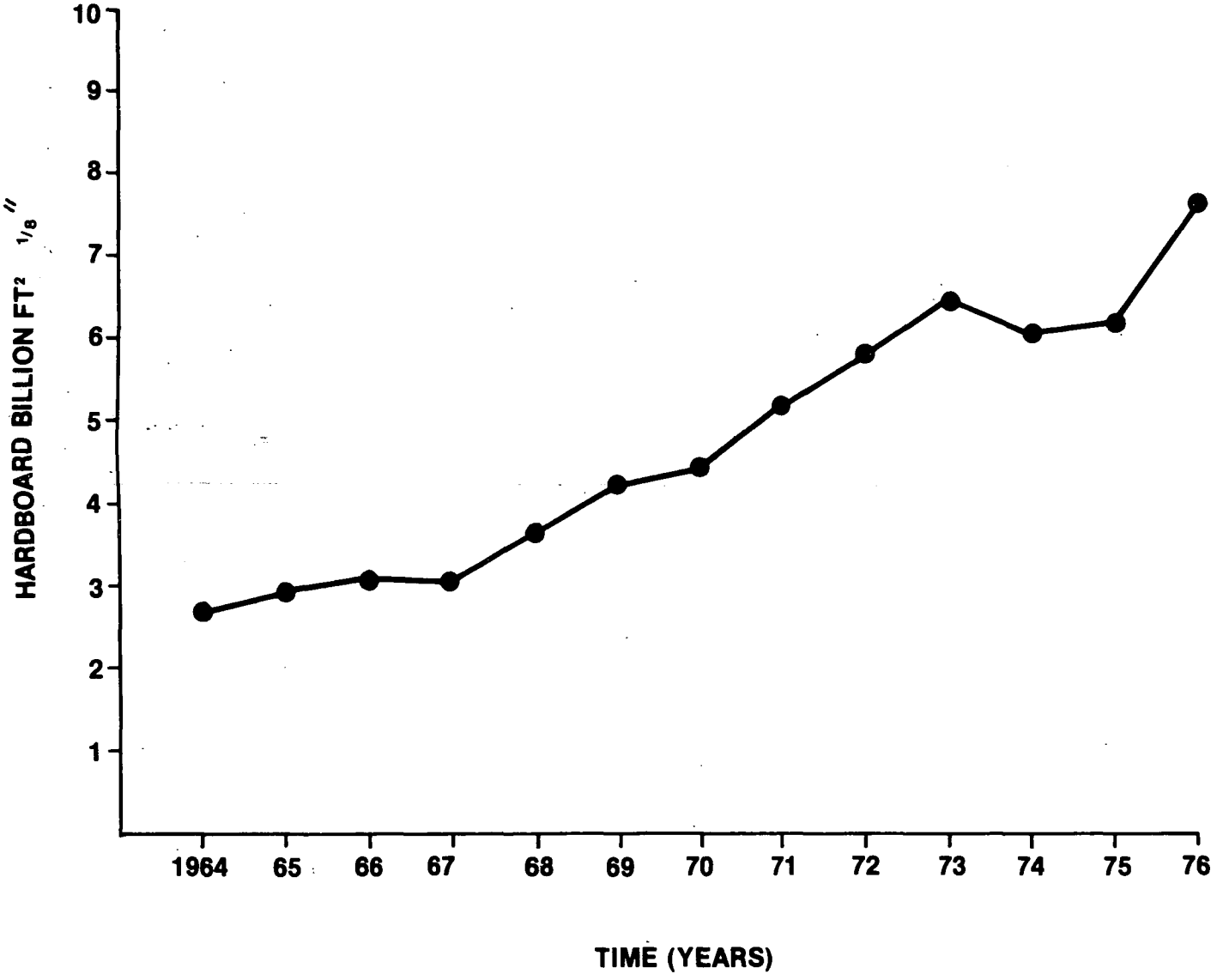


Figure III - 3

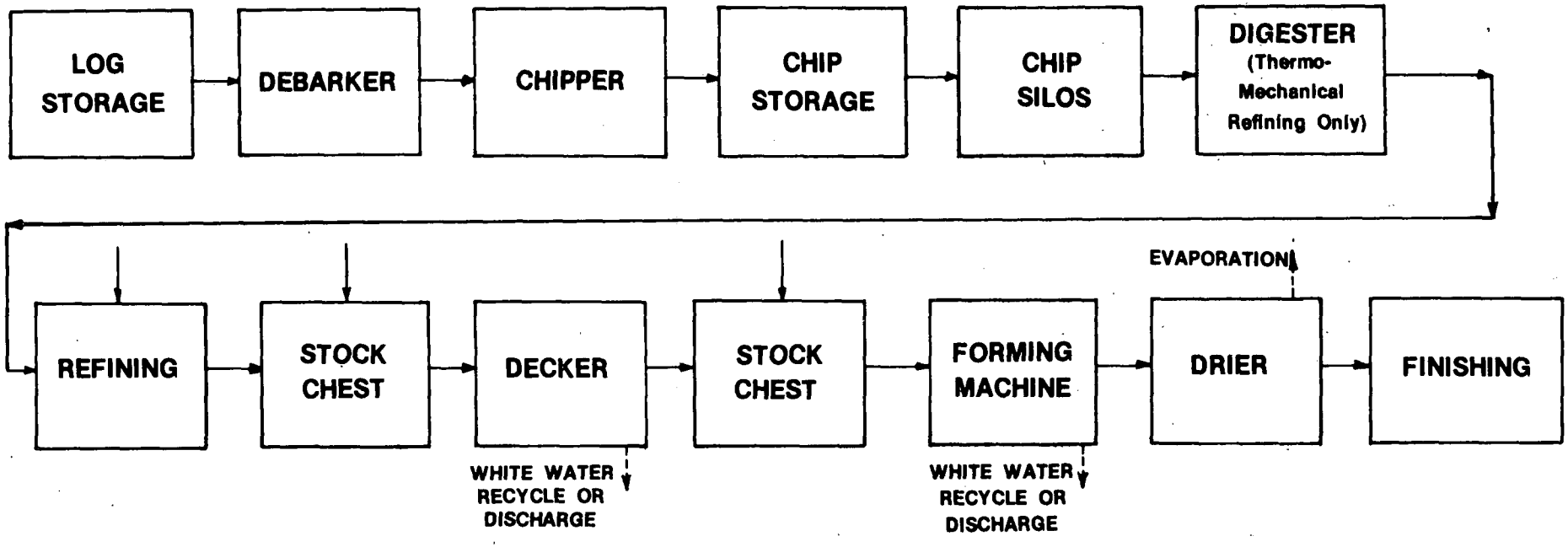
Table III-8. Method of Ultimate Waste Disposal by Insulation Board Plants Responding to Data Collection Portfolio.

Ultimate Disposal Method	Number of Plants
Direct Discharge	5
Discharge to POTW	6
Self-Contained Dischargers Spray Irrigation	3*
No Discharge (Plants generating no wastewater or recycling all wastewater)	2

* One plant uses spray irrigation as a treatment method; however, the effluent from this system is directly discharged.

SOURCE: Data collection portfolios.

DIAGRAM OF A TYPICAL INSULATION BOARD PROCESS



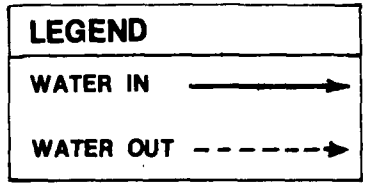


Figure III - 4

When roundwood is used as a raw material, it is usually shipped to the plant by rail or truck and stored in a dry deck before use. The roundwood is usually debarked by drum or ring barkers before use, although in some operations a percentage of bark is allowable in the board. The barked wood then may be chipped, in which case the unit processes are the same as those plants using chips exclusively as raw materials (MacDonald, 1969). Those plants utilizing groundwood normally cut the logs into 1.2- to 1.5-meter (4- to 5-foot) (MacDonald, 1969) sections either before or after debarking so that they will fit into the groundwood machines. The equipment used in these operations is similar to that used in the handling of raw materials in other segments of the timber products industry.

Groundwood is used by two insulation board plants in the United States. It is usually produced in conventional pulpwood grinders equipped with coarse burred artificial stones of 16 to 25 grit with various patterns. The operation of the machine consists primarily of hydraulically forcing a piece of wood against a rotating stone mounted horizontally. The wood held against the abrasive surface of the revolving stone is reduced to fiber bundles. Water is sprayed on the stone not only to carry away the fibers into the system, but also to keep the stone cool and clean and lubricate its surface (Macdonald, 1969). The water spray onto the stone is necessary as it not only accomplishes the above goals, but reduces the possibility of fires occurring from the friction of the stone against the wood.

While most fractionated wood is purchased from other timber products operations, in some cases it is produced on site. Currently, little chipping occurs in the forest; however, in the future this is expected to become a major source of chips. Chips are usually transported to the plants in large trucks or railcars. They are stored in piles which may be covered but are more commonly exposed. The chips may pass through a device used to remove metal grit, dirt, and other trash which could harm equipment and possibly cause plate damage in the refiners. This may be done wet or dry. Pulp preparation is usually accomplished by mechanical or thermo-mechanical refining.

Refining Operations--Mechanical refiners basically consist of two discs between which the chips or residues are passed. In a single disc mill, one disc rotates while the other is stationary. The feed material passes between the plates and is discharged at the bottom of the case. The two discs in double disc mills rotate in opposite directions, but the product flows are similar to a single disc mill. Disc mills produce fibers that may pass through a 30- or 40-mesh screen, although 60 percent of the fibers will not pass through a 65-mesh screen. The disc plates generally rotate at 1,200 or 1,800 rpm or a relative speed of 2,400 or 3,600 rpm for a double disc mill. Plate separations are generally less than 1.0 cm (0.40 in). A variety of disc patterns are available, and the particular pattern used depends on the feed's characteristics and type of fiber desired (Runckel, 1973).

A thermo-mechanical refiner is basically the same as a disc refiner except that the feed material is subjected to a steam pressure of 4 to 15 atm (40 to 200 psi) for a period of time from 1 to 45 minutes before it enters the refiner. In some cases, the pressure continues through the actual refining process.

Pre-steaming softens the feed material and thus makes refining easier and provides savings on energy requirements; however, yield may be reduced up to 10 percent. The longer the pretreatment and the higher the pressure, the softer the wood becomes. The heat plasticizes primarily portions of the hemicellulose and lignin components of wood which bind the fibers together and results in a longer and stronger fiber produced (Runckel, 1973).

Subsequent to the refining of the wood, the fibers produced are dispersed in water to achieve consistencies amenable to screening. For most screening operations, consistencies of approximately one percent fiber are required. Screening is done primarily to remove coarse fiber bundles, knots, and slivers. The coarse material may be recycled and passed through secondary refiners which further reduce the rejects into usable fibers for return to the process. After screening, the fibers produced by any method may be sent to a decker or washer.

Decker Operations--Deckers are essentially rotating wire-covered cylinders, usually with an internal vacuum, into which the suspension of fibers in water is passed. The fibers are separated and the water is often recirculated back into the system. There are a number of reasons for deckering or washing, one of which is to clean the pulp. When cleaning the pulp a spray of water may be sprayed on the decker as it rotates. The major reason for deckering, however, is for consistency control. Control of dissolved solids is also a factor in some cases. While being variable on a plant-to-plant basis, the consistency of the pulp upon reaching the forming machine in any insulation board process is extremely critical. By dewatering the pulp from the water suspension at this point, it can be mixed with greater accuracy to the desired consistency. Washing of the pulp is sometimes desirable in order to remove dissolved solids and soluble organics which may result in surface flaws in the board. The high concentration of these substances tends to stay in the board and during the drying stages migrates to the surface. This results in stains when a finish is applied to the board.

After the washing or decking operation, the pulp is reslurried in stages from a consistency of 15 percent to the 1.5 percent required for the forming. The initial dilution of approximately 5 percent consistency is usually followed by dilutions of 3 percent and finally, just prior to mat formation, a dilution of approximately 1.5 percent. This procedure is followed primarily for two reasons: (1) it allows for accurate consistency controls and more efficient dispersion of additives; and (2) it reduces the required pump and storage capacities for the pulp. During the various stages of dilution, additives are usually added to the pulp suspension. These range from 5 to 20 percent of the weight of the board,

depending on the product used. Additives may include wax emulsion, paraffin, asphalt, starch, polyelectrolytes, aluminum sulfate, thermoplastic, and/or thermo-setting resin. The purpose of additives is to give the board desired properties such as strength, dimensional stability, and water absorption resistance.

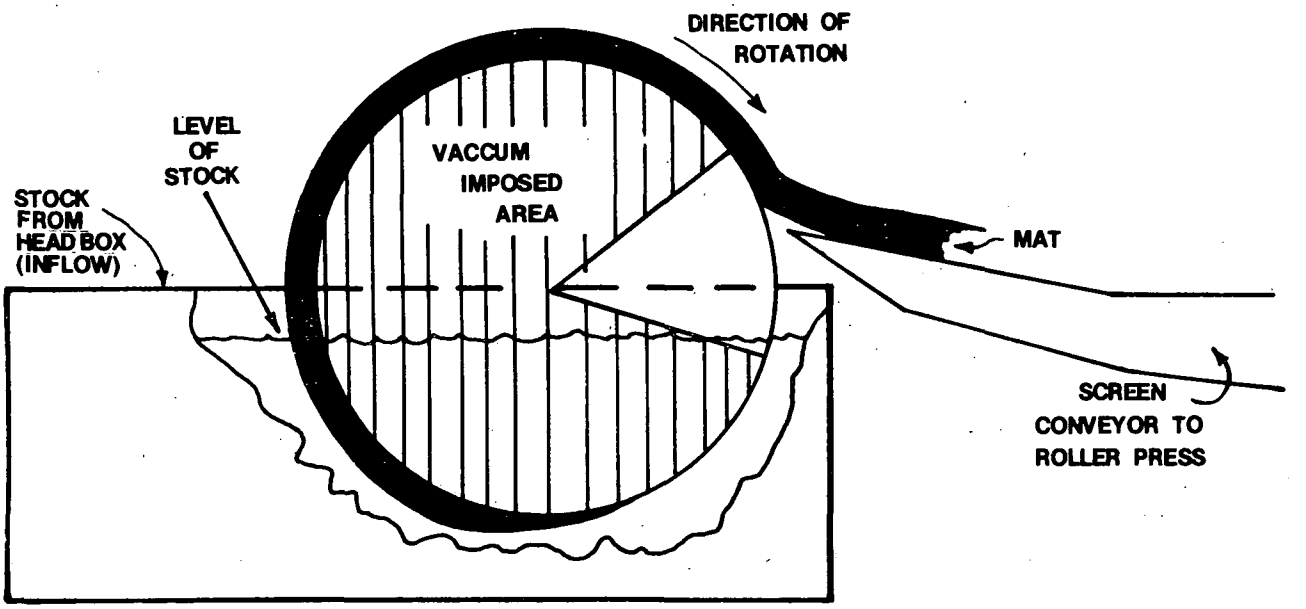
After passing through the series of storage and consistency controls, the fibers in some cases pass through a pump-through refiner, directly ahead of the forming machine. The main purpose of the pump-through refiner is to disperse agglomerated fiber clumps and to shorten the fiber bundles. The fibrous slurry, at approximately 1.5 percent consistency, is then pumped into a forming machine which removes water from the pulp suspension and forms a mat.

Forming Operations--While there are various types of forming machines used to make insulation board, the two most common are the fourdrinier and the cylinder forming machines. The fourdrinier machine used in the manufacture of insulation board is similar in nature to those used in the manufacture of hardboard or paper. The stock is pumped into the head box and onto a table with an endless traveling screen running over it. The stock is spread evenly across the stream by special control devices and an interlaced fibrous blanket, referred to as a mat, is formed by allowing the dewatering of the stock through the screen by gravity assisted by vacuum boxes. The partially formed mat travelling on the wire screen then passes through press rollers, some with a vacuum imposed, for further dewatering.

Cylinder machines are basically large rotating drum vacuum filters with screens. Stock is pumped through a head box to a vat where again a mat is formed onto the screen. In this case, the mat is formed by use of a vacuum imposed on the interior of the rotating drum. A portion of the rotating drum is immersed into the stock solution as indicated in Figure III-5. As water is forced through the screen, a mat is eventually formed when the portion of the cylinder rotates beyond the water level in the tank and the required amount of fiber is deposited on the screen. The mat is further dewatered by the vacuum in the interior of the rotating drum and is then transferred off the cylinder onto a screen conveyor, or felt, where it then passes through roller presses similar to those utilized in fourdrinier operations.

Both the fourdrinier and the cylinder machines produce a mat that leaves the roller press with a moisture content of about 40 to 45 percent and the ability to support its own weight over short spans. At this point, the mat leaves the forming screen and continues its travel over a conveyor. The wet mat is then trimmed to width and cut to length by a traveling saw which moves across the mat on a bias making a square cut without the necessity of stopping the continuous wetlap sheet.

After being cut to desired lengths, the mats are dried to a moisture content of 5 percent or less. Most dryers now in use are gas or oil fired tunnel dryers. Mats are conveyed on rollers through the tunnel with hot



SCHEMATIC DIAGRAM OF CYLINDER FORMING MACHINE

Figure III - 5

air being circulated throughout. Most dryers have 8 to 10 decks and various zones of heat to reduce the danger of fire. These heat zones allow for higher temperatures when the board is "wet" (where the mat first enters) and lower temperatures when the mat is almost dry.

The dried board then goes through various finishing operations such as painting, asphalt coating, and embossing. Those operations which manufacture decorative products will usually have finishing operations which use water-base paints containing such chemicals as various inorganic pigments, i.e., clays, talc, carbonates, and certain amounts of binders such as starch, protein, PVA, PVAC, acrylics, urea formaldehyde resin, and melamine formaldehyde resins. These are applied in stages by rollers, sprayers, or brushes. The decorative tile then may be embossed, beveled, or cut to size depending on the product desired.

Sheathing in some operations receives additional molten asphalt applications to all six surfaces. It is then sprayed with water and stacked to allow humidification to a uniform moisture content.

Wet-dry (S2S) hardboard is produced by some insulation board plants. While the equipment as described for insulation board is the same as described above including the dry mat trimmer; wood furnish, degree of refining, and additives are varied. Allowing the mats to age, redrying them, and pressing the mat by large steam heated hydraulic presses consolidates the mat to the desired density for hardboard.

Various sanding and sawing operations give board-products the correct dimensions. Generally, the dust, trim, and reject materials created in finishing operations are recycled back into the process.

Wet-Process Hardboard

Scope of Study

The scope of this document includes all wet-process hardboard plants (SIC 2499) in the United States. Wood is used in wet-process hardboard plants as the primary raw material.

General Description of the Industry

Hardboard is a form of fiberboard, which is a broad generic term applied to sheet materials constructed from ligno-cellulosic fibers. Hardboard is a "compressed" fiberboard, with a density over 0.50 g/cu cm (31 lb/cu ft). The thickness of hardboard products ranges between 2 to 13 mm (nominal 1/12 to 7/16 in).

Production of hardboard by the wet process method is accomplished by thermo-mechanical fiberization of the wood furnish. One plant produces wet-dry hardboard using primarily mechanical refining. Dilution of the wood fiber with fresh or process water then allows forming of a wet mat

of a desired thickness on a forming machine. This wet mat is then pressed either wet or after drying. Chemical additives help the overall strength and uniformity of the product. The use of manufactured products are many and varied requiring different processes and control measures. The quality and type of board is important in the end use of the product.

The following are but a few of the end uses of hardboard:

- Interior Wall Paneling
- Exterior Siding
- Display Cabinets
- Base of Painted Tile Panels
- Concrete Forms
- Nonconductor Material for Electrical Equipment
- Door Skins (panels)
- TV Cabinets and Furniture

The American Society for Testing and Materials sets standards for the various types of hardboard produced.

Hardboard which is pressed wet immediately following forming of the wet-lap is called wet-wet or smooth-one-side (S1S) hardboard, that which is pressed after the wet-lap has been dried is called wet-dry or smooth-two-side (S2S) hardboard.

There are 16 wet-process hardboard plants in the United States, representing an annual production in excess of 1.5 million metric tons per year. Seven of the plants produce only S1S hardboard. Nine plants produce S2S hardboard. Of these nine, five plants also produce insulation board, while three plants also produce S1S hardboard.

Table III-9 lists the wet-process hardboard plants in the U.S.

The geographic distribution of these plants is depicted in Figure III-6. The total annual U.S. production of hardboard from 1964 through 1976 is shown in Figure III-7. This total production includes dry-process hardboard as well as wet-process hardboard. Although the relative amounts of production between dry- and wet-process hardboard vary from year to year, a generalized rule of thumb is that 25 percent of the total production is wet-process hardboard.

Scope of Coverage of Data Base

Data collection portfolios were sent to 15 of the 16 wet-process hardboard plants. The remaining plant did not receive a data collection portfolio, but did provide the historical monitoring and production data requested. Each of the plants responded to the survey. Eight plants were visited during this study, and seven were sampled. In addition, the full record compiled by the E.C. Jordan Company during their 1975-1976 study of the wet-process hardboard industry was reviewed during the course of this study. All 16 plants were visited by E. C. Jordan. Table III-10 presents the method of ultimate disposal utilized by each of the 16 wet-process hardboard plants.

Table III-9. Inventory of Wet-Process Hardboard Plants.

Evans Products Corvallis, Oregon	Masonite Corporation Ukiah, California
Champion Building Products Dee (Hood River), Oregon	Superwood Corporation Duluth, Minnesota
Masonite Corporation Laurel, Mississippi	Superwood Corporation North Little Rock, Arkansas
Abitibi Corporation Roaring River, North Carolina	U.S. Gypsum Company Danville, Virginia
Superior Fibre Superior, Wisconsin	Abitibi Corporation Alpena, Michigan
Temple-Eastex Diboll, Texas	Boise Cascade International Falls, Minnesota
Weyerhaeuser Company Broken Bow, Oklahoma	U.S. Gypsum Company Pilot Rock, Oregon
Forest Fibre Stimpson Lumber Company Forest Grove, Oregon	U.S. Gypsum Company Greenville, Mississippi

SOURCE: 1977 Directory of the Forest Products Industry.

GEOGRAPHICAL DISTRIBUTION OF HARDBOARD MANUFACTURING FACILITIES IN THE UNITED STATES

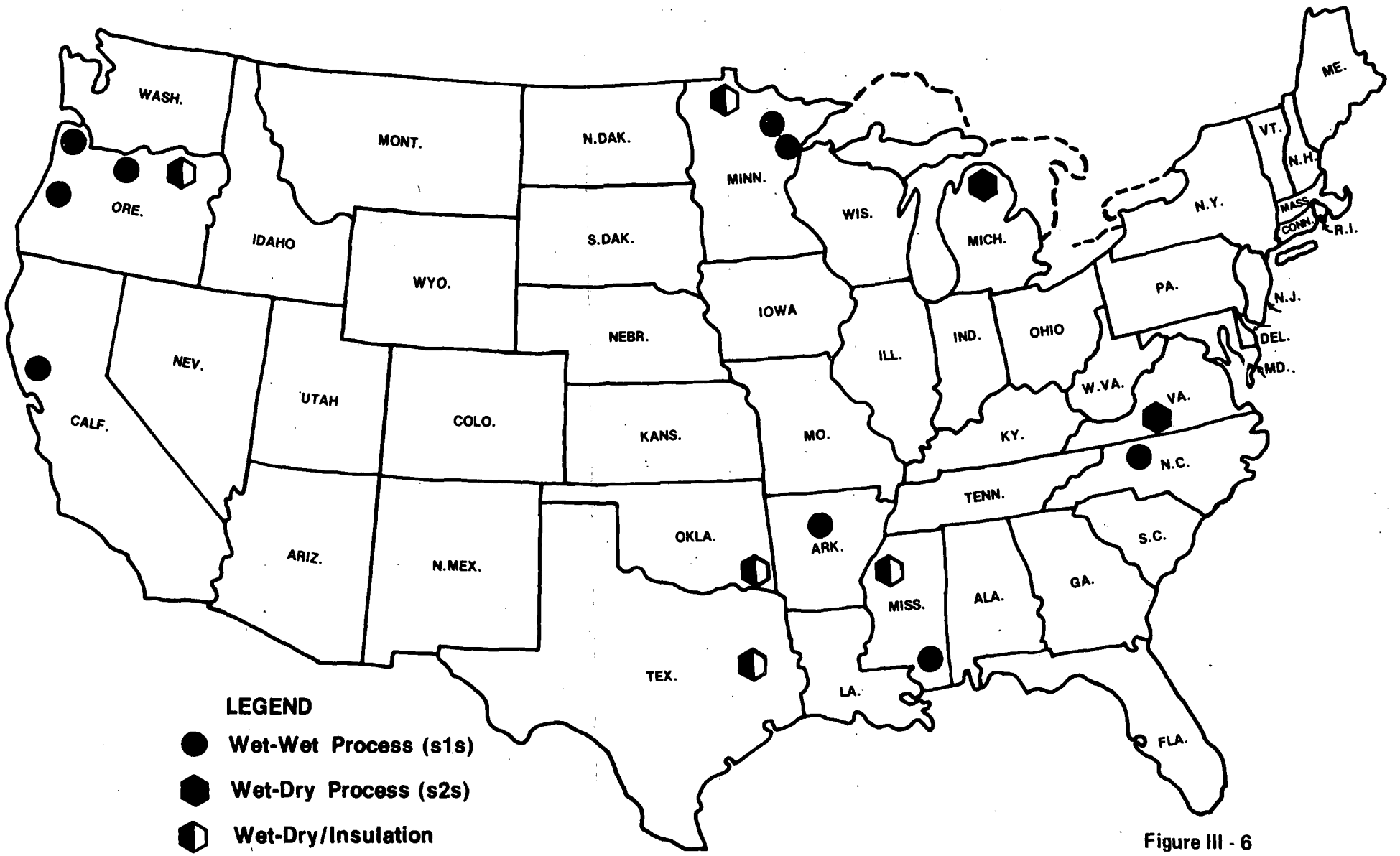


Figure III - 6

TOTAL BOARD PRODUCTION FIGURES : INSULATION BOARD

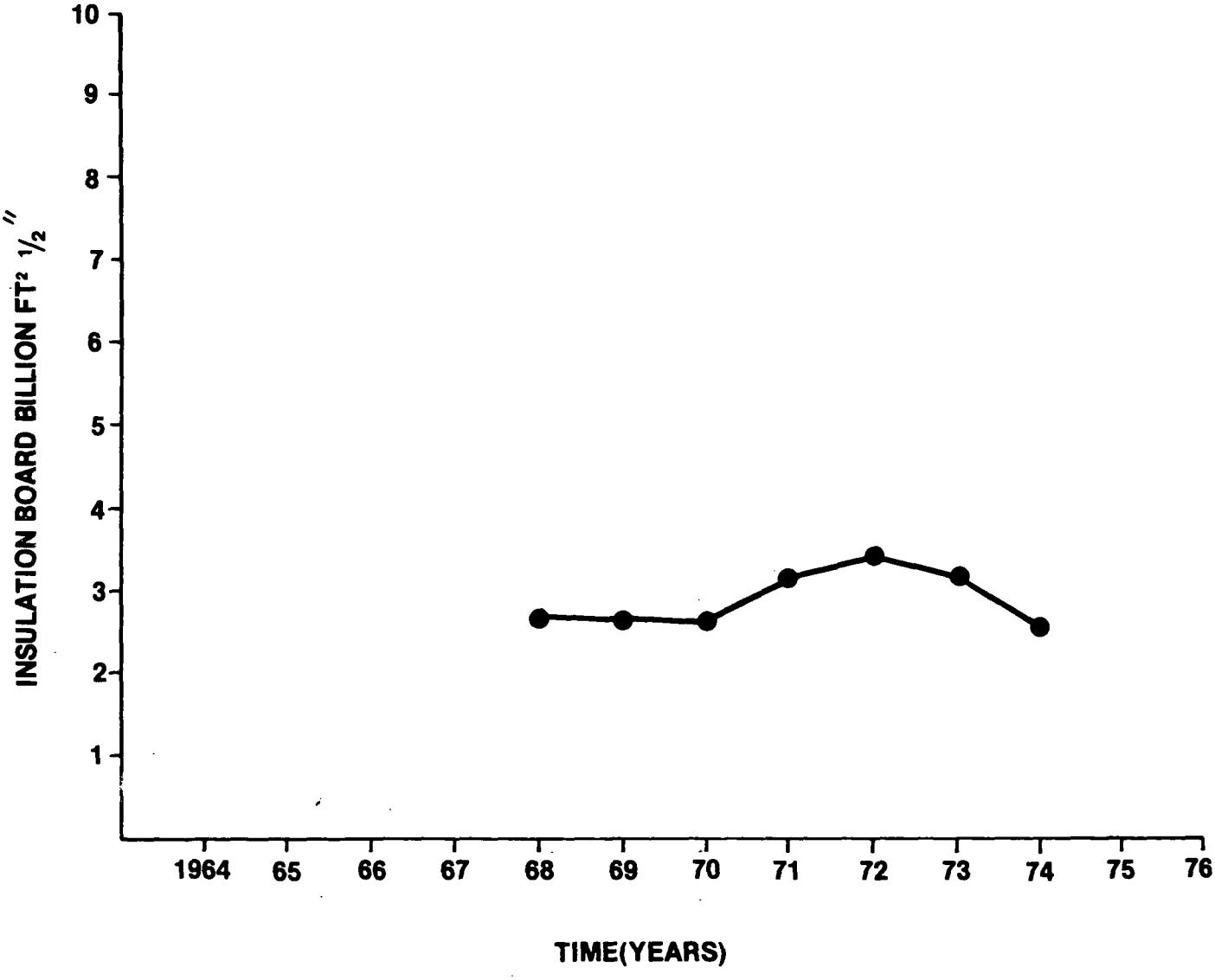


FIGURE III - 7

Table III-10. Method of Ultimate Waste Disposal by Wet-Process Hardboard Plants.

Ultimate Disposal Method	Number of Plants
Direct Discharge	13
Discharge to POTW	2
Self-Contained Dischargers Spray Irrigation	1*

* Two other plants use spray irrigation to dispose of part of their wastewater.

SOURCE: Data collection portfolios.

Units of Expression

Units of production in the hardboard industry are reported in square meters (sq m) on a 3.2 mm (1/8 in) thick basis, as well as in thousand kilograms per day (Kkg/day). Most plants provided production data directly on a weight basis. The hardboard industry is not yet metricized and uses English units to express production, square feet (sq ft) on a one-eighth inch (in) basis or in tons per day (TPD). Liquid flows from the industry are reported in kiloliters per day (Kl/day) and million gallons per day (MGD). Conversion factors from English units to metric units are shown in Appendix C.

Process Description

Raw Material Usage--The basic raw material used in the manufacture of hardboard is wood. The wood species involved range from hardwoods (oak, gum, aspen, cottonwood, willow, sycamore, ash, elm, maple, cherry, birch, and beech) to softwoods (pine, douglas fir, and redwood).

Wood receipts may vary in form from unbarked long and short logs to chips. Chip receipts may be from whole tree chipping, forest residue (which includes limbs, bark, and stumps), sawmill waste, plywood trim, and sawdust. The deliveries may be of one species, a mixture of hardwood, or mixed softwoods. The geographic location of each mill determines the species of wood used to produce the hardboard. The species and mixture may change due to availability.

Moisture content of the wood receipts varies from 10 percent in the plywood trim to 60 percent in green fresh wood.

Chemicals used as raw material in the hardboard process consist of vegetable oils, primarily linseed or tung, tall oil, ferric sulfate, wax, sulphuric acid, thermoplastic and/or thermosetting resin, aluminum sulfate, petrolatum, defoamer, and paint. No one mill uses all these chemicals in its process, nor is the degree of chemical use the same for all mills. Some of the functions of these chemicals are for binding, sizing, pH control, retention, weather-proofing, and foam reduction. The chemical usage ranges from 0.5 to 11.0 percent of the total production.

Wood Storage and Chipping--Most of the mills surveyed stored the wood raw material, in chip form, in segregated storage piles. Most mills have a paved base under the chips. Rough logs received are stockpiled prior to debarking and chipping.

Of those mills receiving rough logs, four out of eight remove the bark by mechanical means with the bark either burned or used as landfill. The remaining four mills that receive rough roundwood chip the logs with the bark attached. Seven mills receive their wood in chip form only, which in most cases includes the bark from the log. Only six mills screen their chips before processing. Some of the mills using chips containing bark can tolerate only a minimum amount of bark in the final product and have auxiliary equipment (i.e., centricleaners) to clean the stock. One

mill reported that bark in the stock improves the cleanliness of the caul plates in the press and presents no problems in production. Only 7 of the 16 mills surveyed washed the chips before processing.

For production control and consistency, the majority of the mills maintained a chip inventory of 60 to 90 days. Although the yield is lower and the chips are more contaminated (bark, dirt, etc.), the use of waste material and forest residue is increasing each year in the production of hardboard. As the availability decreases and the costs increase for quality chips, the greater use of lower quality fiber requires additional equipment to clean the chips before processing.

Fiber Preparation--Before refining or defibering, the chips are pretreated with steam in a pressure vessel or digester. The steaming of the chips under pressure softens the lignin material that binds the individual fibers together and produces a chip that reduces the power consumption required for mechanical defibering. The degree of softening when the chips are raised to a certain temperature varies with different wood species. Steaming of the chips also increases the bonding between fibers when the board is pressed.

Cooking conditions are determined by the wood species involved and the pulp required for the grade of hardboard being produced. A major difference exists in the cooking conditions used in the manufacturing of S1S (smooth-one-side) and S2S (smooth-two-sides).

S1S hardboard is sometimes produced with a thick mat of coarsely refined fiber and an overlay of a thin layer of highly refined fiber. The overlay produces a high quality, shive-free, smooth surface. The bulk of the board can contain coarse fiber, which allows proper drainage during the pressing operation. The refining requires less energy and the cooking conditions are less stringent. Although an overlay system is used in some plants, most S1S hardboard is manufactured with the same pulp throughout the board. S2S hardboard requires more highly refined fiber bundles and more thorough softening. This requires higher preheating pressures and longer retention time. More refining equipment and horsepower is required to produce S2S hardboard. The severity of the cook drastically affects the raw waste loading of the mill effluent. Most S2S hardboard is manufactured using an overlay system of fine fiber bundles.

To contend with frozen chips, some mills in cold climates add preheating for thawing ahead of the cooking cycle.

The predominant method used for fiber preparation consists of thermal and mechanical pulping. This involves a preliminary treatment of the raw chips with steam and pressure and then mechanically defibering the softened chips to an acceptable pulp. The thermo-mechanical process may take place with a digester-refiner as one unit (i.e., Asplund system), or the stock may be discharged through a blow line to the refiners.

Primary, secondary, and tickler refiners may be found in the process depending on the type of pulp required. With more refining the pulp becomes stronger, but its drainage characteristics are reduced.

Some mills use raw chips in the process which bypass the digester and are refined in a raffinator or refiner. These chips are usually of a species that breaks down easily and has a tendency to overcook in the digester. The amount of raw chips, which produce a weaker pulp, are a small percentage of the total chips used and are blended, after refining, with the cooked chips.

The cooking cycles for the thermo-mechanical process for S1S hardboard have ranges of 2 to 5 minutes at 5.4 to 10.2 atm (80 to 150 psi) for softwood and 40 seconds at 9.5 to 12.2 atm (140 to 180 psi) for hardwood.

Another method of fiber preparation, used by two mills, is the explosion or gun process. The chips are fed into a small pressure vessel and cooked (at one mill) for 70 to 110 seconds at 20.4 to 27.2 atm (300 to 400 psi). Just prior to discharge, for approximately 5 seconds, the pressure is increased to 44.2 atm (650 psi). The cooked chips are discharged through a quick-opening valve to a cyclone. The sudden release of pressure explodes the chips into a mass of fiber. The steam condenses in the cyclone and fibers fall into a stock chest where they are mixed with water. Fiber yield is lower than the thermo-mechanical process due to the hydrolysis of the hemicelluloses under high pressure. The raw waste loading is also considerably higher using the gun digesters.

To restore moisture to chips containing a low moisture content (e.g., plywood trim), one mill injects water with the chips as they are being cooked in the digester.

The refining or defibering equipment is of the disc type, in which one disc may be rotating or both may rotate; the unit may be pressurized or a gravity type. A combination of pressure and gravity type refiners is usually used in the process. Both types of refiners have adjustable clearances between the rotating or fixed discs depending on the type of stock desired. The maintenance and life of the refiner discs are dependent on the cleanliness of chips that are fed to the refiners.

Small tickler or tertiary pump-through refiners are used to provide a highly refined, shive-free stock for the overlay system as required by some mills. Small refiners are also used for rejects from the stock cleaning systems.

The primary and most secondary refiners use large amounts of fresh water for cooling. This is uncontaminated water and is discharged without treatment or may be reused in the process water system. Fresh or process white water is injected directly into the refiner to facilitate refining.

Stock Washing and Deckers--A washer is used to remove solubles. A decker is a screen used to separate fibers from the main body of water. Deckering results in removing some solubles from the fiber bundles.

After primary refining and dilution with white water, over 50 percent of the mills surveyed wash the stock to remove the dissolved solids. The most widely used washing equipment is the drum type, gravity or vacuum. The washer is equipped with showers that wash the stock as it is picked up by the drum. Two mills used counter-current washers for their stock. This consists of two or three drum washers in a series, with the last drum effluent used for shower water on the second drum and second drum effluent sent to the first washer. White water is added as shower water on the third drum. This type of washing is highly efficient and is used to extract as much of the dissolved solids possible. The extracted solids are used in a byproduct system. Another mill uses a two-roll press for washing. As the water is squeezed from the stock passing through the nip of the press, it carries away dissolved solids.

The effluent from all the above stock washers has a high concentration of soluble organics which are usually mixed into the white water system and must be discharged for treatment or be recycled within the washing system. The amount of dissolved solids that are readily washed from the stock depends on the species of wood, the amount of cooking, and amount of defibering by the refiners.

Of the 16 mills surveyed, those having stock washers consist of 4 out of 7 mills producing S1S hardboard and 7 out of 9 mills producing S2S hardboard.

Those mills having stock washers usually have them located after the primary refiners. Some locations screen the stock after washing, sending the slivers and oversize back through the primary refiner. Five mills, one without a stock washer, used centri-cleaners in the system to remove non-fiber material (bark, dirt, etc.) from the stock.

Consistency of the stock as it travels through the process is controlled by instruments using recycled white water for dilution. One mill, based on experience, checks the consistency by "feel." The pH may be controlled with fresh water or chemicals. Other chemicals are added at various locations as required.

Forming--Most of the mills using the wet process form their product on a fourdrinier-type machine similar to those used in producing paper. Diluted stock is pumped to the headbox of the former where the consistency is controlled, usually with white water, to an average of 1.5 to 1.7 percent as the stock is fed to the travelling wire of the fourdrinier. As the stock travels with the machine, wire water is drained through the wire. At first the water drains by gravity, but as the stock and wire continue they pass over a series of suction boxes that remove additional water with a vacuum. As the water is being removed the stock is felted together into a continuous fibrous sheet called a "wet mat." At the end of the forming machine the wet mat leaves the travelling wire and is picked up by another moving screen that carries the mat through

one or more roll presses. This step not only removes more water but also compacts and solidifies the mat to a level at which it can support its own weight over short spans. As the wet mat leaves the prepress section, it is cut, on the fly, into lengths as required for the board being produced. The mat, still with a high moisture content (50 to 65 percent) is carried to the hydraulic press section when producing S1S hardboard. In the manufacturing of S2S hardboard, the mat is conveyed first through the drier and then pressed, in a dry state.

The water drained from the mat as it travels across the forming machine is collected in a pit under the machine or in a chest. This "white water" contains a certain amount of wood fibers (suspended solids), wood chemicals (dissolved solids), and dissolved additive chemicals depending on the size of the machine wire, the amount and number of suction boxes, the freeness or drainage of the stock, and the physical properties of the product.

The water draining by gravity from the first section of the former contains the larger amount (rich) of fiber and is usually recycled to the fan pumps that supply the stock to the forming machine. The lean white water collected under vacuum in some wells is collected and recycled as dilution water throughout the process.

The amount of white water that can be recycled is dependent upon board quality demands. Recycled white water causes an increase in the sugar content of the process water and therefore in the board. If the sugar content (dissolved solids) are allowed to accumulate beyond a certain point, problems such as boards sticking in the press, bleedouts from the finish products, objectionable board color, and decreased paintability have been encountered.

The reuse of white water also reduces the amount of fresh water required. The wet trim from the mat on the forming machine is sent to a repulper, diluted, usually screened, and recycled back into the process system ahead of the forming machine.

Pressing--After forming to the desired thickness, the fibers in the mat are welded together into a tough grainless board, in the hardboard press. The press is hydraulically operated, capable of pressing 14 to 26 boards at one time. Press plates may be heated with steam or with a heat transfer medium up to 230° C. Unit pressures on the board up to 68 atn (1000 psi) are achieved in the press. The press may be fitted with caul plates or the board may be pressed directly between the press plattens. Caul plates may be smooth or embossed for a special surface effect on the board. The press may be hand or automatically loaded and unloaded.

In S1S hardboard manufacturing the wet mat is fed into the press as it comes from the forming machine. Screens are used on the back side of S1S mats in the press. In this state the S1S requires 4 to 10 minutes in the press. The squeezing of the water from the wet mat results in washing

much of the migrating sugars from the surface of the board. To assist the bond of the fibers in the press, resins are added to the stock before it reaches the forming machine. From the press the S1S hardboard may be conveyed to a drier, or kiln, or humidifier.

As the S2S hardboard leaves the forming machine, it may enter a pre-drying oven which evaporates 95 percent of the moisture in the board. When a pre-dryer is used, hot board is delivered directly to the press. After drying the board may be pressed or sent to storage and pressed when required. The strength of the S2S hardboard has to be sufficient to withstand the many handling situations that take place while the board is in the unpressed state.

As stated before, the S2S hardboard requires a much harder cook, and more fine refining than S1S. These finer fibers allow the consolidating chemical reaction to take place when pressing the dry board. Thermo-setting resins cannot be used as a binder in S2S because it pre-cures when the forming water is evaporated in the drier. Higher temperatures, higher pressures, and shorter pressing time (1 to 5 minutes) are required in pressing the dry S2S hardboard.

The water from the press squeeze-out on S1S hardboard has a high organic content and is usually drained away for treatment.

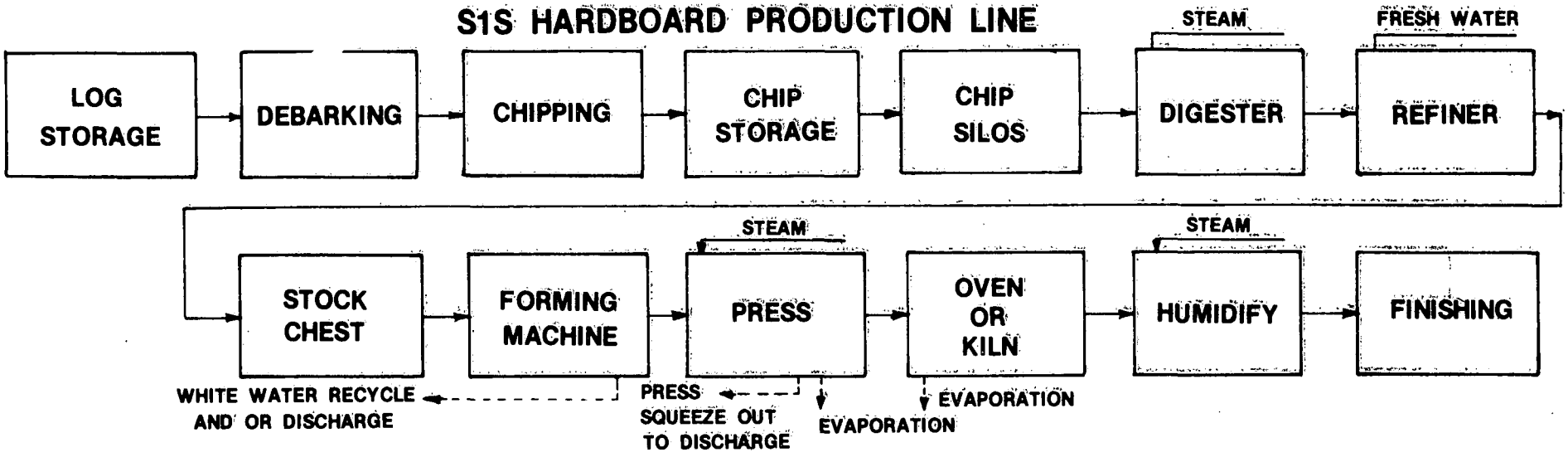
Oil Tempering and Baking--After pressing, both S1S and S2S hardboard may receive a special treatment called tempering. This consists of treating the sheets with various drying oils (usually vegetable oils) either by pan-dripping or roll coaters. The hardboard is sometimes passed through a series of pressure rolls which increase the absorption of the oils and remove any excess. The oil is stabilized by baking the sheet from 1 to 4 hours at temperatures of 150° to 177°C. Tempering increases the hardness, strength and water resistance of the board.

Humidification--As the sheets of hardboard discharge from the press or the tempering baking oven they are hot and dry. To stabilize the board so as to prevent warping and dimensional changes they are subject to a humidification chamber. The sheets are retained here until the proper moisture content, usually 4.5 to 5 percent, is reached. In the case of siding products where exposure to the elements is expected, humidification to 7 percent is common.

Figures III-8 and III-9 depict diagrams of typical S1S and S2S production processes, respectively.

FLOW DIAGRAM OF A TYPICAL WET PROCESS HARDBOARD MILL

S1S HARDBOARD PRODUCTION LINE



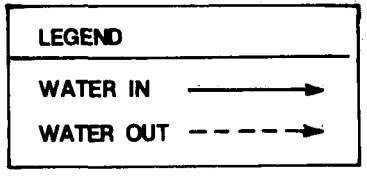
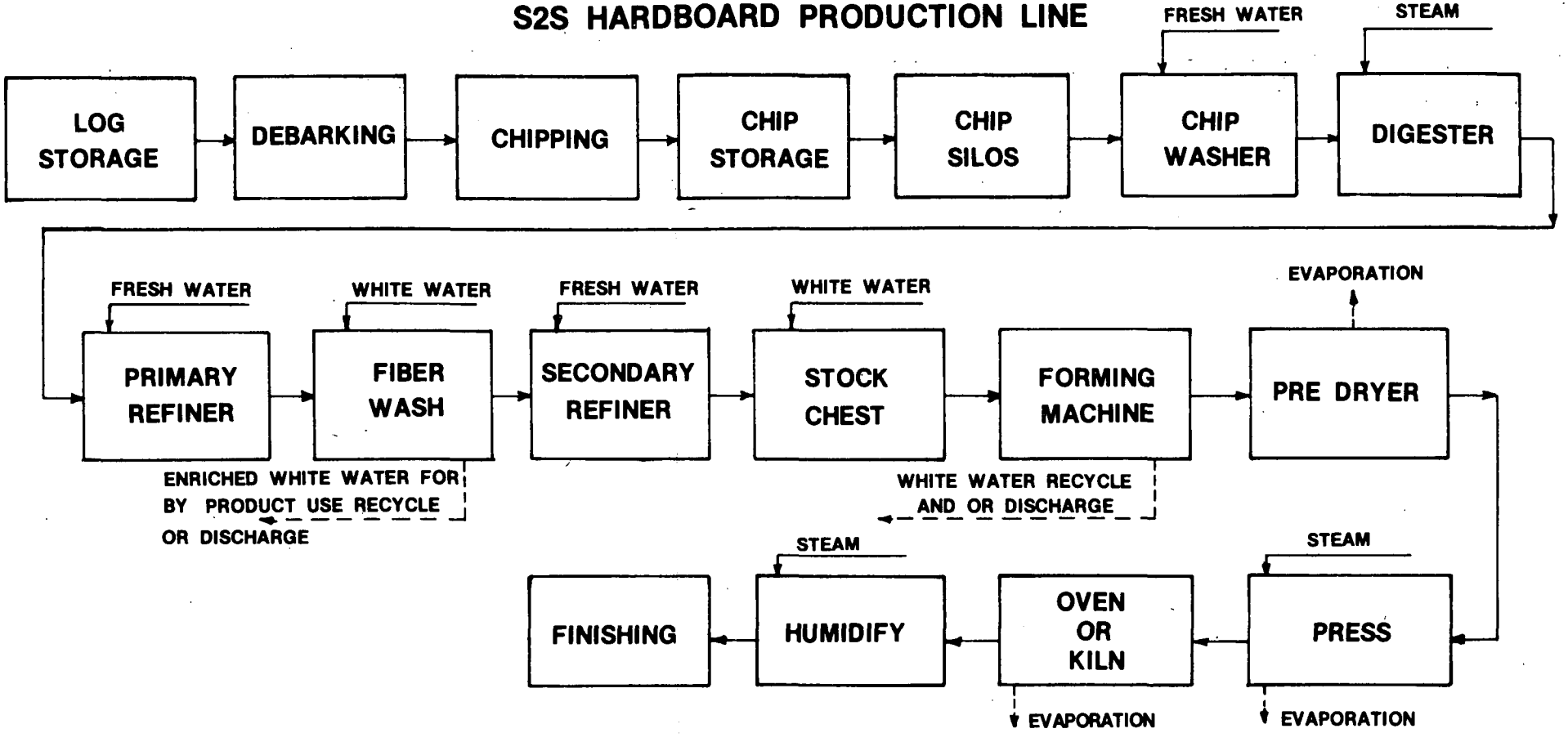


Figure III - 8

FLOW DIAGRAM OF A TYPICAL WET PROCESS HARDBOARD MILL
S2S HARDBOARD PRODUCTION LINE



LEGEND

WATER IN ——→

WATER OUT - - - -→

Figure III - 9

SECTION IV

INDUSTRIAL SUBCATEGORIZATION

General

In the review of existing industrial subcategorization for the wood preserving, insulation board, and hardboard industries, it was necessary to determine whether significant differences exist within each industry to support the current subcategorization scheme, or whether modifications are required. The rationale for subcategorization is based upon emphasized differences and similarities in such factors as: (1) plant characteristics and raw materials; (2) wastewater characteristics, including priority pollutant characteristics; (3) manufacturing processes; and (4) methods of wastewater treatment and disposal.

The entire technical data base, described in Section III, was used in the review of subcategorization.

Wood Preserving

In developing the previously published effluent limitation guidelines and pretreatment standards for the wood-preserving segment of the timber products processing industry, it was determined that plants comprising this segment exhibited significant differences which sufficiently justified multiple subcategorization. The subcategorization of the wood-preserving segment was based primarily on the method of conditioning stock preparatory to preservative treatment. The Wood-Preserving subcategory is comprised of plants that do not condition stock in the retort prior to injection of preservative. The WoodPreserving-Steam subcategory includes plants that employ steam conditioning or vapor drying. The Wood-Preserving-Boultonizing subcategory is comprised of plants that use the Boulton conditioning process. The complete definitions of the three existing subcategories are as follows:

Wood-Preserving--The Wood-Preserving subcategory includes all wood-preserving processes in which steaming or Boultonizing is not the predominant method of conditioning; and all pressure or non-pressure processes which employ water-borne salts and in which steaming or vapor drying is not the predominant method of conditioning.

Wood-Preserving-Steam--The Wood-Preserving-Steam subcategory includes all processes that use direct steam impingement on the wood being conditioned as the predominant method of conditioning, discharges resulting from wood-preserving processes that use vapor drying as a means of conditioning any portion of their stock, discharges that result from direct steam conditioning wood-preserving processes that use fluor-chromium-arsenate-phenol treating solutions (FCAP), discharges resulting from direct steam conditioning processes and procedures where the same retort is used to treat with both salt-type and oil-type preservatives,

and discharges from plants which direct steam condition and apply both salt-type and oil-type treatments to the same stock.

Wood-Preserving-Boultonizing--The Wood-Preserving-Boultonizing subcategory covers those wood-preserving processes which use the Boulton process as the method of conditioning stock.

The rationale for choosing these subcategories was anchored to differences within the industry in the volume of process wastewater generated and to variations in the state of technology existing when the subcategories were developed. The economic viability of using process steam in 1973-1974 to evaporate wastewater was also a factor that was considered. Plants in the Wood-Preserving subcategory were required to meet a no discharge limitation because a widely used technology existed to achieve a no discharge through wastewater recycling. Likewise, exemplary plants employing the Boulton method of conditioning had achieved a no discharge of process wastewater by forced evaporation in 1974, and this standard was applied to all Boulton plants.

Plants that used steaming as the predominant method of conditioning were permitted a discharge because of the relatively large volume of wastewater generated by the open-steaming method used by most of the plants at that time.

Rationale for Subcategorization Review

Since the original Draft Development Document was published in 1974, several of the conditions which led to the separate subcategorization of steam conditioning and Boultonizing plants have changed. Differences in wastewater volume between the two subcategories have largely disappeared. Furthermore, the primary method used by Boulton plants to achieve a no discharge--forced evaporation of wastewater using process steam--is more expensive than it was in 1974 due to increased energy costs.

Subcategorization of plants which treat only with inorganic salt-type preservatives into a separate subcategory is still valid. Technology currently available to achieve the existing no discharge limitation in plants treating with inorganic type salts is effective, relatively inexpensive, and widely employed in the industry.

The following discussion pertains to the rationale for a possible modification in those subcategorizies which treat with organic, oil-type preservatives, the wood-preserving-steam, and wood-preserving-Boultonizing subcategories. Factors considered in this subcategorization review are:

Plant characteristics and raw materials
Wastewater characteristics
Manufacturing processes
Methods of wastewater treatment and disposal

Plant Characteristics and Raw Materials

Plants that employ the Boulton process as the predominant method of conditioning are concentrated in the western states; those that use steam conditioning are concentrated in the south and east. However, species of wood, not geography, is the factor that determines the method of conditioning employed. The Boulton process is used primarily to condition unseasoned Douglas fir, which is the primary pole species in the western states, while steam conditioning is used with Southern pines. However, many plants that treat unseasoned Douglas fir, and thus are classified as Boulton plants, also employ steaming for special purposes such as thawing frozen stock before treatment or flash cleaning of the surfaces of stock following treatment. Likewise, since current AWPA standards permit steam conditioning of certain western species such as Ponderosa pine, some plants that use Boultonizing as the predominant method of conditioning also use steam conditioning occasionally. Similarly, some eastern plants that steam condition most of their stock may use the Boulton process to condition green oak piling or cross-ties. Boultonizing is the predominant conditioning method at a few of the plants in the south and east that specialize in cross-tie production.

Age--With the exception of method of conditioning, which is dictated by timber species, Boulton and steaming plants have very similar characteristics. Average plant age, for example, is 48 and 47 years for Boulton and steaming plants, respectively, based on responses to the data collection portfolio (Table IV-1).

Age in and of itself is not a significant factor in determining the efficiency and economic viability of a plant; nor does it necessarily influence either the volume or the quality of process wastewater. Regardless of age, all plants employ the same basic treating processes, use the same type of equipment, and treat with the same preservatives. The average age of wood-preserving plants is high because the industry developed rapidly in the 1920's and 1930's in consort with the demand by the railroads and utilities for treated wood products. Most of the old plants have been updated several times since they were first constructed. The waste-management programs at these plants are fully as advanced in most cases as those at plants constructed 30 years later.

Size--Boulton plants are of the same general size range, based on number of pressure retorts, as plants that use steam conditioning. This similarity is evident from Table IV-2, which shows the percentage of plants by region of the U.S. that have one retort, two retorts, etc. For example, 65 percent of the West Coast plants, which are primarily Boulton plants, have fewer than three retorts. The comparable percentage for the rest of the industy--where steam conditioning predominates--is also 65 percent.

Table IV-1 Date of Construction of a Randomly Selected Sample of Boulton and Steaming Plants.

Boulton Plant No.	Date Constructed	Steaming Plant No.	Date Constructed
62	1910	536	1926
451	1928	192	1927
760	1906	616	1948
1120	1907	345	1946
1040	1924	1021	1902
252	1924	972	1922
150	1912	864	1919
991	1962	786	1926
85	1901	528	1964
713	1913	695	1924
1100	1886	963	1961
384	1924	437	1936
969	1945	166	1904
101	1959	1150	1928
827	1955	258	1945
996	1952	817	1940
243	1930	1093	1957
377	1965	670	1896
566	1942	939	1912
		879	1946
		233	1906
		749	1945
		144	1908
Average age (years)	48		47

SOURCE: Data collection portfolios.

Table IV-2 Size of Plants by Region Based on Number of Retorts.

Number of Retorts	Percent of Region				
	NE	SE	SW	Atlantic Coast	West Coast
1	38	41	38	34	28
2	31	27	30	23	37
3	22	20	15	23	0
4	6	8	2	10	7
5 or more	3	4	15	10	28

SOURCE: Data collection portfolios and AWPA, 1975.

That portion of the industry that Boultonizes stock tends to have a higher percentage of large plants than the steaming segment. For example, 35 percent of the West Coast plants have more than three retorts as compared to 15 percent for the rest of the industry. None of the West Coast plants reported three retorts, while 20 percent of all other plants are so equipped.

Production capacity is perhaps a better index of plant size than number of retorts. For plants with the same number of retorts that treat only stump-green stock, the production of the steaming plant would exceed that of the Boulton plant by a factor of two or more because of the longer time required for the Boulton process. This inherent production advantage of steaming plants is mitigated in part by the fact that the Boulton segment of the industry has a higher percentage of 4- and 5-cylinder plants than the steaming segment.

Products Treated--Boulton and steaming plants produce the same range of treated products. This similarity can be seen in Table IV-3, which shows the percentage of the plants by region that treat each of several products. Overall, the West Coast (Boulton) plants tend to be more diversified than the remainder of the industry in that a higher percentage of these plants treat each product than the average for the industry as a whole.

Preservatives Used--The type of preservatives used by a plant is an important consideration in determining the pollutants contained in the process wastewater and, to some degree, the quality of the wastewater. Table IV-4 shows that Boulton (West Coast) plants use the same range of preservatives as the industry as a whole. However, a considerably higher percentage of Boulton plants use creosote and salt-type preservatives than the remainder of the industry.

Method of Drying--As is the case with the foregoing plant characteristics, method of drying stock preparatory to preservative treatment is about the same industry-wide regardless of conditioning method. This fact is shown in Table IV-5, which gives the number of plants by region using air drying, vapor drying, kiln drying, and combinations thereof.

Wastewater Characteristics

Wastewater Volume--Data collected in 1973-1974 in preparation of the Development Document for the wood-preserving segment of the timber products industry revealed that steaming plants generate a much larger volume of wastewater than Boulton plants of similar size. The difference in wastewater generation between the two types of plants has been narrowed considerably during the intervening years as a result of aggressive pollution-control efforts among steaming plants in the East. Factors that have contributed to this change include the following:

Table IV-3 Percentage of Plants by Region that Produce Each Type of Treated Product.

	Percent of Region				
	NE	SE	SW	Atlantic Coast	West Coast
Poles	41	51	48	39	69
Piling	38	56	50	55	52
Posts	59	56	68	71	76
Barn Poles	44	56	58	58	69
Dimension	75	65	72	87	76
Timbers	81	76	70	77	90
Ties	53	40	37	52	48
Other	34	20	25	32	55

SOURCE: AWPA, 1975.

Table IV-4 Types of Preservatives Used by Region.

Preservatives	Percent of Region				
	NE	SE	SW	Atlantic Coast	West Coast
Creosote and Solutions	53	48	78	52	86
Pentachlorophenol	50	68	62	65	55
Salts	53	37	25	61	62

SOURCE: AWPA, 1975.

Table IV-5 Percentage of Plants by Region that Employ Various Methods of Drying Stock.

Drying Method	Percent of Region				
	NE	SE	SW	Atlantic Coast	West Coast
Kiln Drying	16	33	28	35	45
Vapor Drying	9	4	15	13	3
Air Drying	81	60	65	74	83
Kiln or Vapor	0	0	0	3	3
Kiln or Air	13	24	20	22	38
Vapor or Air	9	0	8	10	3

SOURCE: Data collection portfolios and AWPA, 1975.

1. Adoption of closed steaming as a replacement for open steaming by a high percentage of plants.
2. Replacement of barometric-type with surface-type condensers.
3. Recycling of barometric cooling water.
4. Predrying of a higher percentage of production than previously, thus reducing total steaming time.
5. Segregation of contaminated and uncontaminated waste streams.
6. Inauguration of effective plant maintenance and sanitation programs.
7. Recycle of coil condensate.

Improvements were also made in the waste management programs at Boulton plants between 1973 and 1977. However, the changes that produced the greatest result with the smallest investment were made at these plants prior to 1973 in response to early enforcement of stringent local and state pollution control regulations.

Data on current wastewater volumes at steaming and Boulton plants are given in Tables IV-6 and IV-7, respectively. Included in the tables are the total daily volume of wastewater generated and the ratio of wastewater generated to production for each of the plants that gave definitive wastewater volume data in their respective data collection portfolio responses.

The average wastewater volumes reported are 24,100 and 25,700 l/day for steaming and Boulton plants, respectively, and the average volumes per day per cubic meter of production are 163 and 138 liters. Two of the Boulton plants (150 and 231) clearly have wastewater volumes that are significantly different from the population as a whole. Omitting these plants, the average daily volume and volume per unit of production are 12,900 and 98.1 l/day-cu m, respectively.

Eleven of the 41 steaming plants use open steaming. If these plants are dropped from the calculation, the comparable volume data for steaming plants become 12,200 l/day and 122 l/day-cu m. It appears from these data that the average volume of wastewater per plant per day is approximately the same for Boulton plants and closed-steaming plants. When the comparison is based on volume per unit of production, wastewater generation is approximately 78 percent higher for steaming than for Boulton plants. This difference is even greater in the case of plants that use open steaming. However, it is of interest that the range defined by $X \pm$ one standard deviation for this latter statistic has a high percentage overlap between the Boulton and steaming processes. For example, the range for the Boulton plants is 20.0 to 175 l/day-cu m, while that for steaming plants is 17.4 to 226 l/day-cu m.

Wastewater Parameters--Since Boulton and steaming plants treat with the same types of preservatives, the wastewater generated by the two types of plants have similar preservative contaminants. This is verified by data presented in Table IV-8. These data are based on

Table IV-6 Wastewater Volume Data for 41 Steaming Plants.

Plant	Volume (l/day)	Volume (l/cu m)	Plant	Volume (l/day)	Volume (l/cu m)
986	18,168	174	592	18,925	57.5
689	946	16.0	685	5,678	200
199	1,325	103	631	20,818	107
192	56,775	235	661	9,463	48.1
197	727	12.0	777	17,033	429
455	1,325	74.8	616	871	6.68
333	30,280	213	437	41,635	350
817	13,248	---	133	62,453	270
247	18,925	4.85	313	41,635	346
322	27,252	82.9	217	27,252	231
983	3,785	33.4	1004	18,925	102
258	56,775	501	1246	5,678	200
749	3,028	17.4	1300	75,700	382
233	22,332	146	1080	8,952	61.5
111	5,382	94.9	271	124,905	428
879	11,355	103	172	25,360	298
105	33,687	303	721	52,990	187
813	15,140	58.8	972	9,463	278
326	1,893	17.4			
856	3,316	57.5	$\bar{X}_{41}$	24,098	163
670	11,355	89.5			
241	41,635	114	$\bar{X}_{30}$	12,154	122
1021	41,635	77.5			
			S	9,633	104

SOURCE: Data collection portfolios.

Table IV-7. Wastewater Volume Data for 18 Boulton Plants.

Plant	Volume (l/day)	(l/cu m)
364	9,724	279
536	26,495	128
377	3,785	38.8
713	26,495	70.8
85	1,136	4.01
757	1,223	18.7
	20,818	69.5
499	26,495	93.6
503	7,570	122
612	11,355	106
781	5,678	52.1
622	9,463	76.2
150	189,250	668
252	3,407	56.1
	20,818	105
1120	16,351	74.8
231	65,405	255
451	16,351	275
$\bar{X}_{18}$	25,657	138
$\bar{X}_{16}$	12,948	98.1
S	9,152	77.5

SOURCE: Data collection portfolios.

Table IV-8. Wastewater Parameters for Boulton and Steaming Plants.

Plant Type	COD (mg/l)	Total Phenols (mg/l)	pcp (mg/l)	Oil & Grease (mg/l)
Boulton conditioning as practiced in the West	1710	184.0	5.73	35
	3705	729.6	---	10
Avg.	2710	456.8	5.73	22
Closed Steaming as practiced in the East	1430	482.2	---	35
	12625	264.5	143.5	1685
	8167	48.5	73.5	520
	7990	221.9	152.5	700
	3595	302.4	49.0	980
	16965	120.0	81.0	1380
	3080	32.3	17.9	535
	6690	81.0	540.0	1045
Avg.	7567	194.1	151.1	860

SOURCE: Sampling conducted during pretreatment study and verification sampling conducted during the present study.

analyses of two or three grab samples collected at the outfall of the oil-water separators at each plant. The differences evident between average values for the two types of plants are typical. Phenol concentrations are higher for Boulton wastewater than for steaming wastewater. However, the concentrations of the other parameters are smaller for the Boulton wastewater than for the steaming wastewater.

Differences between Boulton and steaming wastewater in COD and pentachlorophenol contents are largely due to differences in oil and grease content. Oil-water emulsions are of frequent occurrence in steaming plant wastewaters, a fact that accounts for the correspondingly higher average oil content. It is probable that wood extractives, principally resins and carbohydrates, act as emulsifiers, thus contributing to this condition. Because the water removed from wood during the Boulton process leaves the retort in vapor form and thus is free of wood extractives, emulsions occur with considerably less frequency in Boulton wastewater. The higher oil content of the steaming wastewater accounts in large part for the high oxygen demand of these wastes and serves as a carrier for concentrations of pentachlorophenol that far exceed its solubility in water (17 mg/l at 20°C).

Manufacturing Processes

The conditioning method employed is the only step in the manufacturing process that distinguishes Boulton plants from steaming plants. Both conditioning methods have the same function, i.e., to reduce the moisture content of unseasoned stock to a level which allows the requisite amount of preservative to be forced into the wood. Conditioning also increases the permeability of the wood so that the preservative will penetrate the sapwood zone as required by AWPA standards.

The above stated objectives are accomplished in the Boulton process by heating the stock in a preservative bath under reduced pressure in the retort. The preservative serves as a heat transfer medium. Water removed in vapor form from the wood during the Boulton process passes through a condenser to an oil-water separator where low-boiling fractions of the preservative are removed. The Boulton cycle may have a duration of 48 hours or longer for large poles and piling, a fact that accounts for the lower production per retort day as compared to plants that steam condition.

Conventional steam conditioning is a process in which unseasoned or partially seasoned stock is subjected to direct steam impingement at an elevated pressure in a retort. The maximum permissible temperature is set by industry standards at 118°C, and the duration of the steaming cycle is limited by these standards to 20 hours. Steam condensate that forms in the retort exits through traps and is conducted to oil-water separators for removal of free oils. Removal of emulsified oils requires further treatment.

In closed steaming, a widely used process variation, the steam needed for conditioning is generated in situ by covering the coils in the retort with water from a reservoir and heating the water by passing process steam through the coils. The water is returned to the reservoir after oil separation and reused during the next steaming cycle.

The actual treating process employed is independent of conditioning method and is of three basic types. Two of them are referred to in the industry as "empty-cell" processes and are based on the principle that part of the preservative oil forced into the wood is expelled by entrapped air upon the release of pressure at the conclusion of the treating cycle, thus leaving the cell walls coated with preservative. The pressure cycle is followed by a vacuum to remove additional preservative. Retentions of 96 to 192 kilograms per cubic meter are generally sought in these processes. The retention attained is controlled in part by the initial air pressure employed at the beginning of the cycle.

The third method, known as the "full-cell" process, differs from the other two in that the treating cycle is begun by evacuating the retort and breaking the vacuum with the preservative. The preservative is then forced into the wood under pressure, as in the other processes. Most of the preservative remains in the wood when the pressure is released. Retentions of 320 kilograms per cubic meter or higher are usually the goal for this process is used.

Stock treated by all three methods is frequently given a short steam treatment to "clean" the surface of poles and pilings and to reduce exudation of oil after the products are placed in service.

Methods of Waste Treatment and Disposal

Based on method of wastewater treatment and disposal, respondents to the data collection portfolio were distributed as follows:

Method	No. of Plants	Percent of Plants
Recycle--No Discharge	62	32
Evaporation--Forced or Natural	66	34
Publicly Owned Treatment Works	42	21
Secondary Treatment--Including Spray Irrigation	15	8
Special (Injection, Incineration)	2	1
Direct Discharge	9	4
Total	196	100

Plants that recycle all process wastewater are primarily those that treat only with salt-type preservatives and fire retardants. However, included in the recycle category are a few plants that employ creosote and penta-

chlorophenol to treat dry stock (lumber, millwork, etc.). Plants that treat with salts have with few exceptions achieved no discharge as required by current EPA guidelines. The exceptions are those few plants that treat with the FCAP formulation. Because this formulation is compatible with steam conditioning, the plants were allowed a variance in the guidelines. ACA and CZC preservatives are also compatible with steam conditioning, but only one or two plants that using these formulations are known to have a discharge.

Capital requirements to achieve no discharge for a plant that treats only with salt-type preservatives are relatively small compared to steam or Boulton plants, all of which treat with oil-type preservatives. Because of the nature of the closed system for salt treating plants, operating costs are low. Some small return on the initial investment can be realized in that small quantities of otherwise wasted chemicals are recovered and reused. Costs for recycle systems are presented in Section VIII.

With only a few exceptions plants that utilize the POTW as part of their wastewater management program are those that treat with oil-type preservatives. The number of such plants has increased from 17 percent in 1974 to an estimated 21 percent in 1977, based on data supplied by the data collection portfolios. The ratio of steaming to Boulton plants in this group is roughly 80:20. This is the same approximate ratio between the two types of plants that exists in the industry as a whole.

Utilization of the POTW by a wood preserving operation depends upon both the location of the operation and the willingness of the municipal authorities to accept industrial wastewater. Usually only those plants located in or near urban areas have the opportunity to use the POTW for wastewater disposal. Plants which for various reasons cannot utilize POTW service represent roughly 50 percent of all plants in the industry. With the exception of plants that treat with salt formulations, all of the plants in this group generate a volume of wastewater that exceeds all recycle capabilities that are technically feasible. This situation is aggravated by rainwater, since rainwater that falls on or near the production facilities must be collected and disposed of in a proper manner.

Evaporation, both natural and forced, is the method adopted by most of the plants in this group, and is the only alternative for Boulton plants which, under current guidelines, are not allowed a discharge. This restriction was based on the fact that exemplary Boulton plants were successfully achieving no discharge of process wastewater by forced evaporation in 1973-1974 when the guidelines were developed.

Evaporation is a viable method of pollution abatement when land is available at a reasonable cost and can be so used. This situation exists in many of the Atlantic Coastal, Southwestern, and Southeastern states where most steaming plants are located. For this reason, all of the steaming plants in these regions that depend upon evaporation for waste disposal--either wholly or in part--have lagoons that frequently are equipped with

spray systems to expedite evaporation. Since these plants have the option of discharging treated wastewater within the constraints imposed by the guidelines, evaporation is often used in combination with biological treatment, aerated lagoons, or soil irrigation.

An option on evaporation system type is generally not available to Boulton plants because of the non-availability or high cost of land. Eighty-four percent of the plants in California, Oregon, and Washington are located in densely populated areas such as Seattle, Portland, Longview, Long Beach, Tacoma, Stockton, etc. Since these plants cannot use a biological treatment process because of discharge restrictions, they must use forced evaporation to dispose of their excess wastewater. Seventy-five percent of the Boulton plants from the West that responded to the data collection portfolios use evaporation. The remainder discharge to a POTW.

Evaporation systems actually used by Boulton plants vary from sophisticated cooling towers equipped with auxiliary heating equipment to simple open vats fitted with steam coils. The several-fold increase in the cost of energy since 1974 has resulted in much higher operating costs of forced evaporation, which is highly energy intensive. One plant owner who recently installed a cooling tower specifically for wastewater evaporation reported that his annual gas consumption increased 97 percent, or 100,000 therms, during the first seven months of operation. Based on his calculations, the cost for gas alone during this period amounted to $1.80/cu m, or 4.8 percent of the plant's total operating cost. It is estimated that fuel cost for evaporation is $115.22 per 1000 liters based on a gas cost of $70.67/1000 cu m and an average heating efficiency of 60 percent. However, much higher costs have been reported by others (EPA, 1976).

A second Boulton plant with a daily wastewater flow of 20,800 liters reports that it is spending more than $200,000 for the equipment needed to recycle its wastewater. Both ultrafiltration and reverse osmosis units have been installed. The permeate from the system will be used as boiler make-up water and the sludge will be burned for fuel. Although this would be a considerable investment for most wood-preserving plants, it may be less costly than evaporating the water using process steam. Data released by the plant that installed a cooling tower for wastewater evaporation indicate an average operating cost of $4,069 per month.

Proposed Subcategories

A careful consideration of the plant characteristics, raw materials, wastewater volume produced, wastewater characteristics, manufacturing processes, and available methods of wastewater treatment and disposal as currently exist in the industry today suggests that wood preserving plants could be subcategorized according to type of preservatives used rather than method of preconditioning stock.

This objective could be met by two subcategories, defined as follows:

Wood Preserving-Inorganic Chemicals--The wood-preserving-inorganic chemicals subcategory includes all wood preserving processes in which inorganic water-borne preservatives and fire retardants are the only chemicals employed.

Wood Preserving-Organic Chemicals--The wood-preserving-organic chemicals subcategory includes all wood preserving processes in which organic preservatives are used; all processes in which the same retort is used to apply both organic and inorganic preservatives; all processes in which both inorganic and organic preservatives are used to treat the same stock; and all processes in which plant configuration is such that direct cross contamination occurs between wastewaters from adjacent retorts, one of which is used for inorganic salts.

The type of preservative used in the industry is a basis for subcategorization in the original effluent guidelines. Possible modifictions to this subcategorization involve grouping all plants using inorganic salt-type preservatives into one subcategory and all those using organic preservatives into a second subcategory, as shown above. This modification would change existing subcategories in the following manner:

The method of conditioning stock for preservative treatment would be dropped as a criterion for subcategorization.

Furthermore all plants treating with inorganic salt-type preservatives would be grouped into the same subcategory and would be required to meet the same discharge requirements. Plants treating with FCAP currently are included in the Wood-Preserving-Steaming subcategory. FCAP was treated differently from other salt-type preservatives in developing the original subcategories because, unlike CCA, it can be used to treat steam-conditioned wood and was being so used by several plants in 1973-1974. Ammoniacal copper arsenate (ACA) and chromated zinc chloride (CZC) can be similarly employed. Because the same well-developed and extensively used technology by which the plants treating with CCA preservatives have achieved no discharge is equally applicable to plants that employ these other heavy-metal salts, all plants treating with inorganic salt-type preservatives could be grouped into a common subcategory. Only two of two hundred plants responding to data collection portfolios indicated that FCAP is used. One of these (Plant 773) has already achieved no discharge and the other (Plant 817) is discharging some FCAP wastewater to the POTW. Industry-wide, 0.530 million kilograms of FCAP were used in 1975 (AWPA, 1976). It would seem obvious, therefore, that more than two plants are using this preservative. This amount represents 5.0 percent of the total consumption of salt-type preservatives.

An additional change resulting from the modifications would be that plants applying non-pressure treatments with organic preservatives would be grouped with those applying organic preservatives by pressure

processes. Plants using non-pressure processes are currently included in the Wood-Preserving subcategory. Special consideration should be afforded to plants that apply non-pressure organic treatments. Non-pressure plants should be precluded from an allowable discharge, regardless of whether pressure treating plants are allowed to discharge by final proposed effluent limitations. This conclusion is supported by the fact that non-pressure plants do not produce process wastewater, and all non-pressure plants responding to the data collection portfolio are currently achieving no discharge. Grouping non-pressure processes with pressure processes would likewise have little effect on the industry. Total production by non-pressure plants is estimated to be less than one percent of the total for the industry.

Insulation Board

Although effluent limitations guidelines for the insulation industry have not been promulgated, the final Draft Development Document for the Timber Products Processing Point Source Category (Phase II) proposed the following subcategories for insulation board:

Insulation Board--The Insulation Board Subcategory includes those plants whose manufacturing procedure does not involve subjecting the wood raw material to a pressure created by steam.

Insulation Board Manufacturing With Steaming or Hardboard Production--This subcategory includes those plants whose manufacturing procedure includes steam conditioning of the wood raw material before refining, or those plants which produce hardboard at the same facility.

The rationale for selection of these subcategories was anchored primarily to differences in the raw waste loads exhibited by plants which employ steaming and/or hardboard production and plants which do not. Other factors considered were the nature of raw materials, plant size and age, nature of water supply, plant location and land availability, and water usage. The effects on raw waste loading due to these factors were not considered to be of sufficient significance to warrant further subcategorization.

Rationale for Subcategorization Review--In order to determine the validity of the proposed subcategorization, and to determine whether changes within the industry since 1974 warrant modification of subcategorization, the industry was reviewed and surveyed with a focus on wastewater characteristics and treatability as related to:

Raw materials
Manufacturing processes
Products produced
Plant size and age
Geographical location

Analysis of the above factors, supported by data presented in Section V, Raw Wastewater Characteristics, of this document, affirms the validity of separate subcategorization for insulation board, mechnical pulping and refining, and insulation board, thermomechanical pulping and refining and/or hardboard production at the same facility.

Raw Materials--The primary raw material used in the manufacture of wood fiber insulation board is wood. This material is responsible for the major portion of the BOD and suspended solids in the raw waste. Other additives, such as wax emulsions, asphalt, paraffin, and aluminum sulfate, comprise less than 20 percent of the board weight and add very little to the raw waste load. Literature and operating data submitted by several mills has indicated that wood species, season of wood harvesting, and the presence of bark and/or whole tree chips in wood furnish affect the raw waste load of fiberboard plants. Due to a lack of sufficiently detailed plant data to quantify the effects of these variables upon raw waste load, there was no sound basis for subcategorization strictly on the basis of raw material used to produce the board.

Four of the insulation board plants produce insulation board using mineral wool as a raw material. Two of these plants produce large quantities of mineral wool insulation board on separate forming lines within the same facility or in facilities separate from the wood fiber insulation board plant. One plant produces approximately 50 percent of its total production as mineral wool insulation board on the same forming machine that it uses to produce wood fiber insulation board. Wood fiber and mineral wool wastewater from these two plants completely comingle prior to monitoring. These plants were not used to determine raw waste loads for wood fiber insulation board. One plant produces less than 10 percent of its total production as mineral wool insulation board, using the same forming equipment as is used for wood fiber insulation board. Raw waste load data from this plant was used to develop raw waste loads for wood fiber insulation board as the contribution from the mineral wood production was considered to have no significant effect on the overall raw waste load. All other plants analyzed for raw waste load used only wood as the primary raw material.

Four plants indicated that wastepaper was used for a minor portion of their raw material in wood fiber insulation board production. Insufficient information was available to determine the effect of small amounts of wastepaper furnish on raw waste loads at these plants.

Manufacturing Process--Although a plant may have various auxiliary components in its operation, the major difference in manufacturing processes which affect raw waste loads is whether steam, under pressure, is used to precondition the chips prior to refining. The steam cook softens the wood chips and results in the release of more soluble organics from the raw material. A discussion of this phenomena is presented in Section V, Raw Waste Characteristics. Data received from

insulation board plants supports the conclusion that steaming of furnish significantly increases the raw waste load.

Of the five insulation board plants which also produce hardboard at the same facility, all but one steam condition most or all of the wood furnish used for insulation board. The remaining plant steam conditions approximately 10 percent of the wood furnish for insulation board. Raw waste load data from this plant is not significantly different from the one plant which steam conditions all its wood furnish and which produces solely insulation board.

Products Produced--The ability of an insulation board plant to recycle process wastewater is highly dependent upon the type of product produced. Insulation board plants which produce primarly structural type board products such as sheathing, shinglebacker, etc., demonstrate lower raw waste loads due primarily to the increased opportunity of process water recycle at these plants. Two insulation board plants that do not steam condition their wood furnish had reduced their flow per unit of production to less than 3000 liters/metric ton (750 gallons/ton). One of these plants produces primarily structural type board products. Two insulation board plants that steam condition their wood furnish achieved complete recycle of process whitewater, resulting in no discharge of process wastewater. Both of these plants produce solely structural type products.

Structural type products do not require as smooth a surface finish as decorative products and can absorb a greater amount of wood sugars and other dissolved material from the process whitewater system.

Consideration was given to subcategorization on the basis of type of board product produced, i.e. structural versus decorative. However, the equipment at most plants is readily adaptable to the production of both types of board, and most plants rotate the type of board produced based on product demand, which is highly variable. Subcategorization according to board type would severely limit the ability of these plants to respond to competitive pressures, and would make the issuance of permits by enforcement agencies a difficult task. Therefore, subcategorization solely on the basis of product type is not considered feasible.

Plant Size and Age--There is a substantial difference in the age and in the size of the plants in the insulation board industry. However, older plants have been upgraded, modernized, and expanded so that age, in terms of process, is meaningless. Because of this, the differences in wastewater characteristics related to the age of the plant are not discernible, nor is the prorated raw waste load due to plant size. Raw waste load data presented in Section V supports this conclusion.

Geographical Location--Insulation board plants are widely scattered throughout the United States--from the east to west coast and from Minnesota to Mississippi. The geographic location of each plant dictates

the species of wood that is used in the plant's process. Although each species generates varying raw waste loads, each plant, with its own process methods, produces a salable product from many types of soft and hard woods. Plants in cold climates may use frozen chips, necessitating the use of pre-steaming to thaw the chips. This can result in a small increase in raw waste loading. Plants in cold climates are also subject to more pronounced seasonal variations in treatment efficiency of biological treatment systems, however the effects of cold climate on biological treatment systems can be mitigated by proper design considerations. The geographic location of the surveyed mills did not reveal significant differences in the annual raw waste loading.

Wet-Process Hardboard

Effluent limitations guidelines for wet-process hardboard plants promulgated in 40 CFR 429 included all wet-process hardboard plants in a single subcategory defined as:

Wet-Process Hardboard--Plants engaged in the manufacture of hardboard using the wet matting process for forming the board mat.

Since these regulations were promulgated, industry representatives have presented data in negotiations with the EPA which support separate subcategorization for wet-wet (S1S) hardboard and wet-dry (S2S) hardboard.

In November, 1975, the EPA retained a contractor to evaluate and review the BAT regulations and the existing subcategorization of the industry. The Summary Report on the Re-Evaluation of the Effluent Guidelines for the Wet-Process Hardboard Segment of the Timber Products Processing Point Source category was completed in July, 1976. The recommendation contained in this report was that the wet-process hardboard industry should be recategorized into two subcategories, one for wet-wet hardboard and one for wet-dry hardboard. This recommendation was based on significant differences in the raw waste load characteristics of plants which produce hardboard by the two different processes.

Rationale for Subcategorization Review--In order to determine the validity of the proposed resubcategorization and to determine whether changes within the industry since the Summary Evaluation Report was completed in 1976, the industry was reviewed and surveyed with a focus on wastewater characteristics and treatability as related to:

Raw Materials
Manufacturing Processes
Products Produced
Plant Size and Age
Geographical Location

Analysis of the above factors, supported by data presented in Section V, Raw Wastewater Characteristics, of this document, affirms the validity of

separate subcategorization for wet-wet (S1S) hardboard and wet-dry (S2S) hardboard.

Raw Materials--The primary raw material used in the manufacture of hardboard is wood. This material is responsible for the major portion of the BOD and suspended solids in the raw waste. Other additives, such as vegetable oils, tall oil, ferric sulfate, thermoplastic and/or thermosetting resins, and aluminum sulfate, comprise less than 15 percent of the board weight and add very little to the raw waste load. Literature and operating data submitted by several plants has indicated that wood species, season of wood harvesting, and the presence of bark and/or whole tree chips in wood furnish affect the raw waste load of fiberboard plants. Due to a lack of sufficiently detailed plant data to quantify the effects of these variables upon raw waste load, there was no sound basis for subcategorization strictly on the basis of raw material used to produce the board.

Manufacturing Processes--A plant may have various auxiliary components in its operation; however, the basic process in the production of S1S hardboard or S2S hardboard is similar for all wet process plants.

S1S hardboard is produced with coarse fiber bundles cooked at a relatively low time and pressure, 40 seconds to 5 minutes at pressures of 80 to 180 psi. S2S hardboard, which requires stronger and finer fibers, is produced with cooking times of 1.5 to 14 minutes at pressures of 150 to 200 psi. The longer time and higher pressure cooks release more soluble organics from the raw material (wood), thus affecting the effluent raw waste loading.

The S2S board also requires finer refining and fiber washing to reduce the soluble solids that affect the product in the pressing and finishing operation. These operations result in more raw waste discharge to the effluent; less soluble solids are retained in the finished board. After analyzing the available information and observing the obvious differences between the processes for wet-wet (S1S) and wet-dry (S2S) hardboard, it appeared justifiable to categorize these two products into two subcategories: wet-wet (S1S) and wet-dry (S2S).

Products Produced--The hardboard plant may produce either S1S or S2S board, or both, but the end products at each plant cover a wide range of applications, surface designs, and thickness. The following are some of the end uses of hardboard:

Interior wall panelling
Exterior siding
Store display furniture
Base for tile panels
Concrete forms
Non-conductor material for electrical equipment
Door skins (panels)
TV cabinets and furniture

In conjunction with hardboard, some of the plants produced other products such as insulation board, battery separators, and mineral insulation. Insulation board was produced either on its own forming line or on the same line used for the making of SIS hardboard. The various effluents for each line were comingled upon discharge for treatment with little or no monitoring of flow and/or wastewater characteristics of the separate wastewater streams.

Three plants produce a byproduct by the evaporation of the highly concentrated wastewater which is marketed as an animal feed. Several other mills are investigating this process, which not only yields a salable product but also reduces the raw waste load that would require treatment.

No attempt has been made in this document to justify the subcategorization of those plants that reduce their raw waste flow by capitalizing on the production of byproducts.

Size and Age of Plants--There is a considerable difference in age as well as size of the plants in the hardboard industry. Older plants have been upgraded, modernized, and expanded so that age in terms of manufacturing process is meaningless. Because of this, the differences in wastewater characteristics related to age of the plant are not discernible nor is the prorated raw waste flow due to the plant size. Raw wasteload data presented in Section V supports this conclusion.

Geographical Location--The plants are widely scattered throughout the United States, from the east to west coast and from Minnesota to Mississippi. The geographic location of each plant dictates the species of wood that is used in the plant's process. Although each species generates varying raw waste loads, each plant, with its own process methods, produces a salable product from many types of soft and hard woods.

Plants in cold climates may use frozen chips, necessitating the use of pre-steaming to thaw the chips. This can result in a small increase in raw waste loading. Plants in cold climates are also subject to more pronounced seasonal variations in treatment efficiency of biological treatment systems; however, the effects of cold climate on biological treatment systems can be mitigated by proper design considerations. The geographic location of the plants did not reveal significant differences in the annual raw waste loading.

SECTION V
WASTEWATER CHARACTERISTICS

General

The purpose of this section is to define the wastewater quantity and quality for plants in those subcategories identified in Section IV. Raw waste load (RWL) data are also presented for plants which produce in more than one subcategory, and which have sampling procedures or process flows that produce data extending across more than one subcategory. Raw waste load data are presented for parameters of interest listed in Section VI for each subcategory.

The term "raw waste load," as utilized in this document, is defined as the quantity of a pollutant in wastewater prior to a treatment process. Where treatment processes are designed primarily to recover raw materials from the wastewater stream, raw waste loads are obtained following these processes. Examples are gravity oil-water separators in wood preserving, or fine screens used for fiber recovery in insulation board and hardboard plants. The raw waste load is normally expressed in terms of mass (weight) units per day or per production unit.

For the purpose of cost analysis, representative raw waste characteristics have been defined for each subcategory in order to establish design parameters for model plants.

For the insulation board and hardboard segments, model plants are presented for two size categories based on the range of production encountered in each subcategory. These representative raw waste load values are developed for the purpose of estimating the cost of candidate treatment modules only, and should not be construed to be exemplary.

The data presented in this document are based on the most current, representative information available from each plant contacted. Verification sampling data are used to supplement historical data obtained from the plants for the traditional pollutants, and in most cases is the sole source of quantitative information for priority pollutant raw waste loads.

Wood Preserving

General Characteristics

Wastewater characteristics vary with the particular preservative used, the volume of stock that is conditioned prior to treatment, the conditioning method used, and the extent to which effluents from the retorts are diluted with water from other sources.

Typically, wastewaters from creosote and pentachlorophenol treatments may have high phenolic, COD, and oil contents and may have a turbid

appearance that results from emulsified oils. They are always acid in reaction, the pH values usually falling within the range of 4.1 to 6.0. The high COD contents of such wastes are caused by entrained oils from wood extractives, principally simple sugars, that are removed from wood during steam conditioning. These wastewaters may also contain traces of copper, chromium, arsenic, zinc, and boron at plants that use the same retort for both water-borne salts and oil-type preservatives, or that apply dual treatments to the same stock; i.e., treat with two preservatives, one of which is a salt formulation. Trace organic priority pollutants of significance in the Organic Preservatives Subcategory are principally volatile organic solvents such as benzene and toluene, and polynuclear aromatic components of creosote which are contained in the entrained oils. Specific phenolic compounds identified in the wastewater included phenol, the chloro-phenols, and the nitro-phenols.

Many plants use the same preservative, follow the same basic treating practices, and, therefore, generate qualitatively similar wastewaters. Quantitatively, however, wastewaters differ widely from plant to plant, and even from month to month at the same plant. Plant-to-plant variations are illustrated in Table V-1, which gives the range of selected parameters for wastewater collected at nine plants in 1975, during the pretreatment study, and at six plants in 1977, during the verification sampling program. These data are for samples collected from equalization tanks or basins after gravity oil separation with existing equipment. In many cases, only partial oil removal was being achieved.

Among the several factors influencing both the concentration of pollutants and volume of effluent, total conditioning time, whether by steaming or Boultonizing, is the most important. Water from conditioning accounts for most of the loading of pollutants in a plant's effluent, and is usually also the most important from the standpoint of volume. With regard to volume, rainwater that falls on or in the immediate vicinity of the retorts and storage tank farms--an area of about 0.4 hectares (1 acre) for the average plant--is also important. Contaminated rainwater presents a treatment and disposal problem at most plants, but can be especially troublesome for plants in areas of high rainfall. For example, a plant located in an area that receives 152 cm of rain annually must be equipped to process an additional 5.3 million liters of contaminated water.

Wastewaters resulting from treatments with inorganic salt formulations are low in organic content, but contain traces of heavy metals used in the preservatives and fire retardants employed. Average analytical data based on weekly sampling of the effluent for a year from a plant treating with both salt-type preservatives and a fire retardant are given in Table V-2. The presence and concentration of a specific ion in wastewater from such treatments depend on the particular formulation employed and the extent to which the waste is diluted by washwater and stormwater.

Table V-1a. Range of Pollution Parameters for Wastewaters from Nine Plants following Gravity Oil Separation. 1975 Data Based on Two or More Grab Samples.

Parameter	Concentration Range (mg/liter)	
	Creosote	Pentachlorophenol
Chemical Oxygen Demand	1,865-15,695	7,180-16,760
Total Phenols	52-733	---
Pentachlorophenol	---	53-156
Oil and Grease	100-730	145-3,850
Total Solids	320-7,985	5,700-9,410
Dissolved Solids	230-7,504	570-5,572
Suspended Solids	85-904	264-4,320

Table V-1b. Range of Pollution Parameters from Six Plants Following Gravity Oil Separation. 1977 Verification Data Based on the Average of Three 24-Hour Composite Samples.

Parameter	Concentration Range (mg/liter)		
	Creosote	Pentachlorophenol	Combined*
Chemical Oxygen Demand	3,690-8,960	1,840-18,700	3,010-3,710
Total Phenols	60.0-1,530	1.87-328	57.6-415
Pentachlorophenol	5.85-12.4	39.5-142	22.3-158
Oil and Grease	46.0-1,910	13.0-1,610	474-927
Total Suspended Solids	5.00-157	8.00-609	139-163
Total Dissolved Solids	28.0-959	111-5,490	449-1,140

* Combined wastewaters occur after mixing wastewater streams from creosote and PCP oil-water separators.

Table V-2. Range of Pollutant Concentrations in Wastewater from a Plant Treating with CCA- and FCAP-Type Preservatives and a Fire Retardant

Parameter	Concentration Range (mg/liter)
COD	10-50
As	13-50
Phenols	0.005-0.16
Cu	.05-1.1
Cr^{+6}	0.23-1.5
Cr^{+3}	0-0.8
F	4-20
PO_4	15-150
NH_3-N	80-200
pH	5.0-6.8

Source of Data: Pretreatment Document

Overall, there has been considerable improvement in the industry in recent years with regard to both volume and quality of raw wastewater. Volume reductions have been achieved primarily through the use of closed steaming and control of non-contact water. Improvements in quality, particularly for oil and grease and COD content, have mainly resulted from improvements in oil-water separating equipment and prevention of emulsion formation by installation of positive-displacement pumps.

Wastewater and Plant Characteristics

Characteristics of wood preserving plants which were visited during the pretreatment study and during the present study, or plants which provided historical data for raw waste streams in response to the data collection portfolio, are presented in Table V-3, which also shows discharge volume, preservatives used, conditioning process, and daily production. Specific raw wastewater characteristics after gravity oil separation are given in Table V-4. The amount of emulsified oils in the raw wastewater cause characteristics to vary from plant to plant. Characteristics are further effected by the efficiency of gravity oil-water separation and the amount and quality of rainwater runoff or other non-process wastewaters which may dilute the raw wastewater.

Seven of the nineteen plants sampled treat with inorganic as well as organic preservatives. Although the inorganic treating operations are for the most part self-contained and produce little or no wastewater, the process wastewater from the organic treating operations contains significant amounts of heavy metals. This "fugitive metal" phenomena is due to cross contamination between the inorganic and organic treating operations. Personnel, vehicles, and soil which come in contact with heavy metals from the inorganic treating operations can transport the metals into the organic treating area where rainfall washes them into collection sumps. One plant visited (Plant 154) rinses material treated with inorganic preservatives with a fresh-water spray and the resulting contaminated wastewater flows into the collection sump of the organic preservative retorts. Two organic preservative plants (194 and 150) had concentrations of metals in their pre-treated wastewater discharged to a POTW, although no inorganic treatments were employed at the plant. Concentrations of copper, chromium, arsenic, and zinc found at the plant outfall of these nine plants are presented in Table V-5.

These tabular values have been corrected for background concentrations levels of the four metals. Plant 154, which treats with chromated zinc chloride (CZC), exhibits the highest concentrations of chromium and zinc.

Raw Waste Loadings

Waste load calculations for COD, total phenols, pentachlorophenol, and oil and grease following gravity oil-water separation are shown in Table V-6 for each of 19 plants sampled during the pretreatment study and the

Table V-3. Characteristics of 19 Wood-Preserving Plants from which Wastewater Samples were Collected during 1975 Pretreatment Study and during Verification Sampling Program of the Present Study.

Plant No.	Conditioning Process	Preservatives[1]	Treatment or Pretreatment[2]	Discharge Volume (liters/day)	Daily Production (m^3/day)
162	Steaming	C,P	Floc, Oxidation pond, Lagoon, Sand filtration for PCP effluent	34,020	348
170	Vapor Drying	C	Floc, Sand filtration, pH adj., Aerated lagoon, Oxidation pond	94,500	198
186	Steaming	C,P	Oxidation pond	94,500	226
112	Steaming	C,P	Oxidation pond, Spray-evap. pond	20,790	85
130	Steaming	P, CCA	pH adj.	<950	55
192	Steaming	C, P	Floc	45,360	156
180	Steaming	C	Floc	18,900	76
132	Steaming	C, P, CCA	pH adj.	7,560	142
142	Steaming	C, P, CCA, FR	Floc	51,975	212
100	Steaming	C, P	Oxidation pond, pH adj.	20,800	85

Table V-3. Characteristics of 19 Wood-Preserving Plants from which Wastewater Samples were Collected during 1975 Pretreatment Study and during Verification Sampling Program of the Present Study (continued)

Plant No.	Conditioning Process	Preservatives[1]	Treatment or Pretreatment[2]	Discharge Volume (liters/day)	Daily Production (m^3/day)
198	Steaming	C, CCA	Floc, pH adj., Chlor.	6,425	96
164	Steaming	C, P, CCA	pH adj., Floc., Chlor., Sand filtration	11,350	110
114-a	Boulton	C, P, ACA, FR	Secondary oil separation, Oil absorbing media	26,400	283
114-b	Boulton	C, P, ACA, FR	Secondary oil separation, Oil adsorbing media	39,800	329
154	Boulton	C, P, CZC, FR	Floc	18,900	142
194-a	Steaming	C, P	Floc	22,680	187
194-b	Steaming	C, P	Floc	45,400	204
134	Boulton	PCP	Evaporation Tower	173,000	62
156	Steaming	C, P	Activated sludge, Oxidation ponds, Spray irrigation	35,400	335

Table V-3. Characteristics of 19 Wood-Preserving Plants from which Wastewater Samples were Collected during 1975 Pretreatment Study and during Verification Sampling Program of the Present Study (continued)

Plant No.	Conditioning Process	Preservatives[1]	Treatment or Pretreatment[2]	Discharge Volume (liters/day)	Daily Production (m^3/day)
168	Steaming	C, P	Aerated lagoon, Oxidation pond, Spray evaporation	53,000*	269*
150	Steaming	C, P	Secondary oil separation, Oxidation pond, Spray irrigation, Aerated Racetrack	251,000	463

1--Creosote (C), pentachlorophenol-petroleum (P), salt-type preservatives (CCA-ACA-CZC), fire retardants (FR)
2--All plants process wastewater through gravity-type separators.
*--Information obtained from historical data suplied by plant.
a--Data collected during 1975 Pretreatment Study.
b--Data collected during 1977 Verification Sampling Program.

Table V-4. Wastewater Characteristics after Gravity Oil Separation for 19 Wood Preserving Plants.

Plant	Concentration (mg/l) Total Phenols	PCP	O&G	COD	Discharge Volume (liters/day)	Daily Production (m /day)
130					<950	55
192	510.9	860*	24,450*	147,555*	45,360	156
170	383.3		35	1,355	94,500	198
164	10.8	306.0	1,755	10,460	11,340	110
194-a	69.2	34.5	720	6,375	22,680	187
180	501.3		735	15,695	18,900	76
132	302.4	49.0	980	3,595	7,560	142
142	101.3	26.7	1,785	15,275	51,975	212
150	34.3	57.1	951	8,844	237,000	463
100	32.3	17.9	535	3,080	20,800	85
114-b	1272		39.4	5,797	57,900	329
168	45.0	158	927	3,706		
198	334.4		35	2,460	6,425	96
134			1,357	7,316	167,000	62.3
194-b	40.0	6.3	1,903	8,979	28,800	204
162	335.3	47.8	1,365	8,880	34,020	348
154	184.0	5.70	35	1,710	18,900	142
186	62.1	24.3	520	7,080	94,500	226
114-a	508.6	0.09	10	3,705	26,400	283
112	292.9	50.3	605	7,115	20,790	85
156	238	22.3	474	3,010	35,400	335

* These values were not included in the average waste loadings listed in Table V- 7.

Data presented were collected during the 1975 Pretreatment Study and the Verification Sampling Program of the present study.

Table V-5. Concentrations of Metals in Process Water at Plant Outfall for Nine Wood Preserving Plants: Salts .

	(mg/l)			
Plant No.	Cu	Total Cr	As	Zn
130	3.91	1.23	1.00	---
132	0.70	0.44	0.05	---
142	0.15	0.0	0.01	0
198	1.68	0.46	0.71	---
164	0.47	0.02	0.03	---
114-a	0.43	0.00	0.00	0.78
114-b	0.13*	---	---	1.68*
154	0.00	6.53	---	40.9
194-a	0.0350*	---	---	0.395*
150	---	0.09*	---	0.00
Background	0.10	0.07	0.02	0.22

Note: Table values have been corrected for background levels.

*--Background levels not available for these plants. The 1975 Pretreatment study background levels were used to correct these values.
--Two non-salt preservative plants are included due to significant amounts of metals present, these are plants 194-a and 150.

Data presented in the above table were obtained from the following sources:
7 plants - Pretreatment Study
3 plants - current Verification Sampling and Analysis Program
1 plant - sampled during both studies

Table V-6. Raw Waste Loadings After Gravity Oil Separation for 19 Wood Preserving Plants.

Plant	Total Phenols		PCP		O&G		COD	
	kg/day (lb/day)	kg/1000m^3 (lb/1000ft^3)	kg/day (lb/day)	kg/1000m^3 (lb/1000ft^3)	kg/day (lb/day)	kg/1000m^3 (lb/1000ft^3)	kg/day (lb/day)	kg/1000m^3 (lb/1000ft^3)
112	6.09 (13.4)	71.6 (4.47)	1.05 (2.32)	12.3 (0.768)	12.6 (27.8)	148 (9.24)	148 (326)	1740 (109)
114-a	13.4 (29.5)	47.4 (2.96)	0.00238 (0.00525)	0.000525 (0.00840)	0.264 (0.582)	0.933 (0.0583)	97.8 (216)	346 (21.6)
192	23.2 (51.2)	149 (9.31)						
168								
100	0.672 (1.48)	7.90 (0.493)	0.372 (0.820)	4.38 (0.274)	11.1 (24.5)	131 (8.18)	64.1 (141)	754 (47.1)
180	9.47 (20.9)	125 (7.81)			13.9 (30.6)	183 (11.4)	297 (655)	3903 (244)
132	2.29 (5.05)	16.1 (1.01)	0.370 (0.816)	2.61 (0.163)	7.41 (16.3)	52.2 (3.26)	27.2 (60.0)	191 (11.9)
150	8.13 (17.9)	17.6 (1.10)	13.5 (29.8)	29.2 (1.82)	225 (496)	487 (30.4)	2096 (4622)	4527 (283)
142	5.27 (11.6)	24.8 (1.55)	1.39 (3.06)	6.55 (0.409)	92.8 (204.6)	438 (27.4)	794 (1751)	3745 (234)
134					227 (500.5)	3638 (227)	1222 (2695)	19611 (1225)
164	0.122 (0.269)	1.11 (0.0693)	3.47 (7.65)	31.5 (1.97)	19.9 (43.9)	181 (11.3)	119 (262)	1078 (67.3)
162	11.4 (25.1)	32.8 (2.05)	1.63 (3.59)	4.67 (0.292)	46.4 (102.3)	133 (8.31)	302 (666)	868 (54.2)
154	3.48 (7.67)	24.5 (1.53)	0.108 (0.238)	0.759 (0.0474)	0.662 (1.46)	4.66 (0.291)	32.3 (71.2)	228 (14.2)
194a	1.57 (3.46)	8.39 (0.524)	0.782 (1.72)	4.18 (0.261)	16.3 (35.9)	87.3 (5.45)	45 (320)	773 (48.3)

Table V-6. Raw Waste Loadings After Gravity Oil Separation for 19 Wood Preserving Plants (continued).

Plant	Total Phenols		PCP		O&G		COD	
	kg/day (lb/day)	kg/1000m^3 (lb/1000ft^3)	kg/day (lb/day)	kg/1000m^3 (lb/1000ft^3)	kg/day (lb/day)	kg/1000m^3 (lb/1000ft^3)	kg/day (lb/day)	kg/1000m^3 (lb/1000ft^3)
130								
114-b	73.6 (162)	224 (14.0)			2.28 (5.03)	6.93 (0.433)	336 (741)	1020 (63.7)
198	2.15 (4.74)	22.4 (1.40)			0.225 (0.496)	2.34 (0.146)	15.8 (34.8)	165 (10.3)
194-b	1.15 (2.54)	5.65 (0.353)	0.181 (0.399)	0.889 (0.0555)	54.8 (120.8)	269 (16.8)	259 (571)	1268 (79.2)
156	8.43 (18.6)	25.1 (1.57)	0.789 (1.74)	2.36 (0.147)	16.8 (37.0)	50.1 (3.13)	107 (236)	318 (19.9)
170	36.2 (79.8)	183 (11.4)			3.31 (7.30)	16.7 (1.04)	128 (282)	647 (40.4)
186	5.87 (12.9)	26.0 (1.62)	2.30 (5.07)	10.2 (0.637)	49.1 (108.3)	217 (13.6)	669 (1475)	2960 (185)

Data presented in this table is an average of data from 15 plants compiled during the 1975 Pretreatment Study and from 6 plants compiled during verification sampling of the present study. Two of these plants were sampled during both studies. Information on all parameters was not available at every plant.

present study. Waste loadings, averaged for the plants, are presented in Table V-7. Comparable data for four metals are given in Table V-8. Waste loadings for each pollutant are expressed in units of total daily weight (kg/day, lb/day) and weight per unit volume of treated wood produced based on daily production.

The 13 priority pollutant polynuclear aromatics (PNA's) are listed in Table V-9 along with the number which is used to designate each PNA in later tables.

PNA's are constitutents of creosote and coal tar, and as such are common pollutants in oily wood preserving wastes. Table V-10 presents the concentration of PNA's found in the raw waste samples following gravity oil separation of five wood preserving plants. Data shown are the average concentrations of three 24-hour composite samples collected during the verification sampling program. Corresponding raw waste loads for PNA's, shown in Table V-11, are for the combined effluents from the creosote and PCP separators for plants which have two gravity separation systems.

Design Basis for Model Plant

For the purposes of sizing treatment facilities, computing pollution loadings, and estimating capital and operating costs, a plant having the following characteristics was used as a model:

Work days/year: 300
Preservatives used: Creosote and pentachlorophenol
Daily process water volume: 30,240 liters (8,000 gallons)
Other process-related water (1): 17,010 liters (4,500 gallons)
Average daily discharge: 47,250 liters (12,500 gallons)
Pollutant concentrations (mg/liter):

COD	6,500
Total phenols	135
Pentachlorophenol	25
Oil and grease	895

Daily production: 170 cubic meters (6,000 cubic feet)

These characteristics are based on average values for plants visited and sampled during the original study, during the 1974 Pretreatment Study, and during the present study. All available historical data were also considered in selection of the model plant characteristics. It is virtually impossible to develop a single model plant that is totally representative of an industry composed of 400 plants, none of which is exactly like the others. However, with the exception of plants treating with salt-type preservatives and fire retardants, there is no basis for subcategorization based on effluent parameters, flow rate, differences in processing technology, plant characteristics, or preservatives employed.

Model plant wastewater characteristics for plants which use solely inorganic preservatives are not presented in this document due to the well demonstrated technology available for complete recycling of effluents

Table V-7. Average Waste Loadings for 19 Plants: Creosote and Pentachlorophenol.

Units	Total Phenols	PCP	O&G	COD
		Oil-Water Separator		
kg/1000 m^3	56.2	8.43	336	2452
lb/1000 ft^3	3.51	0.527	21.0	153
kg/day	11.8	2.00	44.4	381
lb/day	26.0	4.41	97.9	840
		Plant Outfall		
kg/1000 m^3	25.5	2.04	34.9	615
lb/1000 ft^3	1.59	0.127	2.18	38.4
kg/day	4.57	0.376	8.46	111
lb/day	10.1	0.829	18.7	245
		Percent Reduction		
kg/1000 m^3	55	76	90	75
kg/day	61	81	81	71

Note: Data presented in this table is an average of data from 15 plants compiled during the 1975 Pretreatment Study and from 6 plants compiled during verification sampling of the present study. Two of these plants were sampled during both studies. Information on all parameters was not available at every plant.

Table V-8. Average Waste Loadings of Process Water at Plant Outfall for Nine Wood Preserving Plants: Salts[1].

Units	Cu	Total Cr	As	Zn
kg/1000 m^3	0.0457	0.166	0.0146	1.45
lb/1000 ft^3	0.00285	0.0104	0.000912	0.0906
kg/day	0.00639	0.0256	0.00135	0.220
lb/day	0.0141	0.0564	0.00298	0.485

[1]--Two non-salt preservative plants were included due to significant amounts of metals present.

Data presented in this table is an average of data from seven plants sampled during the 1975 Pretreatment Study and four plants sampled during the Verification Sampling Program of the present study. Two of these plants were sampled during both studies.

Table V-9. List of Poly Nuclear Aromatics.

1.	Acenapthene
2.	Fluroanthene
3.	Naphthalene
4.	1,2-Benzanthracene
5.	Benzo(a)pyrene (3,4-Benzopyrene)
6.	3,4-Benzofluoranthrene
7.	11,12-Benzofluoranthene
8.	Chrysene
9.	Acenaphthylene
10.	Anthracene
11.	Fluorene
12.	Phenanthrene
13.	Pyrene

Table V-10 . Raw Waste Concentrations of Poly Nuclear Aromatics Obtained at the Outfall of the Gravity Oil-Water Separator.

Plant Code	Type Separator from which Sample was Obtained	Concentrations of Poly Nuclear Aromatics* (mg/l)													Total PNA's
		1	2	3	4	5	6	7	8	9	10	11	12	13	
156	Creosote	1.4	0.87	0.97	0.15	---	---	0.02	0.24	0.93	1.9	1.0	1.9	0.64	10
168	Creosote	1.1	0.63	2.2	0.07	0.01	30	0.03	0.077	0.82	2.5	0.82	2.5	0.36	11
	Combined**	0.68	0.50	1.3	0.03	<0.01	<0.01	<0.01	0.03	<0.01	1.6	0.64	1.6	0.36	6.8
194	Creosote	1.4	1.4	0.32	0.14	---	---	---	0.078	1.1	7.3	2.60	9.3	1.7	25
	PCP	0.59	0.30	0.87	0.023	---	---	---	0.011	0.13	0.98	0.68	0.98	0.19	4.8
150	PCP	0.43	0.40	0.11	0.033	---	---	---	0.033	0.05	1.9	0.77	1.9	0.42	6.0
	Creosote	1.5	0.76	0.65	0.13	---	---	---	0.14	1.1	3.5	1.20	3.5	0.54	13
114	Creosote	3.4	0.34	3.7	0.042	---	---	---	0.025	2.5	1.8	1.0	1.8	0.23	15
	PCP	<0.01	<0.01	0.60	<0.01	---	---	---	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.64

* See Table V-9 for names of Poly Nuclear Aromatics corresponding to numbers 1 through 13.
** Combined sample obtained after effluents from creosote and PCP separator are completely mixed.

Data obtained during verification sampling program.

Table V-11. Raw Waste Loads of PNA's* from the Combined Effluents from Gravity Oil-Water Separators

Plant Code	Raw Waste Load by kg/km^3 (lb/kft^3)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
156	.16 (.0097)	.094 (.0059)	1.4 (.085)	2.24 (.14)	--- ---	--- ---	.29 (.018)	3.4 (.21)	13.0 (.81)	27 (1.7)	14 (.88)	27 (1.7)	8.5 (.53)	140 (8.8)
168**	.086 (.0054)	.062 (.0039)	.16 (.01)	.0038 (.00024)	<.0012 (<.000077)	<.0012 (<.000077)	<.0012 (<000077)	.0038 (.00024)	<.0012 (<.000077)	.21 (.013)	.08 (.005)	.21 (.013)	.038 (.0024)	.85 (.053)
194	.24 (.015)	.24 (.015)	.058 (.0036)	.024 (.0015)	--- ---	--- ---	--- ---	.013 (.00084)	.19 (.012)	1.3 (.079)	.45 (.028)	1.6 (0.1)	.30 (.019)	4.5 (.28)
150	.58 (.036)	.32 (.02)	.24 (.015)	.05 (.0031)	--- ---	--- ---	--- ---	.053 (.0033)	.37 (.023)	1.5 (.092)	.53 (.033)	1.5 (.092)	2.4 (.15)	5.4 (.34)
114	.59 (.037)	.59 (.037)	.66 (.041)	.0077 (.00048)	--- ---	--- ---	--- ---	.005 (.00031)	.45 (.028)	.30 (.019)	.18 (.011)	.30 (.019)	.034 (.0021)	2.72 (.17)

* See Table V-9 for names of poly nuclear aromatics corresponding to numbers 1 through 13.
** Combined sample obtained after effluents from creosote and PCP separator are completely mixed.

Data obtained during verification sampling program.

from these plants. The cost of recycling technology presented in Section VIII, is independent of wastewater strength.

Raw waste loadings of fugitive salts are presented in Table V-8 for plants which treat with both organic and inorganic preservatives. These values are used in Section VIII to estimate the cost of the technology for metal reduction.

Insulation Board

Insulation board plants responding to the data collection portfolio reported fresh water usage rates ranging from 95 to 5,700 thousand liters per day for process water (0.025 to 1.5 MGD). One insulation board plant, 543, which also produces hardboard in approximately equal amounts uses over 4 million liters per day (11 MGD) of fresh water for process water.

Water becomes contaminated during the production of insulation board primarily through contact with the wood during fiber preparation and forming operations, and the vast majority of pollutants are fine wood fibers and soluble wood sugars and extractives.

The process whitewater used to process and transport the wood from the fiber preparation stage through mat formation accounts for over 95 percent of a plant's total wastewater discharge (excluding cooling water). The water produced by the dewatering of stock at any stage of the process is usually recycled to be used as stock dilution water. However, due to the build-up of suspended solids and dissolved organic material which can cause undesirable effects in the board, there may be a need to bleed-off a quantity of excess process whitewater. Various additives used to improve the characteristics of the board also enter the process whitewater and contribute to the waste load.

More specifically, potential sources of wastewater in an insulation board plant include:

- Chip wash water
- Process whitewater generated during fiber preparation (refining and washing)
- Process whitewater generated during forming
- Wastewater generated during miscellaneous operations (dryer washing, finishing, housekeeping, etc.)

Chip Wash Water

Chips are washed in order to remove materials such as grit, dirt, sand, and metal which can cause excessive wear and possible destruction of the refining equipment. Chip washing also provides an opportunity to increase the moisture content of moisture deficient furnish such as plywood or furniture trim. In northern climates, chip washing assists the thaw of frozen chips.

Water used for chip washing is capable of being recycled to a large extent. A minimal makeup of approximately 400 liters per metric ton (95 gallons per ton) is required in a closed system because of water leaving with the chips and with sludge removed from settling tanks. Water used for makeup in the chip washer may be fresh water, cooling water, vacuum seal water from inplant equipment, or recycled process water. Chip wash water, when not fully recycled, contributes to the raw waste load of an insulation board plant. Insulation board plants 543, 491, 75, 763, 67, and 85 indicated in the response to the data collection portfolio that chip washing is done. Plants 763 and 85 fully recycle chip wash water.

Fiber Preparation

The fiber preparation or refiner whitewater system is considered to be the water used in the refining of stock up to and including the dewatering of stock by a decker or washer. As previously discussed, there are three major types of fiber preparation in the insulation board industry: (1) stone groundwood; (2) mechanical disc refining (refiner groundwood); groundwood); and (3) thermo-mechanical disc refining. The water volume required by each of the three methods is essentially the same. In the general case, the wood enters the refining machine at approximately 50 percent moisture content. During the refining operation, the fiber bundles are diluted with either fresh water or recycled whitewater to a consistency of approximately 1 percent solids prior to dewatering to about 15 percent solids at the decker or washer. The water which results from the stock washing or deckering operation is rich in organic solids dissolved from the wood during refining and is referred to as refiner whitewater. This water may be combined with whitewater produced during forming, the machine whitewater (for further use in the system), or it may be discharged from the plant as wastewater.

Forming

After the dewatered stock leaves the decker at approximately 15 percent consistency, it must again be diluted to a consistency of approximately 1.5 percent to be suitable for machine forming. This requires a relatively large quantity of recycled process whitewater or fresh water. The redilution of stock is usually accomplished in a series of steps to allow consistency controls and more efficient dispersion of additives, and to reduce the required stock pump and storage capacities. The stock usually receives an initial dilution down to approximately 5 percent consistency, then to 3 percent, and finally, just prior to mat formation, to approximately 1.5 percent.

During the mat formation stage of the insulation board process, the diluted stock is dewatered at the forming machine to a consistency of approximately 40 to 45 percent. The water drained from the stock during formation is referred to as machine whitewater. Water from the machine whitewater system may be recycled for use as stock dilution water or for

use in the refining operations. Excess machine whitewater may be discharged as wastewater.

Miscellaneous Operations

While the majority of wastewater generated during insulation board production occurs during fiber preparation and mat formation operations, various other operations may contribute to the overall raw waste load.

Drying--The boards leaving the forming machine with a consistency of approximately 40 percent are dried to a consistency of greater than 97 percent in the dryers. Although this water is evaporated to the atmosphere, it is occasionally necessary to clean the dryers to reduce fire danger and to maintain proper energy utilization. This produces a minor wastewater stream in most operations.

Finishing--After the board leaves the dryer, it is usually sanded and trimmed to size. The dust from the sanding and trim saws is often controlled by dust collectors of a wet scrubber type and the water supplied to the scrubbers is sometimes excess process water; however, fresh water is occasionally used. This water is usually returned to the process with the dust.

Plants that produce coated products such as ceiling tile usually paint the board after it is sanded and trimmed. Paint composition will vary with both plant and product; however, most plants utilize a water-based paint. The resulting washup contributes to the wastewater stream or is metered to the process whitewater system. In addition, there are sometimes imperfect batches of paint mixed which are discharged to the wastewater stream or metered to the process whitewater system.

Broke System--Reject boards and trim are reclaimed as fiber and recycled by placing the waste board and trim into a hydropulper and producing a reusable fiber slurry. While there is need for a large quantity of water in the hydropulping operation, it is normally recycled process water. There is normally no water discharged from this operation.

Other Sources--Other potential sources of wastewater in an insulation board plant include water used for screen washing, fire control, and general housekeeping. The water used for washing screens in the forming and decker areas usually enters the process whitewater system. Housekeeping water varies widely from plant to plant depending on plant operation and many other factors. While wastewater can result from water used to extinguish dryer fires, it is an infrequent and intermittent source of wastewater.

Wastewater Characteristics

The major portion of insulation board wastewater pollutants results from leachable materials from the wood and materials added during the

production process. The materials leached from the wood will normally enter into solution in the process whitewater system. If a chip washer is used, a portion of the solubles are dissolved. A small fraction of the raw waste load results from cleanup and finishing operations; however, these operations appear to have little influence on the overall raw waste load. The finishing wastewater in some plants is metered back into the process water with no reported adverse effects.

The process whitewater, accounting for over 95 percent of the waste load and flow from a typical insulation board plant, is characterized by high quantities of BOD (900 to 7,500 mg/l) and suspended solids (500 to 4,000 mg/l) (Gran, 1972).

The four major factors which affect process wastewater quality are: (1) the extent of steam pretreatment; (2) the types of products produced and additives employed; (3) raw material species; and (4) the extent of whole tree chips, forest residue, and bark in the raw material.

The major source of dissolved organic material originates from the wood raw material. From 1 to 8 percent (on a dry weight basis) of wood is composed of water-soluble sugars stored as residual sap and, regardless of the type of refining or pretreatment utilized, these sugars form a a major source of BOD and COD. Steam conditioning of the furnish during thermo-mechanical refining greatly increases the amount of wood sugars and hemicellulose decomposition products entering the process whitewater. The use of steam under pressure during thermo-mechanical refining is the predominant factor in the increased raw waste loads of plants which utilize this refining method.

Basically, two phenomena occur during steaming (Back and Larsson, 1972). The first of these is the physically reversible thermal softening of the hemicellulose.

The second effect consists of time dependent chemical reactions in which hemicellulose undergoes hydrolysis and produces oligosaccharides (short-chained, water soluble wood sugars, including disaccharides). In addition, hydrolysis of the acetyl groups forms acetic acid. The resulting lowered pH causes an increase in the rate of hydrolysis. Thus, the reactions can be said to be autocatalytic. For this reason, the reaction rates are difficult to calculate. Rough estimatations have been made by Back and Larsson, 1972, that indicate the reaction rates double with an increase in temperature of 8 to 10°C.

Figure V-1 demonstrates the increased BOD loading which results from increasingly severe cooking conditions.

The amount of BOD increase due to cooking conditions varies with wood species (Dallons, 1976). Hardwoods contain a greater percentage of potentially soluble material than do softwoods. The effect of species

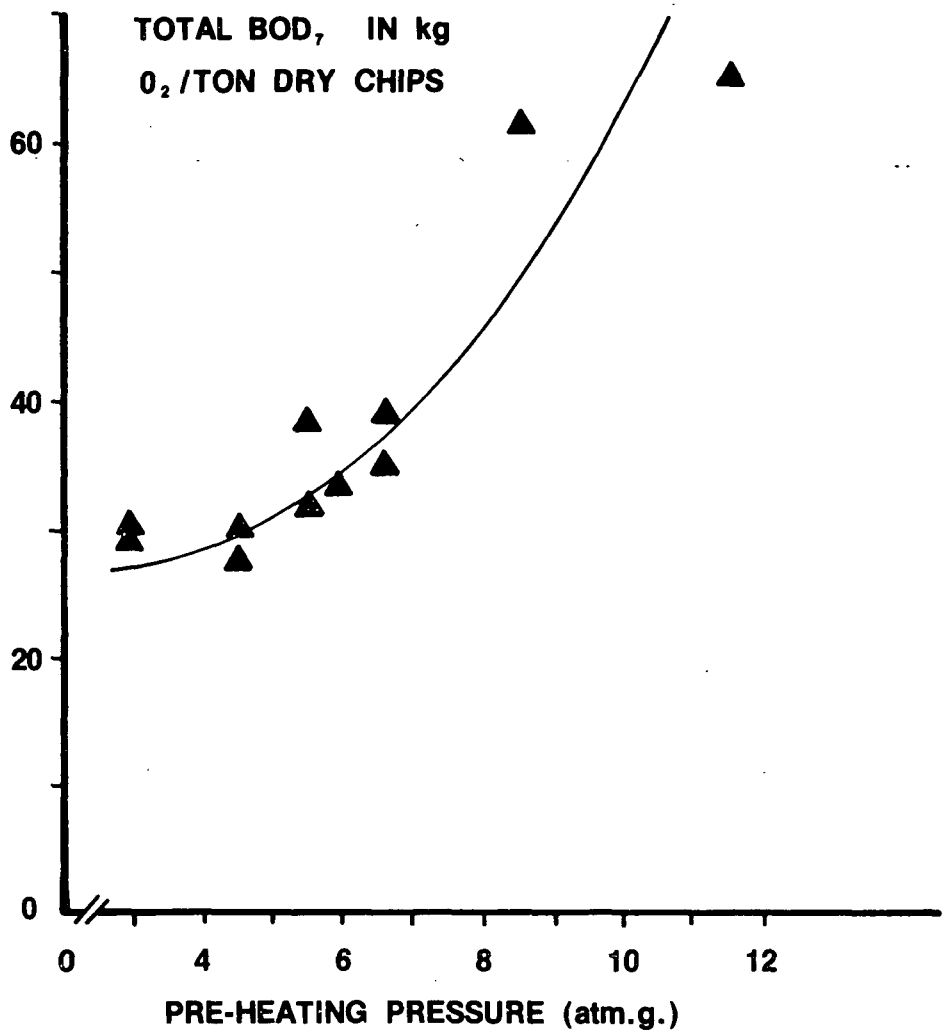


Figure V-1. Variation of BOD with pre-heating pressure

variations on raw waste load is less important than the degree of steaming to which the furnish is subjected.

Two insulation board plants, 543 and 85, presented limited information concerning the effects of whole tree chips, forest residue, and bark in wood furnish on raw waste load. While the use of whole tree chips, residue, and bark results in some increase in raw waste loadings, information currently available is not sufficient to quantify the effects for the industry as a whole.

While a large portion of the BOD in the process wastewater is a result of organics leaching from the wood, a significant (although lesser) portion results from additives. Additives vary in both type and quantity according to the type of product being produced.

The three basic types of product produced by insulation board plants, sheathing, finished tile (ceiling tile, etc.), and hardboard (including medium density siding), receive various amounts of additives. Sheathing contains up to 25 percent additives which include asphalt, alum, starch, and size (either wax or rosin). Finished tile contains up to 10 percent additives which are the same as used in sheathing, with the exception of asphalt. Hardboard contains up to 11 percent additives including organic resins, as well as emulsions and tempering agents such as tall oil. Therefore, the process wastewater will contain not only leachates from the wood and fugitive fiber, but also the portion of the additives not retained in the product.

Maximum retention of these additives is advantageous from both a production cost as well as a wastewater standpoint. Several retention aids are marketed for use in board products to increase the retention of fiber and additives in the mat, the most common of which are polymeric polyelectrolytes.

The primary effect of product type occurs with the production of hardboard in an insulation board plant. Hardboard requires fiber bundles of a higher quality than does insulation board and thus more fiber preparation is usually necessary. For these reasons, the hardboard producing plants will have a greater raw wastewater load than plants which do not produce hardboard.

Table V-12 summarizes the raw wastewater characteristics of those insulation board plants which provided raw waste monitoring data in response to the data collection portfolio. The raw waste loads of the two plants which employ thermo-mechanical pulping methods or which also produce hardboard products are significantly higher than the raw waste loads of the plants which only employ mechanical pulping and refining and which produce no hardboard products.

Table V-12. Insulation Board Raw Waste Characteristics (Annual Averages).

Plant Number	Production		Flow		BOD		TSS	
	kkg/day	(TPD)	kl/kkg	(kgal)/(ton)	kg/kkg	(lbs)/(ton)	kg/kkg	(lbs)/(ton)
Mechanical Pulping and Refining Insulation Board								
917*	201	(220)	2.96	(0.72)	4.33	(8.67)	0.71	(1.42)
					5.70	(11.4)	3.34	(6.67)
993	106	(117)	21.6	(5.21)	5.95	(11.9)	4.67	(9.33)
491**	139	(153)	1.88	(0.45)	2.39	(4.78)	1.55	(3.11)
97	471	(517)	10.5	(2.53)	21.6	(43.2)	47.1	(94.1)
55	246	(270)	1.02	(0.24)	1.27	(2.54)	0.46	(0.923)
Thermo-mechanical Pulping and Refining and/or Hardboard Production at Same Facility								
31	193	(212)	8.11	(1.95)	33.6	(67.1)	17.3	(34.5)
543	605	(665)***	74.0	(17.8)	29.8	(59.5)	28.6	(57.1)
85	359	(395)***	11.1	(2.68)	43.2	(86.3)	---	---
19	225	(248)	-0-		---	---	---	---
69	---	---	-0-		---	---	---	---

* First row of data represents data from primary floc clarifier clearwell. Second row of data represents data obtained during verification sampling for influent to primary floc clarifier clearwell.
** Data represent data obtained during verification sampling.
*** Includes both insulation and hardboard production.

Raw Waste Loads

Table V-12 summarizes the raw wastewater characteristics of those insulation board plants which provided historical raw waste monitoring data in response to the data collection portfolio. Seven of the sixteen insulation board plants provided raw waste historical daorical data for the 12-period from January through December, 1976.

Of the six plants which use mechanical pulping and refining only, and which produce no hardboard, four of the plants (917, 993, 97, and 55) provided sufficient historical raw waste data for analysis. Data from these plants were for raw waste prior to primary treatment, with the exception of Plant 917 which provided information for wastewater following polymer-assisted primary clarification (floc-clarification). Verification sampling was performed at Plant 917 and samples were collected before and after the primary floc-clarifier. Analysis of verification data showed that a BOD reduction of 24 percent and a TSS reduction of 79 percent were being achieved in the primary floc-clarifier. These percentages were used to adjust the raw waste loads to account for the pollutant reduction being achieved in the floc-clarifier. Raw waste loads for Plant 917 are presented in Table V-12 before and after the adjustment.

Plant 917 uses primarily Southern Pine for furnish with some mixed hardwoods. Plant 491 uses primarily Douglas Fir with other mixed softwoods. Plant 993 employs stone grinders to refine a pine furnish. Plant 97 uses a mixture of Southern Pine and mixed hardwoods. Plant 55 uses a furnish of Southern Pine with some mixed hardwood.

Plant 97 demonstrated raw waste loads for BOD and TSS significantly higher than any other plant in the mechanical pulping and refining subcategory, although raw materials, production process, and products produced at Plant 97 are similar to other plants in the subcategory. One factor which may account for the higher raw waste loads from Plant 97 is that the plant recycles all of its primary sludge and waste activated sludge back into the process for fiber recovery and reuse. The build-up in the process whitewater system of waste biological solids which are not retained in the board is the most probable reason for the increased raw waste load. This would also account for the fact that the suspended solids raw waste load from Plant 97 shows a more pronounced increase over other plants in the subcategory than does the BOD raw waste load.

Plant 45 does not monitor the raw wastewater from its wood fiber insulation board plant. Effluent from this plant, following primary treatment, is used as process whitewater in the plant's mineral wool insulation board facility. Although the plant provided historical data for raw wastewater effluent from the mineral wool facility, these data could not be used to characterize raw wastewater from the wood fiber plant; and thus, Plant 45 was not included in Table V-12.

Plant 491 does not monitor raw wastewater quality and provided no historical raw wastewater quality data. Verification sampling was performed at

this plant and raw wastewater data were obtained. Verification data were used to calculate the raw waste load using historical average daily production and average daily flow data provided by the plant in response to the data collection portfolio.

The annual average daily raw waste loads for the five insulation board, mechanical pulping plants for which data are presented in Table V-12 are 7.4 kg/Kkg (14.8 lb/ton) for BOD and 11.4 kg/Kkg (22.8 lb/ton) for TSS.

Of the ten plants which produce insulation board using thermo-mechanical pulping and/or which produce hardboard at the same facility, only three plants (31, 543, and 85) provided sufficient historical data for calculation of raw waste loads. Of these plants, Plant 31 is the only one which produces just insulation board. This plant steam conditions all of its furnish, which consists primarily of hardwood chips.

Plant 543 steam conditions approximately 10 percent of its furnish, which consists primarily of aspen with some whole tree chips. This plant produces approximately 70 percent insulation board and 30 percent hardboard.

The raw waste effluents from insulation board and hardboard production of Plants 543 and 85 are combined prior to raw waste monitoring. Therefore, the individual raw waste load due solely to insulation board could not be calculated.

Plant 763 produces approximately 60 percent insulation board and 40 percent hardboard using a pine furnish for hardboard and pine and hardwood mix for insulation board. This plant steam conditions all of its furnish. Since it does not monitor its raw waste effluent, the raw waste load could not be calculated.

Plant 75 produces approximately 60 percent insulation board and 40 percent hardboard using a pine furnish which is totally steam conditioned. Since this plant does not monitor its raw waste effluent, the raw waste load could not be calculated.

Plant 221 steam conditions all of its hardwood furnish. Since this plant does not monitor its raw waste effluent, the raw waste load could not be calculated.

Plant 67 steam conditions all of its mixed hardwood furnish. This plant produces approximately 50 percent insulation board and 50 percent hardboard. Raw waste effluent from the wood fiber plant at this facility is combined with raw waste effluent from a mineral wool facility at the same location prior to monitoring. Therefore, a representative wood fiber raw waste load could not be calculated.

Plant 11 steam conditions all of its hardwood furnish and produces only insulation board. Since this plant does not monitor its raw waste effluent, the raw waste load from this plant could not be calculated.

Plants 19 and 69 have achieved no discharge of process wastewater through complete close-up of process whitewater systems. Both plants steam condition all furnish and produce solely structured insulation board. Plant 19 uses a hardwood furnish, and plant 69 uses Southern Pine chips and shavings.

Raw waste load data for insulation board plants which use thermo-mechanical pulping and/or produce hardboard at the same facility are presented in Table V-12. It is difficult to obtain a meaningful average for this subcategory since plant 31 is the only plant in the subcategory for which historical data is available and which produces solely insulation board. Historical data for Plants 543 and 85 include raw waste contributions from hardboard production which cannot be separated from the raw waste due to insulation board production.

For the above mentioned reasons, and because the production process and raw materials used by Plant 31 are similar to other plants in the subcategory, raw waste loads exhibited by Plant 31 can be considered as representative of the subcategory. This raw waste load is 33.6 kg/Kkg (67.1 lb/ton) for BOD and 17.3 kg/Kkg (34.5 lb/ton) for TSS.

Priority Pollutant Raw Waste Loads

Raw waste concentrations and raw waste loads for total phenols are shown for four insulation board plants in Table V-13. Data presented in this table were obtained during the verification sampling program. Annual average daily production and annual average daily waste flow provided by the plants in the data collection portfolio were used to calculate the raw waste loads. None of the insulation board plants presented historical data on raw wastewater phenol concentrations in their raw wastewater effluents.

The average concentration of total phenols for the three mechanical pulping insulation board plants (97, 917, and 491) is 0.11 mg/l. The corresponding average total phenols raw waste load for these plants is 0.0012 kg/Kkg (0.0024 lb/ton).

The concentration of total phenols for Plant 31, which uses thermo-mechanical pulping, is 0.29 mg/l. The raw waste load corresponding to this concentration is 0.0024 kg/Kkg (0.0048 lb/ton) of total phenols. The higher concentration of total phenols for the insulation board thermo-mechanical pulping and/or hardboard production is probably due to generation of phenolic materials through hydrolysis of lignin and other wood chemicals during refining under steam pressure.

Raw waste concentrations of 13 heavy metals are presented for four insulation board plants in Table V-14. Data presented in this table were obtained during the verification sampling program. Annual average daily production and annual average daily waste flow provided by the plants in the data collection portfolio were used to calculate the raw waste loads.

Table V-13. Raw Waste Concentrations and Loadings for Insulation Board Plants-Total Phenols

Plant	Raw Waste Concentrations[1] mg/l	Raw Waste Loadings[2] kg/kkg	(lbs/ton)
97	0.09	.0001	(.0019)
31	0.29	.0024	(.0048)
917	0.14	.00040	(.00079)
491	0.11	.0023	(.0045)

1 Data obtained during the verification sampling program.
2 Average daily waste flow and production data for 1976 supplied by plants in response to data collection portfolio were used to calculate waste loadings.

Table V-14. Raw Waste Concentrations and Loadings for Insulation Board--Metals.

	Raw Waste Concentrations (mg/l) Plant Number					Raw Waste Loadings (kg/Kkg)/(lb/ton) Plant Number				
	917	31	491	97	Average Value	917	31	491	97	Average Value
Beryllium	.0005	.00083	.0005	.0005	.0006	.0000042 (.0000083)	.000007 (.000014)	.00001 (.00002)	.0000055 (.000011)	.0000067 .0000133
Cadmium	.00083	.001	.0005	.0005	.0007	.0000028 (.0000056)	.000008 (.000016)	.00001 (.00002)	.0000055 (.000011)	.0000065 .0000132
Copper	.450	.280	.20	.340	.320	.0019 (.0037)	.0023 (.0046)	.000041 (.000082)	.0036 (.0072)	.0019 .0039
Lead	.0013	.021	.0013	.0053	.0072	.000006 (.000011)	.00017 (.00034)	.000027 (.000053)	.000055 (.00011)	.000063 .000126
Nickel	.240	.105	.012	.0088	.0920	.0008 (.0016)	.00085 (.0017)	.00025 (.00049)	.00009 (.00018)	.0005 .0010
Zinc	.720	.517	.250	.550	.510	.003 (.0059)	.0042 (.0084)	.005 (.01)	.006 (.012)	.0046 .0091
Antimony	.00083	.003	.00067	.0021	.0016	.0000021 (.0000042)	.000025 (.000049)	.000014 (.00027)	.000022 (.000044)	.000015 .000037
Arsenic	.002	.0033	.003	.0016	.0025	.000013 (.000025)	.000027 (.000054)	.00006 (.00012)	.000017 (.000034)	.000029 .000058
Selenium	.005	.0043	.0047	.0033	.0043	.000014 (.000027)	.000035 (.00007)	.00007 (.000014)	.000035 (.00007)	.000038 .000076
Silver	.0005	.0006	.0005	.0005	.0005	.0000021 (.0000042)	.0000049 (.0000098)	.00001 (.00002)	.0000055 (.000011)	.0000056 .0000112
Thallium	.00083	.0005	.0008	.0006	.0007	.0000028 (.0000056)	.0000041 (.0000082)	.000017 (.000033)	.0000065 (.000013)	.0000076 .0000152
Chromium	.0013	.0075	.0023	.011	.0055	.0000055 (.000011)	.00006 (.00012)	.00047 (.00084)	.00012 (.00023)	.00016 .00033
Mercury	.0066	.005	.001	.0075	.005	.000028 (.000042)	.000041 (.000082)	.000021 (.000041)	.00008 (.00016)	.000042 .000085

None of the insulation board plants presented historical data for wastewater heavy metal concentrations.

No significant differences in heavy metals concentrations between the two subcategories of insulation board plants were found. The source of heavy metals in the wastewater from insulation board plants is: (1) trace metals present in the wood raw material; and (2) by-products of the corrosion of metal equipment in contact with the process whitewater. The average concentrations and the average raw wastewater loadings of each heavy metal are also presented in Table V-14.

Design Basis for Model Plant

For the purposes of sizing treatment facilities, computing treated effluent pollutant loadings, and estimating capital and operating costs, plants having the following characteristics were used as models for insulation board:

Model Plant A
Insulation Board Mechanical Pulping

Daily Raw Waste Loads:
Daily Process Wastewater Volume: 3.8 million liters/day (1.0 MGD)

BOD	7.4 kg/Kkg (14.8 lb/ton)
TSS	11.4 kg/Kkg (22.8 lb/ton)
Phenols	0.0012 kg/Kkg (0.0024 lb/ton)
Metals	See Table V-14.

Model Plant B
Insulation Board Mechanical Pulping

Daily Process Wastewater Volume: 1.9 million liters/day (0.5 MGD)
Daily Raw Waste Loads:

BOD	7.4 kg/Kkg (14.8 lb/ton)
TSS	11.4 kg/Kkg (22.8 lb/ton)
Phenols	0.0012 kg/Kkg (0.0024 lb/ton)
Metals	See Table V-14.

Model Plant C
Insulation Board Thermo-mechanical Pulping and/or Hardboard Production

Daily Process Wastewater Volume: 3.8 million liters/day (1.0 MGD)
Daily Raw Waste Loads:

BOD	33.6 kg/Kkg (67.1 lb/ton)
TSS	17.3 kg/Kkg (34.5 lb/ton)
Phenols	0.0024 kg/Kkg (0.0048 lb/ton)
Metals	See Table V-14.

Model Plant D
Insulation Board Thermo-mechanical Pulping and/or Hardboard Production

Daily Process Wastewater Volume: 1.9 million liters/day (0.5 MGD)
Daily Raw Waste Loads:

BOD	33.6 kg/Kkg (67.1 lb/ton)
TSS	17.3 kg/Kkg (34.5 lb/ton)

Phenols	(0.0024 kg/Kkg (0.0048 lb/ton)
Metals	See Table V-14.

These characteristics are based on average values for plants which provided historical data on raw waste characteristics and on verification sampling results.

Wet-Process Hardboard

Production of hardboard by wet process requires significant amounts of water. Plants responding to the data collection portfolio reported fresh water usage rates for process water ranging from approximately 190 thousand to 19 million liters per day (0.05 to 5 MGD). One plant, 543, which produces both hardboard and insulation board in approximately equal amounts, reported fresh water use of over 41 million liters per day (11 MGD).

Water becomes contaminated during the production of hardboard primarily through contact with the wood raw material during the fiber preparation, forming, and--in the case of S1S hardboard--pressing operations. The vast majority of pollutants consist of fine wood fibers, soluble wood sugars, and extractives. Additives not retained in the board also add to the pollutant load.

The water used to process and transport the wood from the fiber preparation stage through mat formation is referred to as process whitewater. Process whitewater produced by the dewatering of stock at any stage of the process is usually recycled to be used as stock dilution water. However, due to the build-up of suspended solids and dissolved organic material which can cause undesirable effects in the board, there may be a need to bleed-off a quantity of excess process whitewater.

More specifically, potential wastewater sources in the production of wet process hardboard include:

- Chip wash water
- Process whitewater generated during fiber preparation (refining and washing)
- Process whitewater generated during forming
- Hot press squeezeout water
- Wastewater generated during miscellaneous operations (dryer washing, finishing, housekeeping, etc.)

Chip Wash Water

Chips are washed in order to remove such materials as grit, dirt, sand, and metal which can cause excessive wear and possible destruction of the refining equipment. Chip washing also provides an opportunity to increase the moisture content of moisture deficient furnish such as plywood or furniture trim. In northern climates, chip washing assists the thaw of frozen chips.

Water used for chip washing is capable of being recycled to a large extent. A minimum makeup of approximately 400 liters per metric ton (95 gallons per ton) is required in a closed system because of water leaving with the chips and with sludge removed from settling tanks. Water used for makeup in the chip washer may be fresh water, cooling water, vacuum seal water from inplant equipment, or recycled process water. Chip wash water, when not fully recycled, contributes to the raw waste load of a hardboard plant. Hardboard plants 62, 75, 67, 763, 543, 85, and 406 indicated in responses to the data collection portfolio that chip washing is done. Plants 763 and 85 recycle chip wash water.

Fiber Preparation

The fiber preparation or refiner whitewater system is considered to be the water used in the refining of stock up to and including the dewatering of stock by a decker or washer. There are two major types of fiber preparation in the wet process hardboard industry: thermo-mechanical pulping and refining, and the explosion or gun process. Steam, under pressure, is used to soften and prepare the chips in both processes.

Fiber yield is lower in the explosion process than in the thermo-mechanical process due to the hydrolysis of the hemicellulose under the high pressures required in the gun digesters. The resulting raw waste loading is also higher.

The wood furnish enters the refiner at an approximate moisture content of 50 percent. Subsequent to refining, the fiber bundles are diluted with fresh or recycled process whitewater to a consistency of approximately 1 percent solids prior to dewatering at the decker or stock washer to about 15 percent solids. The water which results from the stock washing or deckering operation is rich in organic solids dissolved from the wood during refining and is referred to as "refiner whitewater". This water may be combined with the machine whitewater, which is produced during forming, for further use in the system; or it may be discharged from the plant as wastewater.

Three plants, 864, 464, and 763 make use of the high dissolved organic solids in this stream by collecting and evaporating the fiber preparation whitewater to produce a concentrated wood molasses by-product which is used for animal feed.

Forming

After the dewatered stock leaves the washer decker at approximately 15 percent consistency, it must again be diluted to a consistency of approximately 1.5 percent to be suitable for machine forming. This requires a relatively large amount of recycled process whitewater or fresh water. The redilution of stock is usually accomplished in a series of steps to allow accurate consistency controls and more efficient dispersion of

additives and to reduce the required stock pump and storage capacities. The stock usually receives an initial dilution down to approximately 5 percent consistency, then to 3 percent, and finally, just prior to mat formation, to approximately 1.5 percent.

During the mat formation stage of the insulation board process, the diluted stock is dewatered at the forming machine to a consistency of approximately 40 to 45 percent. The water drained from the stock during formation is referred to as machine whitewater. Water from the machine whitewater system may be recycled for use as stock dilution water. Excess machine whitewater may be combined with other process whitewater and discharged as wastewater.

Pressing

In the production of S1S hardboard, the mat which leaves the forming machine at 40 to 45 percent solids consistency is loaded into "hot" hydraulic presses to be pressed into hardboard.

The board leaves the press at about 5 percent moisture or less. Although much of the water in the board is evaporated in the press, a considerable amount of wastewater is generated during pressing. This wastewater is generally collected in a pit below the press and discharged as wastewater from the plant, although two plants, 846 and 464, return the press water to the process whitewater system. Wastewater resulting from the pressing operation is more concentrated in dissolved solids than the machine whitewater due to the large amount of water which is evaporated from the board during pressing.

Miscellaneous Operations

While the majority of wastewater generated during the production of hardboard occurs during the fiber preparation, forming and pressing operations, various other operations may contribute to the overall raw waste load.

Drying--It is occasionally necessary to clean the driers in a hardboard plant to reduce fire danger and to maintain proper energy utilization. This produces a minor wastewater stream in most operations.

Finishing--After the board leaves the press or humidifier, it is usually sanded and trimmed to size. The dust from the sanding and trim saws is often controlled by dust collectors of a wet scrubber type and the water supplied to the scrubbers is sometimes excess process water; however, fresh water is occasionally used. This water may be returned to the process with the dust, or it may be discharged as wastewater.

Many plants paint or stain the board after it is sanded and trimmed. Paint composition will vary with both plant and product; however, most plants utilize a water-based paint. The resulting washup contributes to

the wastewater stream or is metered to the process whitewater system. In addition, there are sometimes imperfect batches of paint which are discharged to the wastewater stream or metered to the process whitewater system.

Caul or Press Plate--Another minor wastewater source is caul and press plate wash water. After a period of use, cauls and press plates acquire a surface build-up of resin and organics which results in sticking in the presses and blemishes on the hardboard surface. The cleaning operation consists of submerging the cauls in a caustic cleaning solution for a period of time to loosen the organic matter. Press plates are also cleaned in place with a caustic solution. The cauls are removed, rinsed with fresh water, then put back in use. The tanks used for soaking the cauls are emptied as needed, normally only a few times each year. Rinse water volume varies with frequency of washing of cauls or plates.

Other Sources--Other potential sources of wastewater in a hardboard plant include water used for screen washing, fire control, and general housekeeping.

The water used for washing screens in the forming and decker areas usually enters the process whitewater system. Housekeeping water can vary widely from plant to plant depending on plant operation and many other factors. Wastewater can result from water used to extinguish dryer fires. This is an infrequent and intermittent source of wastewater.

Wastewater Characteristics

The major portion of hardboard wastewater pollutants results from leachable materials from the wood and materials added during the production process. The materials leached from the wood will normally enter into solution in the process whitewater system. If a chip washer is used, a portion of the solubles are dissolved. A small fraction of the raw waste load results from cleanup and finishing operations; however, these operations appear to have little influence on the overall raw waste load.

The major factors which affect process wastewater quality are 1) the severity of cook to which the wood furnish is subjected, 2) the types of products produced and additives employed, 3) raw material species, and 4) the extent of whole tree chips, forest residue, and bark in the raw material.

The effect of steaming on raw waste load was discussed in this section for Insulation Board. The severity of cook to which wood furnish is subjected in S2S hardboard production generally exceeds that used in S1S hardboard production due to the requirement for more highly refined fiber bundles in the S2S product. It would be expected, therefore, that the raw waste load of S2S plants would be higher than that of S1S plants.

Inspection of the raw waste characteristics for both types of plants presented in Table V-15 supports this conclusion.

A thorough review of the literature and information presented by industry sources pertaining to factors influencing variation in raw wastewater characteristics was performed by an EPA contractor in 1976. The conclusions reached were published in Section V of the Summary Report on the Re-evaluation of the Effluent Guidelines for the Wet Process Hardboard Segment of the Timber Products Processing Point Source Category. An attempt was made in the 1976 study to quantify the effects of wood species, seasonal variations in raw materials, and the use of whole tree chips and/or forest residue on new waste characteristics. The conclusion reached in the 1976 study was as follows:

> "It is easily apparent, from the sources discussed, that large variabilities in raw waste characteristics exist from plant to plant in the hardboard industry. It is also apparent that the factors identified as causing the variability are probably valid. However, it is equally apparent that none of the sources investigated thus far has been able to supply the type of data necessary to determine how the reference information relates to quantification of factors influencing variations in raw waste."

During the course of the present study, the material available to the above mentioned contractor was reviewed in detail, as well as current literature and material presented by the plants in the data collection portfolios. No substantial new material was presented to allow quantification of the effects of wood species, whole tree chips and/or forest residue, or seasonal variations in raw material.

While a large portion of the BOD in the process wastewater is a result of organics leaching from the wood, a significant (although lesser) portion results from additives not retained in the product. Additives vary in both type and quantity according to the type of product being produced. Chemicals used as additives in the production of hardboard include vegetable oils, ferric sulfate, aluminum sulfate, petrolatum, thermoplastic and/or thermosetting resins, defoamers, and paints. Thermosetting resins are not used in S2S production since the board is dried prior to pressing. The differences in the type and quantity of additives used from plant to plant did not appear to significantly affect raw waste loads.

Maximum retention of these additives is advantageous from both a production cost as well as a wastewater standpoint. Several retention aids are marketed for use in board products to increase the retention of fiber and additives in the mat, the most common of which are polymeric polyelectrolytes.

Table V-15. S1S Hardboard Raw Waste Characteristics (Annual Averages)

Plant Number	Production		Flow		BOD		TSS	
	kkg/day	(TPD)	kl/kkg	(kgal)/(ton)	kg/kkg	(lbs)/(ton)	kg/kkg	(lbs)/(ton)
S1S Hardboard								
222	88.7	(97.5)	---	---	32.7*	(65.4)	6.90*	(13.8)
262	297	(326)	10.5	(2.54)	37.4	(74.7)	9.15	(18.3)
406	194	(213)	7.65	(1.84)	29.3	(58.6)	12.4	(24.8)
624	117	(129)	8.82	(2.12)	35.6	(71.2)	22.5	(44.9)
48	91.9	(101)	14.0	(3.36)	40.7**	(81.3)	16.8	(33.5)
242***	83.6	(91.9)	17.1	(4.12)	30.1	(60.1)	10.1	(20.2)
	83.6	(91.9)	11.1	(2.66)	26.3	(52.5)	10.1	(20.1)
464†	343	(377)	13.6	(3.26)	1.89	(3.77)	0.56	(1.15)
864††	1446	(1589)	12.3	(2.96)	21.9	(43.8)	5.85	(11.7)

* After primary settling. Hardboard and paper wastewater streams are comingled.
** Actual raw waste BOD is 68.7 kg/kkg. However, only 40.7 kg/kkg is due to production of hardboard. 28.0 kg/kkg enters the process water through recycle of treated effluent.
*** First row represents data from January through December, 1976. Second row represents data from June through December, 1976.
† Raw waste load shown is for combined weak and strong wastewater streams.
†† Data taken after primary clarification, pH adjustment and nutrient addition.

Table V-15a. S1S Hardboard Raw Waste Characteristics (Annual Averages)

Plant Number	Production		Flow		BOD		TSS	
	kkg/day	(TPD)	kl/kkg	(kgal)/(ton)	kg/kkg	(lbs)/(ton)	kg/kkg	(lbs)/(ton)
S1S Hardboard								
222	88.7	(97.5)	---	---	32.7*	(65.4)	6.90*	(13.8)
262	297	(326)	10.5	(2.54)	37.4	(74.7)	9.15	(18.3)
406	194	(213)	7.65	(1.84)	29.3	(58.6)	12.4	(24.8)
624	117	(129)	8.82	(2.12)	35.6	(71.2)	22.5	(44.9)
48	91.9	(101)	14.0	(3.36)	40.7**	(81.3)	16.8	(33.5)
242***	83.6	(91.9)	17.1	(4.12)	30.1	(60.1)	10.1	(20.2)
	83.6	(91.9)	11.1	(2.66)	26.3	(52.5)	10.1	(20.1)
464†	343	(377)	13.6	(3.26)	1.89	(3.77)	0.56	(1.15)
864††	1446	(1589)	12.3	(2.96)	21.9	(43.8)	5.85	(11.7)

* After primary settling. Hardboard and paper wastewater streams are comingled.
** Actual raw waste BOD is 68.7 kg/kkg. However, only 40.7 kg/kkg is due to production of hardboard. 28.0 kg/kkg enters the process water through recycle of treated effluent.
*** First row represents data from January through December, 1976. Second row represents data from June through December, 1976.
† Raw waste load shown is for combined weak and strong wastewater streams.
†† Data taken after primary clarification, pH adjustment and nutrient addition.

Table V-15b. S2S Hardboard Raw Waste Characteristics (Annual Averages)

Plant Number	Production		Flow		BOD		TSS	
	kkg/day	(TPD)	kl/kkg	(kgal)/(ton)	kg/kkg	(lbs)/(ton)	kg/kkg	(lbs)/(ton)
S2S Hardboard								
62	210	(231)	24.7	(5.93)	66.5	(133)	15.9	(31.8)
68	359	(395)†††	11.1	(2.68)	43.2	(86.3)	---	---

† Raw waste load adjusted from non-standard solids method to standard method.
†† Includes both hardboard and insulation board production.
††† 1975 Data.

As previously discussed, the primary effect of product type on raw waste loads occurs with the production of S2S hardboard. S2S hardboard production exhibits a marked effect on raw wasteloads as shown by data presented in Table V-15. The effect of product type on raw waste loads within the S1S and S2S subcategories is generally not discernible, with the one exception being that plant 846 has succeeded in significantly reducing its raw waste load by achieving nearly complete close-up of its process whitewater system. This plant produces primarily industrial grade board.

Raw Waste Loads

Table V-15 summarizes the raw waste characteristics of those hardboard plants which provided historical raw waste monitoring data in response to the data collection portfolio. Ten of the 16 hardboard plants provided raw waste historical data for the 12-month period from January through December 1976. Plant 464 provided data from May 1976, to April 1977.

Plants 763 and 75 do not monitor raw waste effluents, and plant 67 combines the raw waste effluent from its hardboard/insulation board facility with the raw waste effluent from an adjacent mineral wool fiber plant prior to monitoring. The data provided by Plant 67 could not be used to characterize raw waste loads for hardboard production.

Plant 644 did not provide sufficient information to calculate its raw waste load for 1976. The raw waste load presented in Table V-15 for this plant was calculated using 1975 data.

Plant 846 provided data from January 1976 through February 1977 for its treated effluent only. These data were not used to calculate a raw waste load.

Of the nine predominantly S1S hardboard plants, eight plants (222, 262, 406, 624, 48, 242, 464, and 864) provided sufficient historical raw waste data for analysis.

Approximately 90 percent of the total production of Plant 222 is S1S hardboard produced with a plywood trim furnish. The other 10 percent of the plant's production consists of battery separators, which is a paper product. Although the plant indicates that 80 to 90 percent of the raw waste load is due to hardboard production, monitoring by the plant is performed after the raw waste streams are combined. The plant did not monitor the flow rates of the separate wastewater streams during 1976. No flow data were reported by Plant 222. BOD and TSS raw waste loads were reported directly in lb/ton. The raw waste load for this plant is included in Table V-15, but is not included in the calculation of the subcategory average.

Plant 48 produces all S1S hardboard using Douglas Fir for furnish. The raw waste load discharged from this plant is 68.7 kg/Kkg (137.4 lb/ton), however the raw waste load produced during hardboard production is 40.7 kg/Kkg (81.3 lb/ton). The difference is due to the fact that this plant recycles all its treated effluent, which contains 28.0 kg/Kkg (56.0 lb/ton), back to the plant for process water.

Plant 406 produces all S1S hardboard using a furnish which is 55 percent mixed hardwoods and 45 percent mixed softwoods. Thirty percent of this plant's furnish is in the form of unbarked roundwood.

Plant 262 produces all S1S hardboard using an aspen furnish, approximately half of which is unbarked roundwood and half is received as whole tree chips.

Plant 624 produces all S1S hardboard using 75 percent oak and 25 percent mixed hardwoods.

Plant 242 produces all S1S hardboard using all Douglas Fir in the form of chips, sawdust, shavings and plywood trim. Two sets of raw waste load data are presented for plant 242: one for the entire 12 months of 1976 and the other (which was used to calculate the subcategory average) for the last six months of 1976. The latter set represents the raw waste load of the plant after completion of a major in-plant refitting program which reduced the raw waste flow.

Plant 464, which produces approximately equal amounts of S1S and S2S hardboard using Redwood and Douglas Fir, evaporates most of its process wastewater to produce a cattle feed by-product. Data for this plant are shown in Table V-15, but are not included in the subcategory average.

Plant 864 produces approximately 10 percent S2S and 90 percent S1S hardboard using about 80 percent mixed hardwoods (40 percent of which is oak) and 20 percent Southern Pine. This plant evaporates a large amount of process water to produce a cattle feed by-product. Raw waste data reported in Table V-15 for this plant were obtained following primary clarification, pH adjustment and nutrient addition. Plant 864 is not included in the subcategory average; however, data for the plant are shown in Table V-15.

The annual average daily raw waste loads for the S1S hardboard plants, for which data is presented in Table V-15 (excluding Plants 222, 464, and 864), are 33.8 kg/Kkg (67.6 lb/ton) for BOD and 14.2 kg/Kkg (28.3 lb/ton) for TSS.

Of the seven plants which produce predominantly S2S hardboard, four provided sufficient historical raw waste data for analysis. Plant 543 uses thermo-mechanical pulping to prepare approximately 10 percent of its furnish, which consists primarily of aspen with some whole tree chips.

This plant produces approximately 50 percent insulation board and 50 percent hardboard.

Plant 85 uses thermo-mechanical pulping to prepare all of its furnish, which consists primarily of pine with some hardwood and panel trim. This plant produces approximately 70 percent insulation board and 30 percent hardboard.

The raw waste effluents from insulation board and hardboard production of Plants 543 and 85 are combined mixed prior to raw waste monitoring. Therefore, the individual raw waste load due solely to hardboard could not be calculated, and values for these plants are not included in the subcategory average.

Plant 62 is the only plant which produces all S2S hardboard, using various combinations of soft hardwoods and oak. The annual average daily raw waste load reported by this plant is 15.9 kg/Kkg (31.8 lb/ton). Since this value is based on a non-standard analytical method for TSS, a study was conducted during April and May of 1977 to determine the correlation between the TSS as measured by the non-standard method used by the plant, and TSS as measured by Standard Methods. Twenty-one raw waste samples were collected by the plant over a 29-day period. The samples were split at the plant with one fraction analyzed by the plant using the non-standard method and one fraction sent by air freight to ESE's Gainesville laboratory for analysis. The results of the study for raw waste are presented in Table V-16. The least squares linear correlation between the data is shown in Figure V-2.

The annual average daily raw waste load reported by the plant was converted to a concentration using the annual average daily flow and production, adjusted using the least squares linear correlation, and converted back to an adjusted raw waste load. The resulting adjusted raw waste load is 14.1 kg/Kkg (28.2 lb/ton).

Plant 644 produces about 80 percent S2S hardboard and 20 percent S1S hardboard. Its furnish consists of poplar, birch, oak, and pine, 23 percent received as bark-free chips and 77 percent as roundwood. Raw waste load BOD for this plant, 116 kg/Kkg (232 lb/ton), is the highest by far of any fiberboard plant in the country with and is considered to be atypical of the S2S subcategory. For this reason the BOD raw waste load for this plant is not included in the subcategory average. Its TSS raw waste load is, however, characteristic of S2S plants and is included in the subcategory average.

The annual average daily raw waste loads for the S2S subcategory, using BOD and adjusted TSS data from Plant 62 and TSS data from Plant 644 are 66.5 kg/Kkg (133 lb/ton) for BOD and 17.8 kg/Kkg (35.7 lb/ton) for TSS.

Table V-16. Standard and Non-Standard Methods Comparison, Raw Waste Concentrations, Plant 62.

1977 Dates	TSS (mg/l) Raw Wastewater	
	Standard Method	Non-Standard Method
4/21	690	1440
4/22		
4/23		
4/24	500	830
4/25	940	1400
4/26	490	460
4/27	390	520
4/28	770	690
4/29		
4/30		
5/1	670	280
5/2	212	370
5/3	580	710
5/4	240	510
5/5	270	420
5/6		
5/7		
5/8	380	490
5/9	426	620
5/10	1900	2040
5/11	430	570
5/12	510	560
5/13		
5/14		
5/15	1000	1020
5/16	720	410
5/17	9830*	7680*
5/18	890	550
5/19	600	710
Mean	1068	1061

* These values were omitted from the calculations.

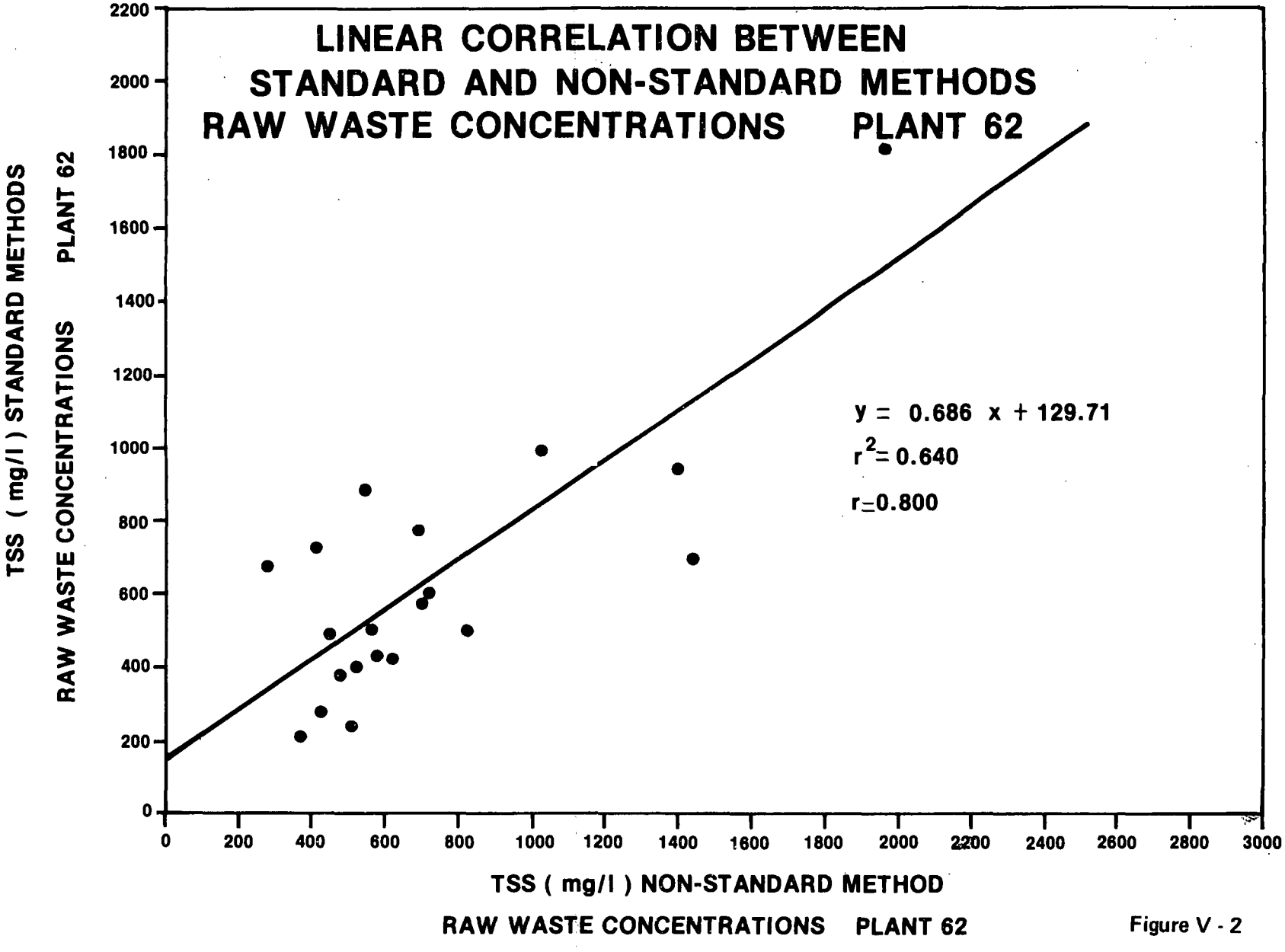

LINEAR CORRELATION BETWEEN
STANDARD AND NON-STANDARD METHODS
RAW WASTE CONCENTRATIONS PLANT 62
y = 0.686 x + 129.71
r2= 0.640
r=0.800
TSS (mg/l) STANDARD METHODS
RAW WASTE CONCENTRATIONS PLANT 62
TSS (mg/l) NON-STANDARD METHOD
RAW WASTE CONCENTRATIONS PLANT 62
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000

Figure V - 2

Priority Pollutant Raw Waste Loads

Raw waste concentrations and raw waste loads for total phenols are shown in Table V-17. Data presented in this table were obtained during the verification sampling program. Two hardboard plants provided historical data on phenols, which is also included in Table V-17. Annual average daily production and annual average daily waste flow provided by the plants in response to the data collection portfolio were used to calculate the raw waste loads.

The average concentration of total phenols for the six hardboard plants for which phenols data are available is 2.0 mg/l. The corresponding average total phenols raw waste load is 0.019 kg/Kkg (0.038 lb/ton). No differentiation should be made between S2S and S1S subcategories based on the available data since the data from Plant 62, the only predominantly S2S plant represented, appears to be uncharacteristically low in total phenols.

Raw waste concentrations of heavy metals are presented for six hardboard plants in Table V-18. Data presented in this table were obtained during the verification sampling program. One hardboard plant provided historical data for lead and chromium which are also presented in the table. Annual average daily production and annual daily waste flow provided by the plants in the data collection portfolio were used to calculate the raw waste loads.

No significant differences in heavy metals concentrations between the two subcategories of hardboard plants were found. The sources of heavy metals in the wastewater from hardboard plants are: (1) trace metals present in the wood raw material; and (2) by-products of the corrosion of metal equipment in contact with the process wastewater. The average concentrations and the average raw waste loadings of each heavy metal are presented in Table V-19.

Design Basis for Model Plant

For the purposes of sizing treatment facilities, computing treated effluent pollutant loadings, and estimating capital and operating costs, plants having the following characteristics were used as models for hardboard:

	Model Plant E S1S Hardboard
Daily Process Wastewater Volume:	3.8 million liters/day (1.0 MGD)
BOD	33.8 kg/Kkg (67.6 lb/ton)
TSS	14.2 kg/Kkg (28.3 lb/ton)
Phenols	0.019 kg/Kkg (0.038 lb/ton)
Metals	See Table V-18.

Table V-17. Raw Waste Concentrations and Loadings for Hardboard Plants Total Phenols.

Plant Code	Raw Waste[1] Concentrations (mg/l)	Raw Waste Loadings[2] kg/Kkg	(lb/ton)
62	0.07	0.0015	(0.003)
242	0.38	0.005	(0.01)
464	1.2	0.015	(0.02)
864	0.24 0.29*	0.003 0.0037*	(0.006) (0.0074)*
624	6.4	0.06	(0.11)
406	3.4*	0.026*	(0.051)*

1 Data obtained during verification sampling program.
2 Average daily waste flow and production data for 1976 supplied by plants in response to data collection portfolio were used to calculate waste loadings.

* Data are 1976 historical data supplied by plant in response to data collection portfolio.

Table V-18. Raw Waste Concentrations and Loadings for Hardboard Plants--Metals.

	Raw Waste Concentrations (mg/l) Plant Number						Raw Waste Loadings (kg/Kkg)/(lb/ton) Plant Number					
	624	40	464	262	242	864	624	40	464	262	242	864
Beryllium	.00067	.0005	.00059	.0005	.0005	.0005	.000006 (.000012)	.000013 (.000025)	.000008 (.000016)	.000005 (.000001)	.000009 (.000017)	.000007 (.000013)
Cadmium	.0031	.0023	.0005	.005	.0005	.0005	.000027 (.000054)	.00006 (.00012)	.000007 (.000013)	.00005 (.0001)	.000009 (.000017)	.000007 (.000013)
Copper	.450	.530	.033	.1	.49	.260	.0039 (.0078)	.014 (.027)	.00044 (.00088)	.0011 (.0021)	.009 (.017)	.0033 (.0065)
Lead	.007	.0047	.055	.002	.002	.0033 .053*	.00006 (.00012)	.00012 (.00024)	.0008 (.0015)	.00002 (.00004)	.000035 (.000069)	.000042 (.000083) .00065* (.0013)*
Nickel	.270	.070	.0057	.006	.0033	.009	.0024 (.0047)	.0018 (.0035)	.0008 (.00015)	.00006 (.00012)	.00006 (.00011)	.00012 .00023
Zinc	1.0	.190	.19	2.3	.78	.550	.009 (.017)	.0048 (.0096)	.003 (.005)	.024 (.048)	.014 (.027)	.007 (.014)
Antimony	.0018	.003	.0058	.0023	.0005	.008	.000016 (.000031)	.00008 (.00015)	.00008 (.00015)	.000024 (.000048)	.000009 (.000017)	.0001 (.00020)
Arsenic	.0013	.001	.0012	.0013	.001	.0012	.000016 (.000023)	.000026 (.000051)	.000016 (.000032)	.000014 (.000027)	.000017 (.000034)	.000015 (.000030)
Selenium	.002	.0008	.0038	.0023	.0033	.0018	.000018 (.000035)	.000020 (.000040)	.00005 (.0001)	.000024 (.000048)	.00006 (.00011)	.000023 (.000045)
Silver	.00067	.007	.0005	.0005	.0005	.00067	.000006 (.000012)	.00018 (.00035)	.000007 (.00013)	.000005 (.000010)	.000009 (.000017)	.000009 (.000017)
Thallium	.0015	.0005	.00099	.0005	.0005	.00067	.000013 (.000026)	.000013 (.000025)	.000013 (.000026)	.000005 (.000010)	.000009 (.000017)	.000009 (.000017)
Chromium	.033	.0073	.072	.008	.001	.420 .470*	.00029 (.00058)	.00019 (.00037)	.0001 (.0019)	.00009 (.00017)	.000017 (.000034)	.006 (.011) .006* (.012)*
Mercury	.002	.00005	.0002	.001	.018	.0017	.000018 (.000035)	.0000012 (.0000025)	.0000027 (.0000053)	.000011 (.000021)	.00031 (.00062)	.000022 (.000043)

* Data are 1976 historical data supplied by plant in response to data collection portfolio.

Table V-19. Average Raw Waste Concentration and Loadings for Hardboard Plants--Metals.

Metal	Average Concentration mg/l	Average Raw Waste Load kg/Kkg	lb/ton
Beryllium	0.00054	0.000008	0.000016
Cadmium	0.0020	0.000027	0.000053
Copper	0.31	0.0053	0.011
Lead	0.21	0.00018	0.00036
Nickel	0.061	0.00087	0.0017
Zinc	0.84	0.010	0.021
Antimony	0.0036	0.000052	0.00010
Arsenic	0.0012	0.000017	0.000035
Selenium	0.0023	0.000032	0.000065
Silver	0.0016	0.000036	0.000072
Thallium	0.00078	0.000010	0.000021
Chromium	0.099	0.0011	0.0022
Mercury	0.0038	0.000061	0.00012

Model Plant F
S1S Hardboard

Daily Process Wastewater Volume:	1.9 million liters/day (0.5 MGD)
BOD	33.8 kg/Kkg (67.6 lb/ton)
TSS	14.2 kg/Kkg (28.3 lb/ton)
Phenols	0.019 kg/Kkg (0.038 lb/ton)
Metals	See Table V-18.

Model Plant G
S2S Hardboard

Daily Process Wastewater Volume:	3.8 million liters/day (1.0 MGD)
BOD	66.5 kg/Kkg (133 lb/ton)
TSS	17.8 kg/Kkg (35.7 lb/ton)
Phenols	0.019 kg/Kkg (0.038 lb/ton)
Metals	See Table V-18.

Model Plant H
S2S Hardboard

Daily Process Wastewater Volume:	1.9 million liters/day (0.5 MGD)
BOD	66.5 kg/Kkg (133 lb/ton)
TSS	17.8 kg/Kkg (35.7 lb/ton)
Phenols	0.019 kg/Kkg (0.038 lb/ton)
Metals	See Table V-18.

These characteristics are based on average values for plants which provided historical data on raw waste characteristics and on verification sampling results.

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

General

One of the most important aspects of the BAT review is to investigate each industry studied for the presence of the priority pollutants in the raw and treated wastes streams discharged either directly or indirectly to the environment. The original consent decree listed 65 compounds or classes of compounds which were to be investigated. This list of 65 appears in Appendix A1. For the purpose of this study, the EPA selected 124 specific compounds corresponding to the original list of 65. These compounds, referred to as "priority pollutants," are listed in Appendix A2.

In addition to the priority pollutants, the traditional parameters including the oxygen demand parameters BOD, COD, and TOC; total dissolved solids, TDS, and total suspended solids, TSS; total phenols; and oil and grease were also investigated during the course of the study. The traditional parameters are, of course, the most widely used indicators of pollution. They are used for design and operational control of waste treatment systems, and are the terms in which current regulations are written. Nearly all available historical information on pollution characteristics of the timber products processing industry is limited to traditional parameters.

The purpose of this section is to describe the methodology used in selecting the priority pollutants of interest in the wood preserving, insulation board, and hardboard segments of the timber products processing industry, and to present the pollutants of specific interest for each subcategory studied.

Methodology

With few exceptions, very little information was available on the presence of the priority pollutants in waste discharges from the timber products processing point source category. The principal raw material used is wood, and although wood itself possesses complex chemical characteristics, pollution from the wood products industries has been studied more in terms of general pollution characteristics, such as oxygen depletion of receiving waters and suspended solids loadings, than in terms of its contribution of potentially toxic compounds to the environment.

The first step in establishing a data base on the priority pollutants was to perform a complete analysis of raw materials used and production processes employed in each segment of the industry. The literature was thoroughly studied for any reference to the presence of priority pollutants in the wood itself, chemical preservatives or additives, slimicides, fungicides, anti-foaming agents, finishing chemicals, paints, etc. The chemistry of each applicable production process was analyzed to

determine the potential for formation of priority pollutants. Each instance where priority pollutants were known to exist, or were believed to be formed in the production process, was documented.

The second step in establishing the priority pollutant data base was to survey each industry segment on the use, production, and/or discharge of priority pollutants. Part IV of the data collection portfolio required each respondent to check whether any of the pollutants listed in the consent decree was used as a raw material, produced in the production process, and/or discharged to the environment. Table VI-1 shows the attachment which the respondent was required to complete for each chemical identified. With the exception of the wood preserving industry, which listed its preservatives as containing many of the priority pollutants, few of the responses contained information on priority pollutants. Unless the plants used materials containing priority pollutants as raw materials or additives, no knowledge of priority pollutants contained in plant discharges was indicated.

The third step in establishing the priority pollutant data base was to conduct a screening sampling program. During the course of this study, at least one plant in each subcategory of the timber products processing industry was visited for the purpose of collecting samples of the raw process wastewater and treated effluent. Sampling and analysis procedures employed followed the Draft EPA Sampling Protocol for Measurement of Toxics, October, 1976, and the EPA Draft Analytical Protocol for the Measurement of Toxic Substances, October, 1976. A complete discussion of sampling and analytical procedures employed is contained in Appendix B.

The basic rationale for selection of plants for screening was to select those plants in each subcategory from which the maximum amount of priority pollutant information could be obtained for each subcategory. Specific criteria applied in each plant selection were as follows:

1. Select a representative plant in subcategory in terms of size, age, geographical location, and processes.

2. Select a plant which uses the greatest number of chemical additives, preservatives, anti-foamants, cleaning solutions, etc., which are commonly used in the subcategory to obtain the maximum amount of priority pollutant information.

3. Select a plant that has most complete treatment in order to obtain basic information about toxic pollutant reduction.

4. Select a plant that chlorinates effluent prior to discharge, if possible, in order to ascertain the effects of post-chlorination.

TABLE VI-1

TOXIC CHEMICAL INFORMATION

For each toxic chemical check on list, and for each wood preservative, fire retardant, fungicide, or mildewcide used in plant, complete the following form:

1. Name of Chemical _____
   Is this a (check one):

   _____ Wood Preservative _____ Other

   _____ Fire Retardant

   _____ Fungicide

   _____ Mildewcide

2. Quantity and frequency of use

   _____ per _____
   amount period

3. Process or operation in which substance is used or generated. _____

   _____

   _____

   _____

4. Is substance discharged from plant? _____Yes _____ No _____ Don't Know

   If yes, is it: _____ Air _____ Water _____ Solid Waste

   If water, is it: _____ Direct Discharge _____ To POTW

5. Quantity and frequency of substance discharged:

	Amount (in units, lbs, tons etc.)	Period per (day, year, etc.)
Gas	_____	_____
	_____	_____
Liquid	_____	_____
	_____	_____
Solid Waste	_____	_____
	_____	_____

6. Description of sampling or monitoring program.

   Does your plant sample or monitor for substance?

   _____ Yes _____ No

   If yes, give details. _____

   _____

   _____

   _____

5. Insure that the selected plant is physically capable of being properly sampled, i.e., the combined raw waste stream and treated effluent can be readily sampled and the flow measured.

Upon completion of the screening program, all the above sources of data were reviewed, and a determination was made as to which priority pollutants were of specific interest in each subcategory. The remainder of the study focused on establishing raw waste characteristics and treatability of these specific priority pollutants, as well as the traditional pollutant parameters.

The Priority Pollutants

The list of 124 priority pollutants investigated during the course of this study can be divided into the following groups for discussion purposes:

Pesticides
Polychlorinated Biphenyls (PCB's)
Phenolic Compounds
Volatile Organic Priority Pollutants
Semi-volatile Organic Priority Pollutants
Inorganic Priority Pollutants

These groups are based upon chemical similarities and method of analysis employed in measuring the compound in wastewater. A discussion of each group follows.

Pesticides and Metabolites

aldrin
dieldrin
chlordane (technical mixture and metabolites)
4,4'-DDT
4,4'-DDE (p,p'DDX)
4,4'-DDD (p,p'-TDE)
a-endosulfan
b-endosulfan
endosulfan sulfate
endrin
endrin aldehyde
heptachlor
heptachlor epoxide
a-BHC (hexachlorocylohexane)
b-BHC (hexachlorocylohexane)
c-BHC (hexachlorocylohexane)
d-BHC (hexachlorocylohexane)
toxaphene

Analysis of pesticides was performed according to the Manual of Analytical Methods for the Analysis of Pesticide Residue in Human and Environmental Samples (EPA, 1974). By their very nature and use, pesticides are toxic to certain living organisms. They can be a hazard to aquatic life, terrestrial life, and man when allowed to enter natural waters in sufficient concentrations. Pesticides may affect the aquatic environment and water quality in several ways. A pesticide with a slow rate of degradation will persist in the environment, suppressing or destroying some organism populations while allowing others to gain supremacy. An imbalance in the ecosystem results. Other pesticides will degrade rapidly, some to products that are more toxic than the parent compound and some to harmless products. Many pesticides have a high potential for bioaccumulation and biomagnification in the aquatic food chain, thereby posing a serious threat to a large number of ecologically important organisms, including man.

All of the priority pollutant pesticides are synthetically produced chlorinated hydrocarbons. The chlorinated hydrocarbons are among the most important groups of synthetic organic pesticides because of their sizeable number, wide use, stability in the environment, toxicity to wildlife and nontarget organisms, and adverse physiological effects on humans. These pesticides readily accumulate in aquatic organisms and in man. They are stored in fatty tissue and are not rapidly metabolized. Humans may accumulate chlorinated hydrocarbon residues by direct ingestion of contaminated water or by consumption of contaminated organisms. Regardless of how chlorinated hydrocarbons enter organisms, they induce poisoning exhibiting similar symptoms but differing in severity. The severity is related to the extent and concentration of the compound in the nervous system, primarily the brain. Deleterious effects on human health are also suspected to result from long-term, low-level exposure to pesticides.

Two references in the literature were found which documented the potential presence of pesticides in wastes from the wood products industry. The first (Loyttyniemi, 1975) presents evidence of lindane (c-BHC) in barking drum effluent. Pine pulpwood being debarked in a drum had recently been sprayed with large amounts of the pesticide. The second reference to pesticides in wood products (Richards and Webb, 1975) is an article describing a laboratory scale experiment in which endrin, malathion, and kepone were added to creosote being used to treat test coupons of pine wood. The purpose of the test was to determine the effectiveness of the additives in preventing attack by marine borer organisms. No commercial instance of pesticide additives to creosote could be determined.

Since the chlorinated organic pesticides are synthetically produced chemicals, and other than the above references, no instance of their use was found in any of the wood products industries, it is highly unlikely that pesticides would be of major concern as pollutants. Analytical results of the screening program supported this assumption.

Table VI-2 shows the range of pesticides concentrations found in screening samples from wood preserving, insulation board, and wet process hardboard plants. These values are well within the range of background levels reported for U.S. surface waters by the EPA (EPA-STORET, 1977).

PCB's

Arochlor (Reg. T.M.) 1242
Arochlor (Reg. T.M.) 1254

PCB's were analyzed in the screening program by hexane extraction followed by gas chromatography using an electron capture detector (GC/ECD).

Polychlorinated biphenyls (PCB's) are a class of compounds produced by the chlorination of biphenyls and are registered in the United States under the trade name, Arochlor (Reg. T.M.). The degree of chlorination determines the chemical properties of PCB's, and generally their composition can be identified by the numerical nomenclature. The first two digits represent the molecular type and the last two digits the average percentage of weight of chlorine (NTIS, 1972).

The toxicity and persistence of PCB's in the environment is widely documented (EPA, 1976). PCB compounds are slightly soluble in water (25-200 ug/l at 25°C), soluble in lipids, oils, organic solvents, and resistant to both heat and biological degradation (NTIS, 1972; Nisbet, et al., 1972). Typically, the specific gravity, boiling point, and melting point of PCB's increase with their chlorine content. PCB's are relatively non-flammable, have useful heat exchange and dielectric properties, and now are used principally in the electrical industry in capacitors and transformers. PCB's are synthetically produced chemicals, although there is some evidence (Johnsen, 1977) that chlorination of biphenyls present in some industrial wastewaters can result in production of PCB's.

No evidence of the use or production of PCB's in timber products processing operations was found in the literature. Presence of PCB's in wastewaters from the wood preserving, insulation board, or hardboard industries is considered to be highly unlikely except incidentally, or as a background contaminant. One S2S hardboard/insulation board plant indicated that electric transformer oil containing PCB's is used in the plant's electrical equipment. This is a common use of PCB's which is probably not confined to the single plant. Equipment using this type of oil is designed to be completely self contained, and no discharge of PCB's to the environment occurs except as a result of equipment failure. Only one screening sample contained a measurable concentration of a PCB. The raw waste sample contained 20.3 ug/l of Arochlor (Reg. T.M.) 1242.

Phenolic Compounds

phenol
2-chlorphenol

Table VI-2. Pesticides in Timber Products' Processing Wastewaters.

Segment	Range of Pesticide Concentrations ug/l (ppb)			
	BHC (all isomers)	Heptachlor	Aldrin	Chlordane
Wood Preserving	0.001 - 0.050	0.013 - 0.684	<0.001	0.035
Insulation Board	0.015 - 0.186	<0.001	0.001	<0.001
Wet Process Hardboard	0.015	<0.001	<0.001	<0.001

SOURCE: 1977 Screening Sampling Program.

2,4-dichlorphenol
p-chlorometa cresol
2,4-dimethylphenol
2,4,6-trichlorophenol
2-nitrophenol
4-nitrophenol
2,4-dinitrophenol
4,6-dinitro-o-cresol
pentachlorophenol

Screening analysis of the phenolic compounds was by adsorption on an anion exchange resin followed by gas chromatography using a flame ionization detector.

Phenolic compounds include a wide variety of organic chemicals. Phenols may be classified as monohydric, dihydric, or polyhydric depending on the number of hydroxyl groups attached to the aromatic ring. Phenol itself, which has one hydroxyl group, is the most typical of the group and is often used as a model compound. The properties of phenol, with certain modifications depending on the nature of the substituents on the benzene ring, are shared by other phenolic compounds.

Since phenols are a natural constituent of wood, water in contact with wood can be expected to contain some concentration of phenols. Hydrolysis of wood is carried out at elevated temperatures in the production of insulation board and hardboard. This reaction, particularly the hydrolysis of lignin which serves as a natural binder in wood, results in the production of phenolic compounds. Phenolic compounds are invariably present in wastewaters that contact creosote, pentachlorophenol-petroleum solutions, and products treated with these preservatives. The primary phenolic constituents present in these wastes are para-, meta-, and ortho-cresol, phenol, and various derivatives of each. Chlorophenol, di-, tri-, and tetrachlorophenols are present, to some extent, in pentachlorophenol solutions used in the wood preserving industry. They can be present in process water in concentrations of from less than 1 mg/l to 600 mg/l or higher.

Phenolic compounds can affect freshwater fishes adversely by direct toxicity to fish and fish-food organisms; by lowering the amount of available oxygen because of the high oxygen demand of the compounds and by tainting of fish flesh. The chlorinated phenols present problems in drinking water supplies because phenol is not removed efficiently by conventional water treatment and can be chlorinated during the final water treatment process to form persistent odor-producing compounds in the distribution system (EPA, 1976).

Concentrations of each of the specific phenols in excess of 1.0 mg/l were found in the raw waste streams of the wood preserving, insulation board,

and wet process hardboard industries. Pentachlorophenol is present in wastewaters from the wood preserving industry, due to its use as a preservative chemical, and in the insulation board and hardboard industries, due to its use as board additive with fungicidal properties.

Volatile Organic Priority Pollutants

All the volatile organic priority pollutant samples were collected in hermetically sealed serum vials, purged with nitrogen gas, and trapped on Tenax GC adsorbent. The volatiles were then thermally desorbed into the Gas Chromatograph/Mass Spectrometer for analysis.

Halomethanes

bromoform (tribromomethane)
carbon tetrachloride (tetrachloromethane)
chloroform (trichloromethane)
chlorodibromomethane
dichlorodiflouromethane
dichlorobromomethane
methyl bromide (bromomethane)
methyl chloride (chloromethane)
methylene chloride (dichloromethane)
trichloroflouromethane

The halomethanes are methane molecules with one or more substituted halogen (chlorine, bromine, fluorine, etc.) atoms. Several of the halomethanes are of commercial importance and are produced in large quantities. Examples include methylene chloride, chloroform and carbon tetrachloride as solvents; chloroform and bromoform for medicinal properties; and dichlorodifluoromethane and trichlorofluoromethane as aerosol propellants and refrigerants. Halomethanes are also formed as by-products of the chlorination of water and wastewater (Symons, et al., 1975; EPA, 1977). Carcinogenic properties of several of the halomethanes have been reported (WHO, 1972; NIOSH, 1975).

Methylene chloride is used as a solvent for pentachlorophenol in a solvent-recovery treating process developed by the Dow Chemical Company. A plant which uses this process, in addition to the Boulton process, was sampled during the screening program. The plant's raw wastewater contained 96.6 mg/l of methylene chloride, and the treated waste contained 21.6 mg/l. Also found in the treated waste at this plant were 5.7 mg/l of chloroform and 9.9 mg/l of trichlorofluoromethane.

One insulation board/S2S hardboard plant which was sampled during screening contained 0.9 mg/l of methylene chloride in its raw process wastewater. The fresh water used at this plant was heavily chlorinated, however, and contained 0.5 mg/l of methylene chloride. Small amounts of chloroform and methylene chloride, generally less than 5 pounds per year, are used in the quality control laboratories of several hardboard mills. None

of the other wood preserving, insulation board, or wet process hardboard plants sampled during the screening program contained halomethanes in their raw or treated wastewaters.

Chlorinated Ethanes

1,1-dichloroethane
1,2-dichloroethane
1,1,1-trichloroethane
1,1,2-trichloroethane
1,1,2,2-tetrachloroethane
hexachloroethane

The chlorinated ethanes are commercially important solvents, cleaning agents, and chemical intermediates. Although their potential toxicity due to direct exposure is well documented (Christensen, et al., 1975), their effect on biota in water is not as clearly established.

1,1,1-trichloroethane is used by several hardboard plants as a degreasing and cleaning agent for electrical equiment, and by at least one hardboard plant as a cleaning agent for hardboard press plates. The amounts of this chemical used for this purpose is generally less than 5 pounds per day. Much of the compound is degraded chemically during use, and none of the screening plants exhibited measurable amounts of 1,1,1-trichloroethane in their raw or treated wastewaters. 1,2-dichloroethane has been shown to be a common by-product of the chlorination of drinking water (Symons, et al., 1975) and was also the only chlorinated ethane found in the screening program. A concentration of 2.6 mg/l of 1,2-dichloroethane was detected in the raw wastewater of an insulation board/S2S hardboard mill which chlorinates its fresh process water. The fresh water sample at this plant, after chlorination, contained 1.2 mg/l of 1,2-dichloroethane.

Aromatic Solvents

Benzene
Toluene (methylbenzene)
Ethylbenzene

The above compounds are common industrial solvents and chemical intermediates. All three compounds can be derived from the distillation of coal and are found in varying amounts in coal tar products, including creosote. Petroleum cuts containing benzene and toluene are commonly used in wood preserving plants which use the vapor-drying process to season railroad ties prior to treatment. Toluene is used in laboratory extractions of treated wood to determine creosote content. Benzene, toluene, and ethyl benzene are used as solvents for finishing compounds applied to finished hardboard panels.

Limited data exists on the toxicity to aquatic life of these solvents (Pontman, 1970).

Concentrations of all three solvents were found in both raw and treated waste streams of wood preserving plants sampled during the screening sampling program. Table VI-3 presents the range of concentrations found for each compound. No measurable quantities of these solvents were found during screening of insulation board or wet process hardboard plants.

Chloroalkyl Ethers

bis (chloromethyl) ether
2-chloroethylvinyl ether

These ethers are synthetically produced as chemical intermediates and for use in the production of pharmaceuticals. Information on aquatic toxicity is extremely limited. No incidence of use in the wood products industry has been reported in the literature or by the surveyed plants. No measurable concentration of these compounds was detected in the screening sampling program.

Dichloropropane and Dichloropropene

1,2-dichloropropane
1,3-dichloropropylene

1,2-dichloropropane is commercially produced as a solvent, a dry cleaning agent, and for use as a soil fumigant. 1,3-dichloropropylene is produced for use as a soil fumigant.

No incidence of use in the wood products industry has been reported in the literature or by the plants surveyed. No measurable concentration of either of these compound has been detected in the screening sampling program.

Chlorinated Ethylenes

vinyl chloride
1,1-dichloroethylene
1,2-trans-dichloroethylene
trichloroethylene
tetrachloroethylene

Vinyl chloride is widely used as a refrigerant, a chemical intermediate, and as a monomer for the common plastic polyvinylchloride. 1,1-dichloroethylene is also produced as a chemical intermediate for use in the plastics industry. 1,2-trans-dichloroethylene, trichloroethylene, and tetrachloroethylene are produced for use as solvents, degreasers, and dry cleaning chemicals.

Table VI-3. Range of Aromatic Solvent Concentrations Found in Samples from Three Wood Preserving Plants.

Solvent	Concentration mg/l	
	Raw Wastewater	Treated Effluent
Benzene	.240-1.40	1.0
Toluene	1.48	4.3
Ethylbenzene	.050-1.90	None Found

SOURCE: 1977 Screening Sampling Program.

Polyvinyl chloride, a clear plastic material formed by polymerization of vinyl chloride, is used by many hardboard plants as a decorative overlay in finished panels. Trichloroethylene is used in very small amounts, 5 to 10 pounds per year, in the laboratories of several hardboard plants. No measurable concentration of any of these compound has been detected in the screening sampling program.

Miscellaneous Volatile Organics

acrolein
acrylonitrile
chlorobenzene

Acrolein is manufactured for use in plastics, organic synthesis, and as a warning agent in methyl chloride refrigerant. Acrylonitrile, a highly toxic compound containing a cyanide group, is used in the manufacture of synthetic fibers, dyes, and adhesives. Chlorobenzene is used as a solvent for paints, as a heat transfer medium, and as an intermediate in production of phenol, aniline, and DDT.

No incidence of use in the wood products industry has been reported in the literature or by the plants surveyed. No measurable concentration of any of these compound has been detected in the screening sampling program.

Semi-Volatile Organic Priority Pollutants

The semi-volatile organic priority pollutants were analyzed using GC/MS following liquid-liquid extraction. Extraction was carried out in two steps, the first step at a pH of 11 or more (base-neutral extraction), followed by an extraction at pH 2 or less (acid extraction).

Poly Nuclear Aromatics (PNA's)

*acenapthene
*acynapthylene
*anthracene
1,2-benzanthracene
3,4-benzofluoranthene
11,12-benzafluoranthene
3,4-benzoperylene
1,12-benzopyrene
*chrysene
*1,2:5,6-dibenzanthracene
*fluorene
*fluoranthene
indeno-(1,2,3-C.D) pyrene
*napthalene
*phenanthrene
*pyrene

The polynuclear aromatic compounds are so named because they consist of two or more benzene rings which share a pair of carbon atoms. These aromatic rings which share a pair of carbon atoms are also called fused-ring hydrocarbons.

All of these PNA's are obtained from coal tar, which is obtained as a by-product of the high temperature cooking of bituminous coal (Morrison and Boyd, 1966). Napthalene is the most abundant of all constituents obtained from coal tar, comprising approximately 5 percent of the coal tar mixture. Since creosote is a product of the fractional distillation of coal tar, creosote would be expected to contain many of the PNA's. Analyses performed on creosote mixtures by several investigators [(Lorenz and Gjovik, 1972) and (NRCC, 1945)] identified the PNA's in the above list marked with an asterisk, as well as a great number of other PNA's not included in the priority pollutant list. It is quite likely that the PNA's listed above which are not marked with an asterisk are also present in trace amounts in some creosote mixtures.

With a few exceptions, the toxicity of individual PNA's is not well documented in the literature. Derivatives of 1,2 benzanthracene have been reported to have carcinogenic properties (Morrison and Boyd, 1966). There is a great deal of information on the acute and chronic toxicity of creosote mixtures (Brislin, et al., 1976). While direct ingestion of large amounts of creosote or prolonged skin contact may cause acute toxicity in humans, animals, and aquatic biota, the chronic effects of small amounts of creosote in the environment appear to pose a much smaller health hazard than similar amounts of chlorinated hydrocarbons.

As expected, PNA compounds were detected in the raw and treated wastewater streams of the wood preserving industry. Table VI-4 presents the range of concentrations for specific PNA's which were found in the raw and treated wastewater samples collected at three wood preserving plants, all of which treated with creosote.

PNA's are relatively soluble in organic solvents and relatively insoluble in water, indicating that efficient oil-water separation is necessary to reduce the PNA content of wastewater. It is significant to note that the one wood preserving plant sampled during screening which employed biological treatment exhibited complete removal of PNA's to below the level of detection.

No incidence of use or production of PNA's was found in the insulation board and wet process hardboard industries, and no measurable quantities of PNA's were detected during the screening program for these industries.

Chlorobenzenes

1,2-dichlorobenzene
1,3-dichlorobenzene

Table VI-4. Range of PNA Concentrations Found in Samples from Three Wood Preserving Plants.

Compound	Concentration, mg/l	
	Raw Wastewater	Treated Effluent
Acenapthene	20.6	0.1
Acenapthylene	2.4 - 3.15	0.36
Anthracene or Phenanthrene*	0.01 - 39.8	0.04 - 7.1
1,2 benzanthracene	0.44 - 3.3	--
Chrysene	1.7 - 2.6	0.13
Fluoranthene	.03 - 23.3	0.01
Fluorene	.015 - 18.8	0.03 - 1.06
Napthalene	0.09 - 27.8	1.1
Pyrene	.03 - 16.5	.01 - 1.18

*Analytical procedure could not distinguish between the two isomers.

SOURCE: 1977 Screening Sampling Program.

1,4-dichlorobenzene
1,2,4-trichlorobenzene
hexachlorobenzene

These compounds are synthetically formed by substitution of two or more chlorine atoms along the benzene ring. The dichlorobenzenes are used as solvents, degreasing agents, and as insecticidal fumigants. The tri- and hexachlorobenzenes are used primarily for their insecticidal and fungicidal properties.

No incidence of use in the wood products industry has been reported in the literature or by the plants surveyed. No measurable concentration of these compounds has been detected in the screening sampling program.

Phthalate Esters

bis (2-ethylhexyl) phthlate
butyl benzyl phthlate
di-n-butyl phthlate
diethyl phthlate
dimethyl phthlate

The phthlate esters are commercially synthesized compounds used extensively as plasticizers and for commercial polymers and plastic end products. No incidence of the use or production of the phthlate esters was found in the literature or in the survey of timber products plants. Analysis of the manufacturing operations and raw materials of the wood preserving, insulation board, and wet process hardboard industries does not provide any evidence for the presence of the phthlate esters in either the raw wastewater streams or treated effluents.

Concentrations between 0.01 and 5.94 mg/l of di-n-butyl, di-ethyl-hexyl, butyl benzyl, and di-ethyl phthlate esters, were found in most of the screening samples.

The possibility that phthlate contamination may have been due to the plastic tubing used during the screening sampling program was investigated. The inlet tubing specified by the EPA protocol was hospital/surgical grade PVC tubing. Pexecon #6 PVC Premium tubing with a 1/4 in inside diameter and a 1/16 in wall thickness was used during the collection of screening samples. It was assumed at the time that use of this tubing would limit organic contamination of the samples. A paper which appeared in the Journal of Environmental Science and Technology (Junk, et al., 1974) contradicts this assumption.

Junk tested for organic contamination of purified water flowing through 25-foot lengths of several commercially obtained types of tubing, including hospital/surgical grade PVC. The results clearly show that significant amounts of organic contaminants were leached from the tubing and that the phthlate esters appeared most frequently among the five most

dominant contaminants. None of the other contaminants were priority pollutants.

Junk's experimental conditions closely approximate conditions encountered during field sampling using peristaltic sampling equipment. The low pH and organic solvents contained in many timber effluents can be expected to increase the amount of contamination leached from the tubing. Furthermore, Junk demonstrated that the amount of contamination may be directly related to the linear velocity of the flow in the tube. Sampling equipment with a high linear flow rate was used in order to prevent settling out of solids in the sampler.

Haloethers

bis (2-chloroethyl) ether
bis (2-chloroisopropyl) ether
bis (2-chloroethoxy) methane
4-bromophenyl phenyl ether
4-chlorophenyl phenyl ether

The haloethers are synthetically produced compounds used commercially as chemical intermediates, solvents, and for their heat transfer properties.

No incidence of use in the wood products industry has been reported in the literature or by the plants surveyed. No measurable concentration of these compounds has been detected in the screening sampling program.

Nitrosamines

N-nitrosodimethylamine
N-nitrosodiphenylamine
N-nitrosodi-n-propylamine

Nitrosamines are highly carcinogenic compounds, some of which may occur in nature and some of which are commercially produced. N-nitrosodimethylamine occurs in trace amounts in tobacco smoke condensates. Nitrosamines can also be formed inside the human digestive tract in the presence of nitrites and nitrates by interaction with secondary and tertiary amines from protein (Mitchell, 1974). N-nitrosodiphenyl amine has been commercially produced for use as an accelerator in vulcanizing rubber.

No incidence of use in the wood products industry has been reported in the literature or by the plants surveyed. One screening sample of a treated effluent from a wood preserving plant exhibited 0.006 mg/l of N-nitrosodiphenyl amine, however the presence of this compound in the amount detected is considered to be incidental to the wood preserving process. No other sample from this or from two other wood preserving plants, two insulation board plants, and two wet process hardboard plants showed a measurable amount of nitrosamines.

Nitro-substituted Aromatics Other than Phenols

nitrobenzene
2,4-dinitrotoluene
2,6-dinitrotoluene

Nitrobenzene is synthetically produced for commercial use in soaps, shoe polish, and as a chemical intermediate. Dinitrotoluene (DNT) is an important intermediate in the production of the explosive TNT (trinitrotoluene).

No incidence of use in the wood products industry has been reported in the literature or by the plants surveyed. No measurable concentration of these compounds has been detected in the screening sampling program.

Benzidine Compounds

benzidine
3,3'-dichlorobenzidine

Benzidine compounds are synthetically produced compounds used primarily in the manufacture of dyes. Carcinogenic properties of benzidine are well established.

No incidence of use in the wood products industry has been reported in the literature or by the plants surveyed. No measurable concentration of these compounds has been detected in the screening sampling program.

Miscellaneous Semi-Volatile Organic Priority Pollutants

1,2 diphenylhydrazine
hexachlorethane
hexachlorobutadiene
hexachloropentadiene
2-chloronapthalene
isophorone
2,3,7,8-tetrachlorodibenzo-p-dioxin

1-1-diphenylhydrazine is a synthetically produced, highly reactive chemical intermediate. Hexachloroethane is a synthetically produced compound used commercially as a solvent and chemical intermediate. Hexachlorobutadienes and hexachloropentadienes are synthetically produced compounds of importance as monomers in the production of plastics. 2-chloronapthalene is synthetically produced for use as solvent for fats, oils, and DDT. Isophorone is also synthetically produced for use as a solvent for pesticides, polyvinyl and nitrocellulose resins, and lacquers. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is an extremely carcinogenic compound produced mainly as a nuisance by-product during chemical synthesis of the herbicide 2,4,5-trichlorophenoxy-acetic-acid (2,4,5-T). Although several compounds of the dioxin family have been detected as

contaminants in commercial pentachlorophenol (Johnson, et al., 1975), TCDD has not been detected and is not believed to occur in pentachlorophenol.

No incidence of use in the wood products industry has been reported in the literature or by the plants surveyed for these compounds. No measurable concentration of these compounds has been detected in the screening sampling program.

Inorganic Priority Pollutants

antimony
arsenic
asbestos
beryllium
cadmium
chromium
copper
cyanide
lead
mercury
nickel
selenium
silver
thallium
zinc

Cyanide was analyzed according to Standard Methods (AHPA, 1976). Asbestos was not analyzed due to the lack of an acceptable procedure for analysis and the extreme improbability that asbestos would appear in discharges of the timber products industry. Metals were analyzed by inductively coupled argon plasma atomic-emission spectroscopy.

Of all the cyanides, hydrogen cyanide (HCN) is probably the most acutely lethal compound. HCN dissociates in water to hydrogen ions and cyanide ions in a pH dependent reaction. The cyanide ion is less acutely lethal than HCN. The relationship of pH to HCN shows that as the pH is lowered below 7, there is less than 1 percent of the cyanide molecules in the form of the CN ion while the rest is present as HCN. When the pH is increased to 8, 9, and 10, the percentage of cyanide present as CN ion is 6.7, 42, and 87 percent, respectively.

The toxicity of cyanides is also increased by elevations in temperature and reductions in oxygen tensions. A temperature rise of 10°C produces a two- to threefold increase in the rate of the lethal action of cyanide. The harmful effects of the cyanides on aquatic life are affected by the pH, temperature, dissolved oxygen content, and the concentration of minerals in the water. The biochemical degradation of cyanide is not affected by temperature in the range of 10 to 35°C.

With lower forms of life, cyanide does not seem to be as toxic as it is toward fish. The organisms that digest BOD were found to be inhibited at 1.0 mg/l and at 60 mg/l, although the effect is more one of delay in exertion of BOD than total reduction.

Certain metals, such as nickel, may complex with cyanide to reduce lethality, especially at higher pH values. On the other hand, zinc and cadmium cyanide complexes may be exceedingly toxic.

No incidence of use of cyanide in the wood products industry has been reported in the literature or by the plants surveyed. No measurable concentration of this compound has been detected in the screening sampling program.

Antimony is a silver-white, lustrous, hard, brittle metal found in nature as stibnite and is used in manufacture of alloys such as hard lead, white metal, type, Babbit metal, and bearing metal. It is also used in fireworks, and for metal coating. Information on the toxicity of antimony and its compounds due to direct exposure has been reported (Browning, 1969). Information on the toxicity of antimony to aquatic biota is more limited.

Arsenic is a shiny, gray, brittle element possessing both metallic and nonmetallic properties. Compounds of arsenic are ubiquitous in nature, insoluble in water, and occur mostly as arsenides and arsenopyrites. Samplings from 130 water stations in the United States have shown arsenic concentrations of 5 to 336 ug/l with a mean level of 64 ug/l (Kopp,1969). Arsenic normally is present in sea water at concentrations of 2 to 3 ug/l.

Arsenic exists in the trivalent and pentavalent states and its compounds may be either organic or inorganic. Trivalent inorganic arsenicals are more toxic than the pentavalent forms both to mammals and aquatic species. Though most forms of arsenic are toxic to humans, arsenicals have been used in the medical treatment of spirochaetal infections, blood dyscrasias, and dermatitis (Merck Index, 1968). Arsenic and arsenicals have many diversified industrial uses including hardening of copper and lead alloys, pigmentation in paints and fireworks, and the manufacture of glass, cloth and electrical semiconductors. Arsenicals are used in the wood preserving industry as treatment chemicals. The most common preservatives containing arsenic are CCA compounds which are mixtures of copper, chromium, and arsenic salts, FCAP which contains chromium, arsenic, and fluoride salts, as well as 2,4-dinitrophenol, and ACA which contains both arsenic and copper. In both formulations, the arsenic exists in pentavalent form.

Table VI-5 presents the common inorganic wood preservatives and fire retardants, and lists the inorganic priority pollutants which are found in these formulations.

Table VI-5. Inorganic Priority Pollutants in Water-borne Preservatives and Fire Retardants.

Industry Designation	Appendix A Compounds				
	As	Cu	Cr	Zn	2,4 dinitro-phenol
Acid Copper Chromate (ACC)		X	X		
Ammonical Copper Arsenate (ACA)	X	X			
Chromated Copper Arsenate (CCA)--Type A	X	X	X		
Type B	X	X	X		
Type C	X	X	X		
Chromated Zinc Chloride (CZC)			X	X	
Fluor Chrome Arsenate Phenol (FCAP)	X		X		X
Fire Retardants			X	X	

SOURCE: Thompson, 1976.

Beryllium is a rare earth metal produced industrially from the mineral beryl ($3\ BeO \cdot Al_2O_3 \cdot 6SiO_2$). Beryllium is also found in chrysoberyl ($BeO \cdot Al_2O_3$) and phenate ($Be \cdot SiO_4$). It is a gray metal with a close-packed hexagonal structure. Major industrial uses of beryllium are as a neutron reflector and moderator in nuclear reactors, in radio tube parts, and in the aerospace industry.

Beryllium is not likely to occur at significantly toxic levels in ambient natural waters (McKee and Wolf, 1963). Although the chloride and nitrate salts of beryllium are very water-soluble, and the sulfate is moderately so, the carbonate and hydroxide are almost insoluble in cold water (Lange, 1961). Kopp and Kroner (1967) reported that for 1,577 surface water samples collected at 130 sampling points in the United States, 85 samples (5.4 percent) contained from 0.01 to 1.22 ug/l with a mean of 0.19 ug/l beryllium. The concentration of beryllium in sea water is 6×10^{-4} ug/l (Goldberg, et al., 1977).

Cadmium is a soft, white, easily-fusible metal similar to zinc and lead in many properties, and is readily soluble in mineral acids. Biologically, cadmium is a nonessential, nonbeneficial element recognized to be of high toxic potential. It is deposited and accumulated in various body tissues and is found in varying concentrations throughout all areas where man lives. Within the past two decades industrial production and use of the metal has increased. Concomitantly, there have been incidences of acute cases of clinically identifiable cadmiosis. Cadmium may function in or may be an etiological factor for various human pathological processes including testicular tumors, renal dysfunction, hypertension, arteriosclerosis, growth inhibition, chronic diseases of old age, and cancer.

Cadmium occurs in nature chiefly as a sulfide salt, frequently in association with zinc and lead ores. Accumulations of cadmium in soils in the vicinity of mines and smelters may result in high local concentrations in nearby waters. The salts of the metal also may occur in wastes from electroplating plants, pigment works, textile and chemical industries. Seepage of cadmium from electroplating plants has resulted in groundwater cadmium concentrations of 0.01 to 3.2 mg/l (Lieber and Welsch, 1954). Kopp and Kroner (1967) on one occasion reported 120 ug/l dissolved cadmium in the Cuyahoga River at Cleveland, Ohio. However, dissolved cadmium was found in less than 3 percent of 1,577 water samples examined in the United States, with a mean of slightly under 10 ug/l. Most fresh waters contain less than 1 ug/l cadmium, and most analyses of seawater indicate an average concentration of about 0.15 ug/l (Fleischer, et al., 1974).

Chromium is the seventeenth most abundant nongaseous element in the earth's crust (Schroeder, 1970); its concentration range in the continental crust is 80 to 200 mg/kg, with an average of 125 mg/kg (NAS, 1974a). Although chromium has oxidation states ranging from -2 to -6, the

trivalent form most commonly is found in nature. Chromium is found rarely in natural waters, ranking twenty-seventh or lower among the elements in seawater and generally is well below 1 ug/l. Kopp (1969) reported that for 1,577 surface water samples collected at 130 sampling points in the United States, 386 samples contained from 1 to 112 ug/l; the mean was 9.7 ug/l chromium. Durum, et al. (1971), in a similar survey of 700 samples, found that none contained over 50 ug/l of hexavalent chromium and 11 contained over 5 ug/l. Chromium is found in air, soil, some foods, and most biological systems; it is recognized as an essential trace element for humans (NAS, 1974a).

Chromium salts are a major component of most common inorganic wood preservative chemical mixtures, as shown in Table VI-5.

Copper occurs as a natural or native metal and in various mineral forms such as cuprite and malachite. The most important copper ores are sulfides, oxides, and carbonates. Copper has been mined and used in a variety of products since prehistoric times. Uses for copper include electrical products, coins, and metal plating. Copper frequently is alloyed with other metals to form various brasses and bronzes. Oxides and sulfates of copper are used for pesticides, algicides, and fungicides. Copper frequently is incorporated into paints and wood preservatives to inhibit growth of algae and invertebrate organisms, such as the woodborer, Teredo, on vessels. The use of copper salts in common inorganic wood preservative chemical mixtures is shown in Table VI-5.

Copper is an essential trace element for the propagation of plants and performs vital functions in several enzymes and a major role in the synthesis of chlorophyll. A shortage of copper in soil may lead to chlorosis which is characterized by yellowing of plant leaves. In copper deficient soils, it may be added as a trace nutrient supplement to other fertilizers.

Copper is required in animal metabolism. It is important in invertebrate blood chemistry and for the synthesis of hemoglobin. In some invertebrate organisms a protein, hemocyanin, contains copper and serves as the oxygen-carrying mechanism in the blood. An overdose of ingested copper in mammals acts as an emetic.

In examining over 1500 surface water samples from the United States, Kopp and Kroner (1967) found soluble copper in 74 percent of the samples with an average concentration of 15 ug/l and a maximum concentration of 280 ug/l of copper. The average concentration of copper in seawater is approximately 3.0 ug/l (Mero, 1964).

In addition to their natural occurrence, lead and its compounds may enter and contaminate the global environment at any stage during mining, smelting, processing, and use. The annual increase in lead consumption in the U.S. during the ten-year period from 1962-1971 averaged 2.9 percent, largely due to increased demands for electrochemical batteries and

gasoline additives (Ryan, 1971). Of the 1971 U.S. lead consumption, approximately 25 percent was as metallic lead or lead alloy (Ryan, 1971; NAS, 1972). Non-industrial sources that may contribute to the possibility of ingestion of lead by man include the indoor use of lead-bearing paints and plaster, improperly glazed earthenware, lead fumes on ashes produced in burning lead battery casings, and exhaust from internal combustion engines.

Most lead salts are of low solubility. Lead exists in nature mainly as lead sulfide (galena); other common natural forms are lead carbonate (cerussite), lead sulfate (anglesite), and lead chlorophosphate (pyromorphite). Stable complexes result also from the interaction of lead with the sulfhydryl, carboxyl, and amine coordination sites characteristically found in living matter. The toxicity of lead in water, like that of other heavy metals, is effected by pH, hardness, organic materials, and the presence of other metals. The aqueous solubility of lead ranges from 500 ug/l in soft water to 3 ug/l in hard water.

Lead enters the aquatic environment through precipitation, lead dust fallout, erosion and leaching of soil, municipal and industrial waste discharges, and the runoff of fallout deposits from streets and other surfaces. Extrapolations from recent studies (EPA, 1972; University of Illinois, 1972) indicate that nationally as much as 5,000 tons of lead per year may be added to the aquatic environment as a result of urban runoff.

Mediterranean and Pacific surface waters contain up to 0.20 and 0.35 mg/l of lead, respectively (NAS, 1972), which is about 10 times the estimated pre-industrial lead content of marine waters. The lead content of rivers and lakes also has increased in recent years (NAS, 1972). It may be inferred from available data that the mean natural lead content of the world's lakes and rivers ranges from 1 to 10 ug/l (Livingstone, 1963); the lead content of rural U.S. soils is 10 to 15 ug/g (Chow and Patterson, 1962), and the usual range of lead-in-soil concentrations is 2 to 200 ppm, exclusive of areas near lead ore deposits (Motto, et al., 1970), although many urban soil concentrations are much higher.

In the analyses of over 1,500 stream samples, Kopp and Kroner (1967) report that lead was observed at measurable levels with a frequency of under 20 percent. The mean concentration of the positive occurrences was 23 ug/l. The highest incidence of occurrence of lead was observed in the Western Great Lakes Basin where the frequency was slightly above 40 percent. The highest recorded concentration was 140 ug/l in the Ohio River at Evansville, Indiana.

As far as is known, lead has no beneficial or desirable nutritional effects. Lead is a toxic metal that tends to accumulate in the tissues of man and other animals. Although seldom seen in the adult population, irreversible damage to the brain is a frequent result of lead intoxication

in children. Such lead intoxication most commonly results from ingestion of lead-containing paint still found in older homes.

Mercury is a silver-white, liquid metal solidifying at -38.9°C to form a tin-white, ductile, malleable mass. It boils at 356.9°C, has a specific gravity of 13.6 and a vapor pressure of 1.2×10^{-3} mm of mercury. Mercury has three oxidation states: (1) zero (elemental mercury); (2) +1 (mercurous compounds); and (3) +2 (mercuric compounds). Mercury is widely distributed in the environment and biologically is a nonessential or nonbeneficial element. Historically it was recognized to possess a high toxic potential and was used as a germicidal or fungicidal agent for medical and agricultural purposes. Mercury intoxication may be acute or chronic and toxic effects vary with the form of mercury and its mode of entry into the organism. The mercurous salts are less soluble than the mercuric and consequently are less toxic. For man, the fatal oral dose of mercuric salts ranges from 20 mg to 3.0 g (Stokinger, 1963). Symptoms of acute, inorganic mercury poisoning include pharyngitis, gastroenteritis, vomiting followed by ulcerative hemorrhagic colitis, and nephritis.

Human poisoning by mercury or its compounds clinically has been recognized. Although its toxic properties are well known, dramatic instances of toxicosis in man and animals have occurred recently, e.g., the Minamata Bay poisonings (Irukayama, et al., 1962; Irukayama, 1967). In addition to the incidents in Japan, poisonings have also occurred in Iraq, Pakistan, and Guatemala as a result of ingestion of flour and seed treated with methyl and ethylmercury compounds (Bakir, et al., 1973).

Chronic mercury poisoning results from exposure to small amounts of mercury over extended time periods. Chronic poisoning from inorganic mercurials most often has been associated with industrial exposure, whereas poisoning from the organic derivatives has been the result of accidents or environmental contamination. Alkyl compounds are the derivatives of mercury most toxic to man, producing illness, irreversible neurological damage, or death from the ingestion of amounts in milligrams (Berglund and Berlin, 1969).

The mercury content of unpolluted U.S. rivers from 31 states where natural mercury deposits are unknown is less than 0.1 ug/l (Wershaw, 1970). Jenne (1972) found also that the majority of U.S. waters contained less than 0.1 ug/l of mercury. The lower limit of detection in these studies was 0.1 ug/l. Total mercury values of 0.045 ug/l recently were determined in Connecticut River water by Fitzgerald and Lyons (1973) using more sensitive methods. Marine waters have been shown to contain concentrations of mercury from a low of 0.03 to a high of 0.2 ug/l, but most marine waters fall within range of 0.05 to 0.19 ug/l mercury (Robertson, et al., 1972). Mining, agriculture, and waste discharges contribute to the natural levels found.

Nickel is a silver-white, metallic element seldom occurring in nature in the elemental form. Nickel salts are soluble and can occur as a leachate

from nickel-bearing ores. Nickel is used industrially for nickel plating; various alloys, especially with silver, in batteries, electrical contacts, and as a catalyst in organic chemical reactions. Kopp and Kroner (1967) detected nickel in the Lake Erie Basin at a frequency of 53 percent and a mean concentration of 56 ug/l. At several selected stations, dissolved nickel ranged from 3 to 86 ug/l and suspended nickel from 5 to 900 ug/l. Nickel is present in sea water at 5 to 7 ug/l (NAS, 1974).

Nickel is considered to be relatively nontoxic to man (Schroeder, et al., 1961) and a limit for nickel is not included in the EPA National Interim Primary Drinking Water Regulations (40 FR 59566, December 24, 1975). The toxicity of nickel to aquatic life, as reported by McKee and Wolf (1963), indicates tolerances that vary widely and that are influenced by species, pH, synergistic effects and other factors.

Selenium is a trace element in the earth's crust which is found naturally in the sulfide ores of the heavy metals. Major industrial uses of selenium are as an ingredient of toning baths in photography, as a pigment for colored glass, electrical components, and as a chemical catalyst.

Biologically, selenium is an essential, beneficial element recognized as a metabolic requirement in trace amounts for animals but toxic to them when ingested in amounts ranging from about 0.1 to 10 mg/kg of food. The national levels of selenium in water are proportional to the selenium in the soil. In low selenium areas, the content of water may be well below 1 ug/l (Lindberg, 1968). In water from seleniferous areas, levels of selenium of 50 to 300 ug/l have been reported (WHO, 1972). Selenium appears in the soil as basic ferric selenite, calcium selenate, and as elemental selenium. Elemental selenium must be oxidized to selenite or selenate before it has appreciable solubility in water.

Selenium is considered toxic to man. Symptoms appear similar to those of arsenic poisoning (Keboe, et al., 1944; Fairhill, 1941). Any consideration of the toxicity of selenium to man must take into consideration the dietary requirement for the element in amounts estimated to be 0.04 to 0.10 mg/kg of food. Considering this requirement in conjunction with evidence that ingestion of selenium in amounts as low as 0.07 mg per day has been shown to give rise to signs of selenium toxicity, selenium concentrations above 10 ug/l should not be permitted in drinking water (Smith, et al., 1936; Smith and West, 1937). The USPHS drinking water standards recommend that drinking water supplies contain no more than 0.01 mg/l of selenium (USPHS, 1962).

Selenium in water apparently is toxic at concentrations of 2.5 mg/l or less to those few species tested. Animals can beneficially metabolize ingested selenium in amounts of 0.01 to 0.10 mg/kg of food.

Biologically, silver is a nonessential, nonbeneficial element recognized as causing localized skin discoloration in humans, and as being

systemically toxic to aquatic life. Ingestion of silver or silver salts by humans results in deposition of silver in skin, eyes and mucous membranes that causes a blue-gray discoloration without apparent systemic reaction (Hill, 1957). Because of its strong bactericidal action, silver has been considered for use as a water disinfectant. Dosages of 0.001 to 500 ug/l of silver have been reported sufficient to sterilize water (McKee and Wolf, 1963). At these concentrations, the ingestion of silver has no obvious detrimental effect on humans.

The 1962 USPHS Drinking Water Standards contained a limit for silver of 0.05 mg/l. This limit was established because of the evidence that silver, once absorbed, is held indefinitely in tissues, particularly the skin, without evident loss through usual channels of elimination or reduction by transmigration to other body sites, and because of the probable high absorbability of silver bound to sulfur components of food cooked in silver-containing water (Aub and Fairhall, 1942).

It is apparent that there is a wide variation in the toxicity of silver compounds to aquatic life and that the degree of dissociation characteristic of these compounds affects toxicity. Little information is available on the movement and chemical stability of these compounds in the aquatic environment.

Thallium is a bluish-white, very soft, easily fusible heavy metal. It forms alloys with other metals and readily amalgamates with mercury. Thallium is found in nature in several mineral forms, particularly in association with the sulfide ores of other heavy metals. Thallium salts are used in rat poison and in electrical components. Toxicity of thallium, both acute and chronic, has been reported in the literature (Browning, 1969).

Zinc is usually found in nature as the sulfide; it is often associated with sulfides of other metals, especially lead, copper, cadmium, and iron. Most other zinc minerals probably are formed as oxidation products of the sulfide; they represent only minor sources of zinc. Nearly 3,000,000 short tons of recoverable zinc per year are mined in the world; about 500,000 tons of this come from the United States.

Zinc (as metal) is used in galvanizing, i.e., coating (not dipping) of various iron and steel surfaces with a thin layer of zinc to retard corrosion of the coated metal. In contact with iron, zinc is oxidized preferentially, thus protecting the iron. The second most important use of zinc, reaching major proportions in the last quarter century, is in the preparation of alloys for dye casting. Zinc is used also in brass and bronze alloys, slush castings (in the rolled or extruded state), in the production of zinc oxide and other chemical products, and in photoengraving and printing plates. Zinc salts are widely used in inorganic wood preservative chemicals, as shown in Table VI-5.

Kopp and Kroner (1967) report that in 1,207 positive tests for zinc on samples from U.S. waterways, the maximum observed value was 1,183 ug/l (Cuyahoga River at Cleveland, Ohio) and the mean was 64 ug/l. Dissolved zinc was measured in over 76 percent of all water samples tested. The highest mean zinc value, 205 ug/l, was found in the Lake Erie Basin, whereas the lowest mean zinc value, 16 ug/l, was observed in the California Basin. In seawater, zinc is found at a maximum concentration of about 10 ug/l.

Zinc is an essential and beneficial element in human metabolism (Vallee, 1957). The daily requirement of preschool-aged children is 0.3 mg Zn/kg body weight. The daily adult human intake averages 0 to 15 mg zinc; deficiency in children leads to growth retardation. Community water supplies have contained 11 to 27 mg/l without harmful effects (Anderson, et al., 1934; Bartow and Weigle, 1932).

The toxicity of zinc compounds to aquatic animals is modified by several environmental factors, particularly hardness, dissolved oxygen, and temperature. Skidmore (1964), in undertaking a review of the literature on the toxicity of zinc to fish, reported that salts of the alkaline-earth metals are antagonistic to the action of zinc salts, and salts of certain heavy metals are synergistic in soft water. Both an increase in temperature and a reduction in dissolved oxygen increase the toxicity of zinc. Toxic concentrations of zinc compounds cause adverse changes in the morphology and physiology of fish. Acutely toxic concentrations induce cellular breakdown of the gills, and possibly the clogging of the gills with mucus. Chronically toxic concentrations of zinc compounds, in contrast, cause general enfeeblement and widespread histological changes to many organs, but not to gills. Growth and maturation are retarded.

Insulation board and wet process hardboard plants which apply painted finishes to their products reported the use of several of the heavy metals including zinc, chromium, and lead as paint additives. Finishing wastes discharged by these plants in raw wastewater are usually less than 500 gallons per day of diluted paint in the washdown water.

The presence of the inorganic heavy metals in the raw and treated wastestreams of plants from the wood preserving, insulation board, and hardboard industries as determined during the screening sampling program are reported in Tables VI-6 through VI-8.

Traditional Parameters

Organic Pollutants

Organic pollutants which are amenable to biological and chemical decomposition in receiving waters exert an oxygen demand on these waters during the process of decomposition. Oxygen demanding wastes consume dissolved oxygen (DO). In appropriate concentrations, DO is essential not only to keep organisms living but also to sustain species reproduction, vigor,

Table VI-6. Metals Analysis: Wood Preserving

Parameter	Concentrations in mg/l					
	Raw Wastewater			Treated Effluent Discharge		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Antimony	0.003	1.00	0.502	0.003	0.008	0.006
Arsenic	0.027	30.0	15.0	0.048	0.340	0.194
Beryllium	0.040	0.040	0.040	N.D.*	N.D.	N.D.
Cadmium	0.140	0.500	0.320	0.140	0.140	0.140
Chromium	0.685	6000	3000	0.039	0.236	0.138
Copper	0.024	5000	2500	0.062	0.062	0.062
Lead	0.188	4.00	2.09	N.D.	N.D.	N.D.
Mercury	0.001	0.007	0.004	0.001	0.019	0.01
Nickel	0.623	1.50	1.06	0.055	0.055	0.055
Selenium	0.024	0.550	0.287	0.010	0.020	0.015
Silver	0.025	0.500	0.263	N.D.	N.D.	N.D.
Thallium	0.050	0.090	0.070	0.060	0.060	0.060
Zinc	0.048	80	40.0	0.065	3.34	1.70

* N.D. indicates not detected.

SOURCE: 1977 Screening Sampling Program.

Table VI-7. Metals Analysis: Insulation Board.

Parameter	Concentrations in mg/l					
	Raw Wastewater			Treated Effluent Discharge		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Antimony	0.005	0.076	0.041	0.004	0.004	0.004
Arsenic	0.007	0.090	0.049	0.025	0.070	0.048
Beryllium	N.D.*	N.D.	N.D.	N.D.	N.D.	N.D.
Cadmium	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chromium	0.053	0.053	0.053	0.039	0.039	0.039
Copper	0.020	0.057	0.039	0.135	0.135	0.135
Lead	0.077	0.077	0.077	N.D.	N.D.	N.D.
Mercury	0.003	0.003	0.003	0.001	0.019	0.010
Nickel	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Selenium	0.005	0.017	0.011	0.006	0.011	0.009
Silver	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Thallium	0.065	0.065	0.065	N.D.	N.D.	N.D.
Zinc	0.265	0.265	0.265	0.052	0.282	0.167

* N.D. indicates not detected.

SOURCE: 1977 Screening Sampling Program.

Table VI-8. Metals Analysis: Hardboard.

Parameter	Concentrations in mg/l					
	Raw Wastewater			Treated Effluent Discharge		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Antimony	0.003	0.003	0.003	0.017	0.017	0.017
Arsenic	0.042	0.125	0.084	0.150	0.150	0.150
Beryllium	N.D.*	N.D.	N.D.	N.D.	N.D.	N.D.
Cadmium	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chromium	0.529	0.529	0.529	0.170	0.170	0.170
Copper	0.120	0.120	0.120	0.172	0.172	0.172
Lead	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Mercury	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Nickel	N.D.	N.D.	N.D.	0.146	0.146	0.146
Selenium	0.006	0.010	0.008	N.D.	N.D.	N.D.
Silver	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Thallium	0.190	0.190	0.190	N.D.	N.D.	N.D.
Zinc	0.032	5.86	2.95	1.66	1.66	1.66

* N.D. indicates not detected.

SOURCE: 1977 Screening Sampling Program.

and the development of populations. At reduced DO concentrations organisms undergo stress that make them less competitive and less capable of sustaining 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 the young, interference with food digestion, acceleration of blood clotting, decreased tolerance to certain toxicants, reduced food utilization efficiency and growth rate, and reduced maximum sustained swimming speed. Fish food organisms are likewise effected adversely in conditions of depressed DO. Since all aerobic aquatic organisms need a certain amount of oxygen, the occurrence of a total lack of dissolved oxygen due to a high oxygen demand of wastes can kill all aerobic inhabitants of the affected area.

The three methods commonly used to measure the organic content of wastewaters are the Biochemical Oxygen Demand (BOD) analysis, the Chemical Oxygen Demand (COD) analysis, and the Total Organic Carbon (TOC) analysis. Each of these methods have certain advantages and disadvantages when applied to industrial wastewaters.

The BOD test is essentially a bioassay procedure involving the measurement of oxygen consumed by living organisms while utilizing the organic matter present in a wastewater under certain standard conditions. Historically, the BOD test has been used to evaluate the performance of biological wastewater treatment facilities and to establish effluent limitation values. Some limitations to the use of the BOD test to control or monitor effluent quality include the following:

1. The standard BOD test takes five days before the results are available. This tends to decrease its usefulness as an operational control monitor.

2. At the start of the BOD test, a seed culture of microorganisms is added to the BOD bottle. If the seed culture is not acclimated (i.e., exposed to a similar wastewater in the past), then it may not readily biologically degrade the waste, and a low BOD value may be reported. This situation is most likely to occur when dealing with complex industrial wastes. The necessity of using acclimated seed often contributes to the difficulty of different analysts obtaining duplicate values of BOD on industrial wastes.

3. The BOD test is sensitive to toxic materials, as are all biological processes. Therefore, if toxic materials are present in a particular wastewater, the reported BOD value may very well be depressed. This situation can be remedied by conducting a microorganism toxicity test, i.e., serially diluting the sample until the BOD value reaches a plateau indicating that the material is at a concentration which no longer inhibits biological oxidation.

It is important to note that most of the state, local, and regional authorities have established water quality regulations utilizing BOD as the major parameter for determination of oxygen demand on a water body. Most of the large body of historical data on organic pollutant loading compiled by the insulation board and hardboard industries is in terms of BOD.

The chemical oxygen demand (COD) determination provides a measure of the oxygen equivalent of that portion of the organic matter in a sample that is susceptible to oxidation by a strong chemical oxidant. It is an important parameter that can be rapidly measured. However, the method fails to include some organic compounds (such as acetic acid) which are biologically available to the stream organisms, while including some biologic compounds (such as cellulose) which are not a part of the immediate biochemical load on the oxygen assets of the receiving water. The carbonaceous portion of nitrogenous compounds can be determined, but there is no reduction of the dichromate by ammonia in a waste or by any ammonia liberated from the proteinaceous matter.

When an industrial wastewater contains substances which tend to inhibit biological degradation of the organic matter, COD or total organic carbon (TOC) may be the best method for determination of the organic load. Because of its prolonged exposure to temperatures in the range of 110° to 121°C (230° to 250°F) and its relatively high content of phenolic compounds, wood preserving process water is sterile upon its discharge from retorts. Its successful biological treatment requires the employment of strains of bacteria that have been acclimated to concentrations of phenolic compounds of 300 mg/liter or higher. On a laboratory scale, this requirement renders BOD determinations difficult and makes the determinations almost impossible to interpret, especially as regards comparisons of results obtained by different analysts. It is not possible to ascertain whether the differences obtained are due to the characteristics of the waste samples or to differences in the bacterial cultures employed and their degree of acclimation to the waste. Since the correlation between BOD and COD for wood preserving wastewaters is high, (Dust and Thompson, 1973), COD is a more useful indicator of organic pollution due to wood preserving wastewater than BOD.

The TOC analysis offers a third option for measurement of organic pollutants in wastewaters. The method measures the total organic carbon content of the wastewater by a combustion method. The results may be used to assess the ultimate potential oxygen-demanding load exerted by the carbonaceous portion of a waste on a receiving stream. There is little inherent correlation among TOC and BOD or COD. A correlation must be determined for each wastewater by comparison of analytical results. TOC analysis is rapid and generally more accurate and reproducible than either BOD or COD, but it requires analytical instrumentation which may be relatively expensive if not utilized fully.

Total Suspended Solids (TSS)

Suspended solids may be (and usually are) composed of organic and inorganic fractions. These fractions, in turn, may be made up of readily settleable, slowly settleable, or nonsettleable materials.

The biodegradable organic fraction will exert an oxygen demand on a receiving water and are reflected in the analyses for organics discussed above.

Suspended solids in water interfere with many industrial processes, causing foaming in boilers and incrustation on equipment exposed to such water, especially as the temperature rises. They are undesirable in process water used in the manufacture of steel, in the textile industry, in laundries, in dyeing, and in cooling systems.

When solids settle to form sludge deposits on a stream or lake bed, they are often damaging to the life in water. Sludge deposits may blanket the stream or lake bed and thereby destroy the living spaces for those benthic organisms that would otherwise occupy the habitat. Organic materials also serve as a food source for sludgeworms and associated organisms.

Solids in suspension may be aesthetically displeasing. Also disregarding any toxic effect attributable to substances leached out by water, suspended solids may kill fish and shellfish by causing abrasive injuries and by clogging the gills and respiratory passages of various aquatic fauna. Indirectly, suspended solids are inimical to aquatic life because they screen out light and promote and maintain the development of noxious conditions through oxygen depletion. This results in the killing of fish and fish food organisms. Suspended solids also reduce the recreational value of the water.

The control of suspended solids from biological treatment systems is especially critical. Not only does the biomass exert an oxygen demand on receiving waters, but there is evidence that toxic residues may be absorbed on or in the floc which if carried over will potentially cause a toxic effect in the receiving waters.

TSS is a particularly important pollution parameter in the insulation board and hardboard industries. Raw wastewaters from these industries contain large amounts of fine cellulose fibers which are not retained in the board. Since many plants in these industries employ biological treatment systems, biological solids produced during treatment must be settled prior to discharge.

Total Phenols

In order to characterize the total phenolic content of the wastewaters from the wood preserving, insulation board, and wet-process hardboard industries, sampling and analysis for total phenols according to Standard Methods' procedure 510B was also carried out during the verification

program. This procedure is a colorimetric analysis for all phenolic compounds which does not discriminate between specific phenolic compounds. Presumably, phenol compounds which are substituted in the para position are not determined by this procedure. It should also be noted that phenols reported by this procedure may be other than those phenols listed as priority pollutants in Appendix A.

Total phenols, however, do give a reasonable indication of the phenolic content of wastewaters, and the relative treatability of phenols in treatment systems can also be determined using this method.

Data reported in Section V, Raw Wastewater Characteristics, and Section VII, Control and Treatment Technology, are for total phenols analyzed for by Standard Methods.

Due to the importance of pentachlorophenol in wood preserving wastes, this compound was analyzed during the verification program using a confirmatory GC/MS procedure developed and tested by the Mississippi State University Forest Products Laboratory.

Oil and Grease

Oil is a constituent of both creosote and pentachlorophenol-petroleum solutions. It may occur in either a free or an emulsified form in wood preserving wastewaters. Concentrations ranging from less than 100 mg/liter to well over 1,000 mg/liter are common after primary oil separation. Many of the priority pollutants found in wood preserving wastewaters, such as pentachlorophenol and polynuclear aromatics, are much more soluble in the oil phase than in the water phase of the waste stream. Oil and grease must be removed to a very low concentration in order to remove these oil soluble pollutants.

pH

pH is related to the acidity or alkalinity of a wastewater stream. It is not a linear or direct measure of either; however, it may properly be used as a surrogate to control both excess acidity and excess alkalinity in water. The term pH is used to describe the hydrogen ion-hydroxyl ion balance in water. Technically, pH is the negative logarithm of the hydrogen ion concentration or activity present in a given solution. A pH of 7 generally indicates neutrality or a balance between free hydrogen and free hydroxyl ions. A pH above 7 indicates that a solution is alkaline, while a pH below 7 indicates that the solution is acidic.

Knowledge of the pH of water or wastewater is useful in determining necessary measures for corrosion control, pollution control, and disinfection. Waters with a pH below 6.0 tend to be corrosive to waterwork structures, distribution lines, and household plumbing fixtures. Also, corrosion can add constituents such as iron, copper, zinc, cadmium, and

lead to drinking water. Low pH waters not only tend to dissolve metals from structures and fixtures but also tend to dissolve or leach metals from sludges and bottom sediments. The hydrogen ion concentration can affect the "taste" of water and, at a low pH, water tastes "sour."

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. 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. For example, metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. The bactericidal effect of chlorine in most cases is less as the pH increases.

Parameters of Interest

Based on results of the raw materials analysis, production processes analysis, plant surveys, and the screening sampling program, specific parameters of interest in the wood preserving, insulation board, and wet process hardboard industries are presented in Tables VI-9 through VI-11, respectively.

Table VI-9. Parameters of Interest in the Wood Preserving Industry.

Traditional Parameters	Priority Pollutants	
	Polynuclear Aromatics (PNA's)	**Halomethanes**
COD	acenapthene	bromoform (tribromomethane)
	acynapthylene	carbon tetrachloride (tetrachloromethane)
Total Phenols	anthracene	chloroform (trichloromethane)
	1,2-benzanthracene	chlorodibromomethane
Oil and Grease	3,4-benzofluoranthene	dichlorodifluoromethane
	11,12-benzafluoranthene	dichlorobromomethane
pH	3,4-benzoperylene	methyl bromide (bromomethane)
	1,12-benzopyrene	methyl chloride (chloromethane)
	chrysene	methylene chloride (dichloromethane)
	1,2:5,6-dibenzanthracene	trichlorofluoromethane
	fluorene	
	fluoranthene	**Heavy Metals**
	indeno-(1,2,3-C.D) pyrene	arsenic
	napthalene	chromium
	phenanthrene	copper
	pyrene	zinc
	Phenolic Compounds	
	phenol	**Aromatic Solvents**
	2-chlorophenol	benzene
	2,4-dichlorophenol	toluene
	p-chlorometa cresol	ethylbenzene
	2,4-dimethylphenol	
	2,4,6-trichlorophenol	
	2-nitrophenol	
	4,nitrophenol	
	2,4-dinitrophenol	
	4,6-dinitro-o-cresol	
	pentachlorophenol	

Table VI-10. Parameters of Interest in the Insulation Board Industry.

Traditional Parameters	Priority Pollutants
BOD	Phenolic Compounds
TSS	phenol
Total Phenols	2-chlorophenol
pH	2,4-dichlorophenol
	p-chlorometa cresol
	2,4-dimethylphenol
	2,4,6-trichlorophenol
	2-nitrophenol
	4-nitrophenol
	2,4-dinitrophenol
	4,6-dinitro-o-cresol
	pentachlorophenol

Table VI-11. Parameters of Interest in the Wet Process Hardboard Industry.

Traditional Parameters	Priority Pollutants
BOD	Phenolic Compounds
TSS	phenol
Total Phenols	2-chlorophenol
pH	2,4-dichlorophenol
	p-chlorometa cresol
	2,4-dimethylphenol
	2,4,6-trichlorophenol
	2-nitrophenol
	4-nitrophenol
	2,4-dinitrophenol
	4,6-dinitro-o-cresol
	pentachlorophenol

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

General

This section presents a discussion of the range of wastewater control and treatment technology at the disposal of the wood preserving, insulation board, and hardboard segments of the timber products processing industry. In-plant pollution abatement is discussed as well as end-of-pipe treatment.

The available performance data for plants in each industry segment is presented, and also the applicability of technology readily transferred from related industries. For the purpose of cost analysis, one or more candidate technologies are selected for each subcategory. For each technology, the levels of reduction in pollutant concentration are reported, for traditional as well as priority pollutants if available.

It should be noted that there are many possible combinations of in-plant and end-of-pipe systems capable of attaining the pollutant reductions reported for the candidate technologies. The model treatment systems proposed for each selected candidate technology are for the purposes of economic analysis only. Each individual plant must make the final decision concerning the specific combination of pollution control measures which are best suited to its particular situation, and should do so only after a careful study of the treatability of its wastewater, including waste characterization and pilot plant investigations.

Pollution abatement and control technology applicable to the industry as a whole were discussed in detail in the original Draft Development Document. Summarized versions, which included updated information on current industry practice, were presented in supplemental studies for wood preserving and hardboard production. The portion of the previous studies which detailed in-plant process changes, waste flow management, and other measures having the potential to reduce discharge volume or improve effluent quality are repeated in this document for the purpose of continuity. Additional information available from the data collection portfolios and/or the current verification sampling program is included in order to present the most recent information.

Various treatment technologies that are either currently employed, or which may be readily transferred to the industry, are summarized in this section. Included in this section are descriptions of exemplary plants and, where available, wastewater treatment data for these exemplary plants. This description is followed by a selection of several treatment regimes applicable to each subcategory.

In-Plant Control Measures

Wood Preserving

Reduction in wastewater volume--The characteristics of wood-preserving wastewater differ among plants that practice modified-closed or closed steaming. In the former process, steam condensate is allowed to accumulate in the retort during the steaming operation until it covers the heating coils. At that point, direct steaming is stopped and the remaining steam required for the cycle is generated within the retort by utilizing the heating coils. Upon completion of the steaming cycle and after recovery of oils, the water in the cylinder is discarded. In closed steaming, after recovery of free oils, the water in the retort at the end of a steaming cycle is returned to a reservoir and is reused instead of being discarded.

The principal advantage of modified-closed steaming over open steaming, aside from reducing the volume of waste released by a plant, is that effluents from the retorts are less likely to contain emulsified oils. Free oils are readily separated from the wastewater; and, as a result of the reduction in oil content, the oxygen demand and the solids content of the waste are reduced significantly relative to effluents from plants using conventional open steaming. Typical oil and COD values for wastewater from a single plant before and after the plant commenced modified-closed steaming are shown in Figures VII-1 and VII-2, respectively. The COD of the wastewater was reduced by about two-thirds when modified-closed steaming was initiated. Oil content was reduced by a factor of ten.

Water used in closed-steaming operations increases in oxygen demand, solids content, and phenol concentration with each reuse. The high oxygen demand is attributable primarily to wood extracts, principally simple sugars, the concentration of which increases with each use of the water. Because practically all of the solids content of the waste is dissolved solids, only insignificant reductions in oxygen demand and improvement in color result from treatments involving flocculation. The progressive changes in the parameters for water used in a closed-steaming operation are shown in Table VII-1 (Miss. Forest Prod. Lab., 1970). It is apparent that in time a blowdown of the steaming water is necessary because of the buildup of dissolved materials.

Within the past two or three years, closed steaming has become a viable technology in the wood-preserving industry. Recent data (Thompson, 1975) show that 71 percent of the plants that steam condition stock are either currently using or plan to adopt closed steaming. The overall effect will be to reduce dramatically the volume of wastewater generated by the average plant. A reduction from the 49,000 liters/day (13,000 gallons/day) estimated in the Development Document to 19,000 liters/day (4,000 gallons/day) for an average two-retort plant is well within reason. Neither value includes rainwater.

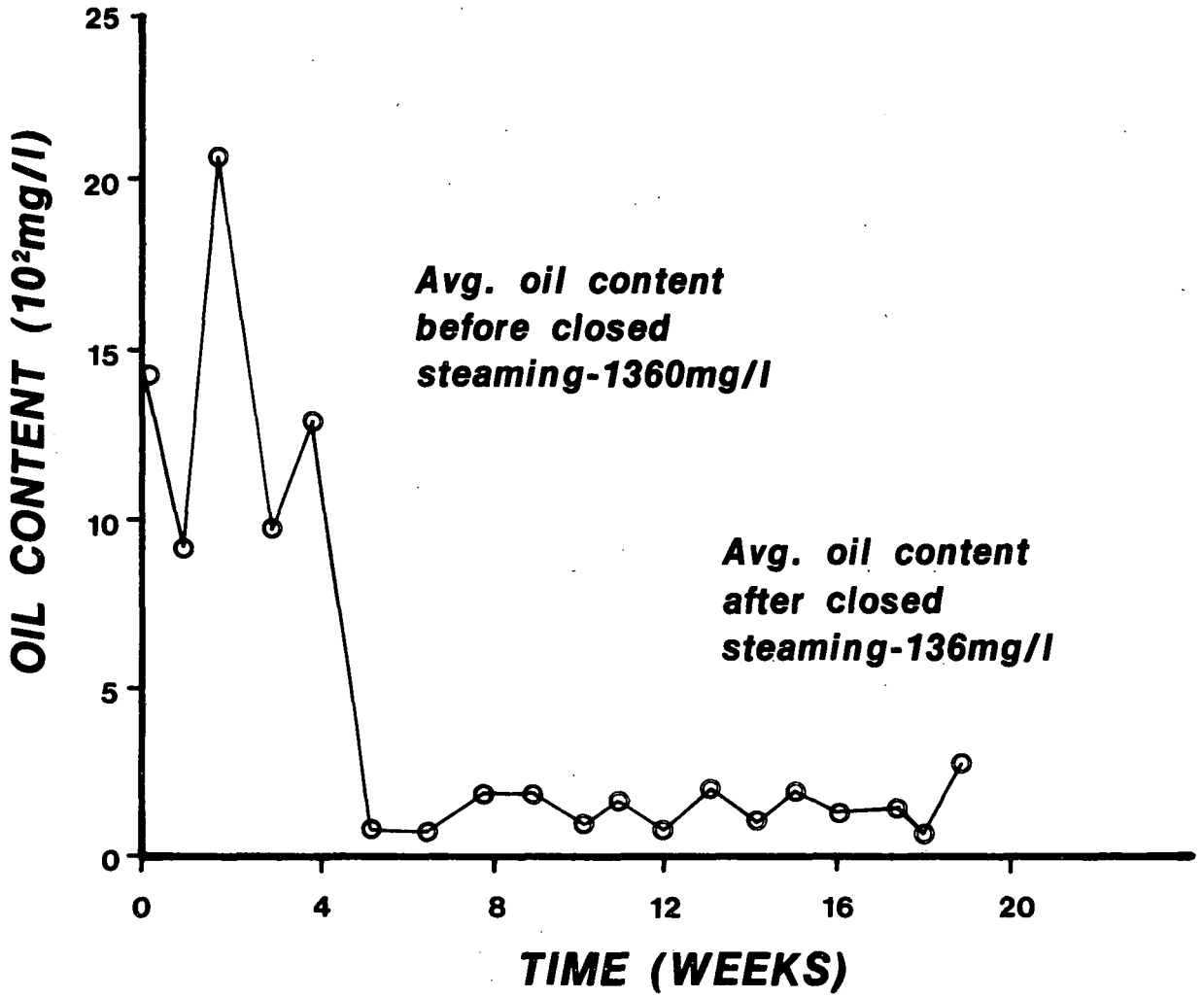


Figure VII - 1 ***Variation in oil content of effluent with time before and after initiating closed steaming (Thompson and Dust, 1971)***

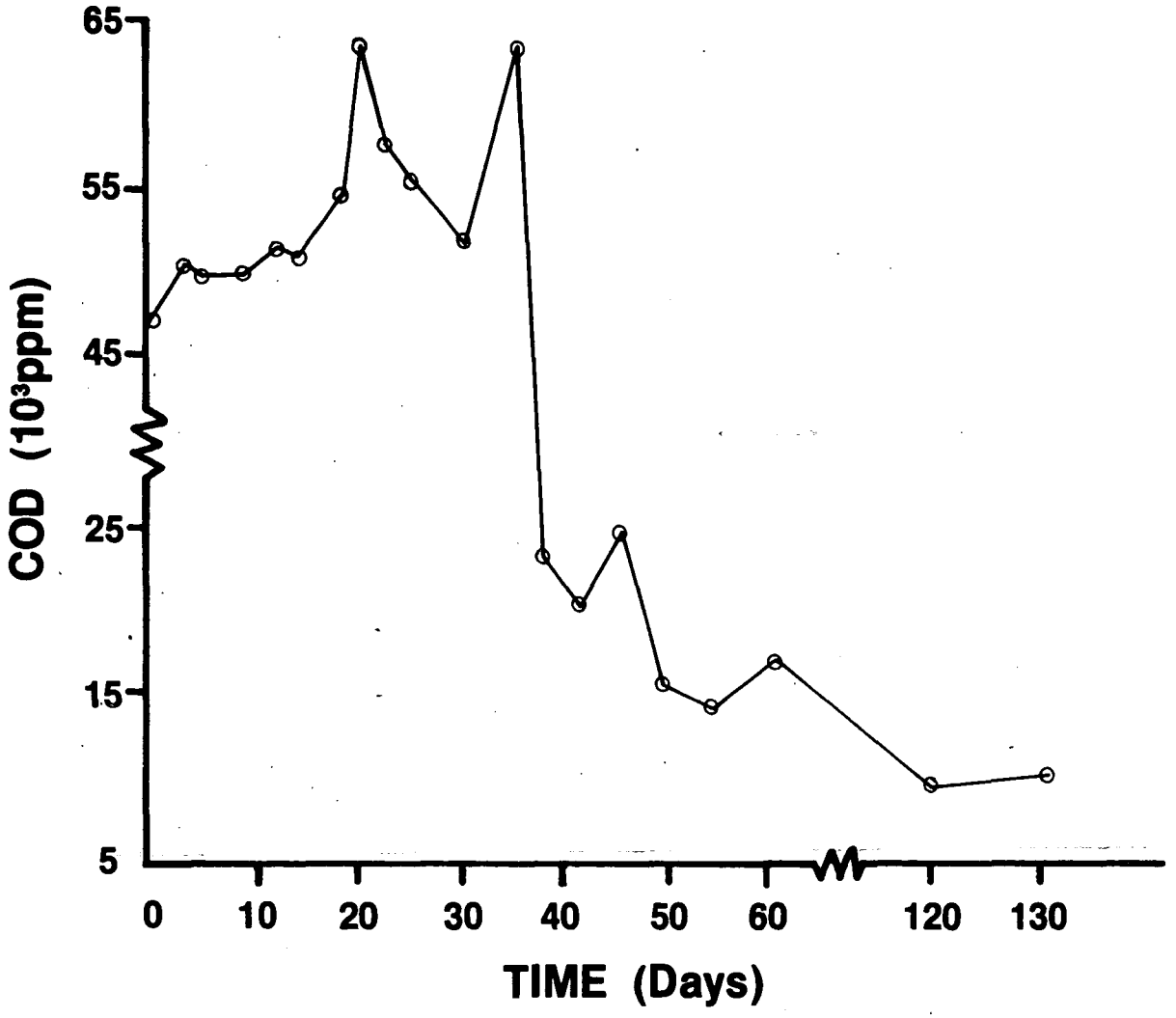


Figure VII - 2 **Variation in COD of effluent with time before and after closed steaming: Days 0-35 open steaming; Days 35-130 closed steaming (Thompson and Dust,1971)**

Table VII-1. Progressive Changes in Selected Characteristics of Water Recycled in Closed Steaming Operations.

Charge No.	(mg/liter) Phenol	COD	Total Solids	Dissolved Solids
1	46	15,516	10,156	8,176
2	169	22,208	17,956	15,176
3	200	22,412	22,204	20,676
4	215	49,552	37,668	31,832
5	231	54,824	66,284	37,048
7	254	75,856	66,968	40,424
8	315	99,992	67,604	41,608
12	208	129,914	99,276	91,848
13	230	121,367	104,960	101,676
14	223	110,541	92,092	91,028
20	323	123,429	114,924	88,796

SOURCE: Mississippi State Forest Products Laboratory, 1970.

Other possible methods of reducing discharge volume are through reuse of cooling and process water and segregation of waste streams. Recycling of cooling water at plants that employ barometric condensers is essential because it is not economically feasible to treat the large volume of contaminated water generated when a single-pass system is used. This fact has been recognized by the industry, and within the past five years there has been a significant increase in the percentage of plants recycling barometric cooling water. This change is indicated in Table VII-2, in which data on disposition of cooling water in 1972 and 1974 are presented. Vacuum water, water removed from the wood during the vacuum cycle following steam conditioning, ends up in the cooling water reservoir and is also recycled.

As an alternative solution to the problem associated with the use of barometric condensers, many plants have installed surface-type condensers as replacement equipment.

Reuse of process water is not widely practiced in the industry. There are, however, noteworthy exceptions to this generalization. Process wastewater from salt-type treatments is so widely used as makeup water for treating solutions that the practice is now common industry-wide. One-hundred and sixty of 184 plants treating with salts that were questioned in 1974 indicated that no discharge of direct process wastewater has been achieved through a combination of water conservation measures, including recycling.

Within that portion of the industry that uses oily preservatives, reuse of process wastewater has been largely confined to some of those that employ the Boulton process. Following oil removal, the process water is discharged to a cooling tower where much of it is evaporated during the normal operation of the tower. Heat can be added to the system by means of a heat exchanger to expedite evaporation of excess water. These and other systems designed to dispose of wastewater by energy input were installed when energy was relatively abundant and inexpensive. As shown elsewhere in this report, the several-fold increase in energy costs since late 1973, when the Draft Development Document was being prepared, has resulted in dramatically increased costs to plants which use forced evaporation.

One of the main sources of uncontaminated water at wood preserving plants is steam coil condensate. While in the past this water was frequently allowed to become mixed with process wastewater, most plants now segregate it, thus reducing the total volume of polluted water, and some reuse coil condensate for boiler feed water. This latter practice became feasible with the development of turbidity- sensing equipment to monitor the water and sound a warning if oil enters the coil condensate return system. Reuse of coil condensate, while of some consequence from a pollution standpoint, can represent a significant energy saving to a plant.

Table VII-2. Equipment and System used with Cooling Water by U.S. Wood-Preserving Plants: 1972 and 1974.

Equipment or System	Percent of Plants 1972	1974
Barometric condensers	60	41
Recycle cooling water	74	84
One-pass system	26	16
Plan to install recycle system	8	33

Insulation Board and Wet Process Hardboard

The production of either insulation board or hardboard requires extensive amounts of process water which ultimately becomes contaminated with dissolved and suspended substances through contact with the wood and additives used as raw material. In the past, most plants used large amounts of fresh water to produce fiberboard products in what was essentially a once-through process. The exclusive use of fresh water in the refining, washing, diluting, and forming of fiberboard results in only one opportunity for dissolved and suspended solids to be retained in the product, and leads to an extensive pollution problem due to the volumes of wastewater generated and the large, costly end-of-pipe treatment facilities required.

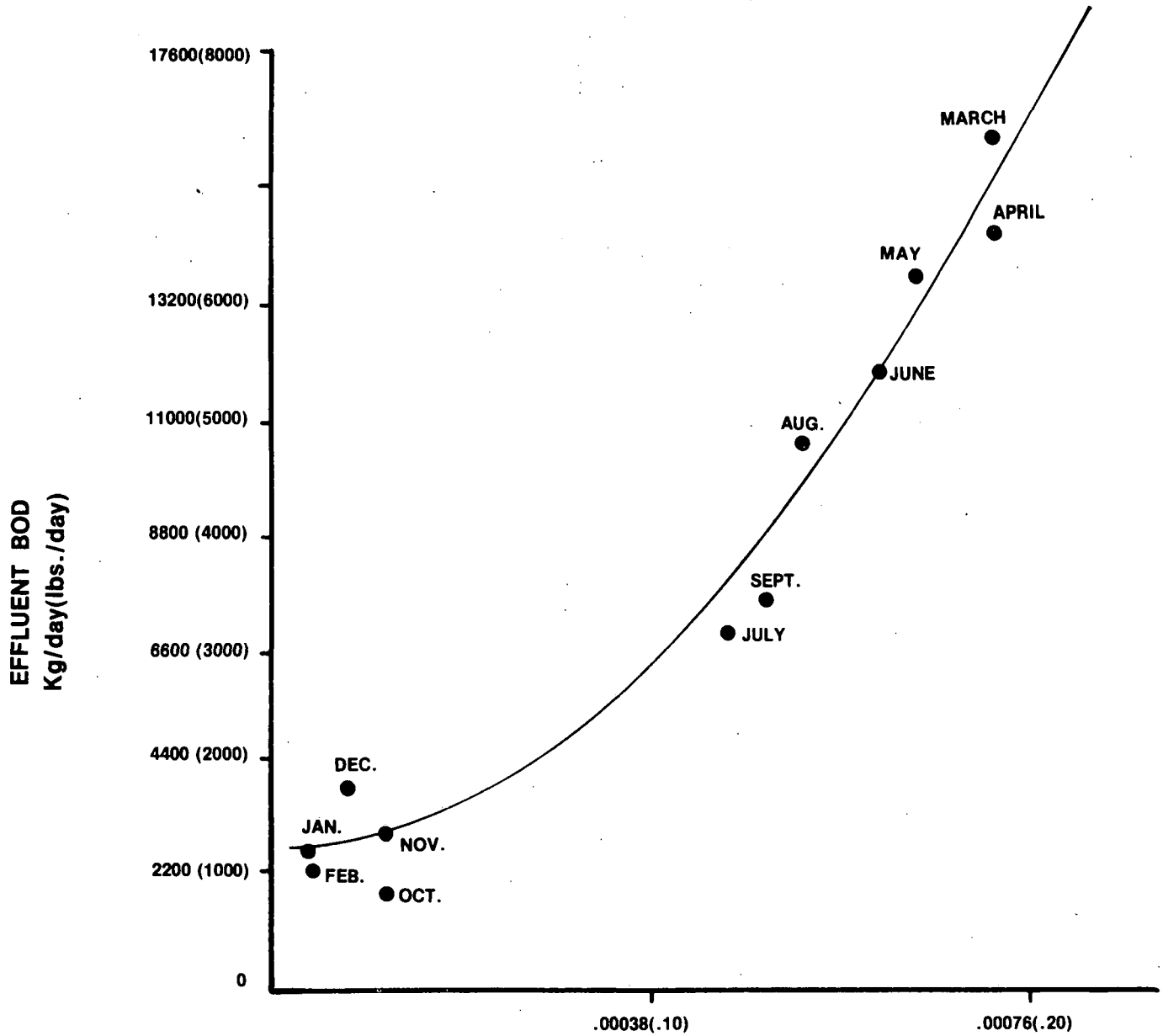
More recent technology used by most plants includes the use of recycled process whitewater in place of fresh water at various points in the system. Process water can be reused for refiner stack dilution, forming machine dilution, shower water, and pump seal water. The use of recycled process whitewater provides the opportunity for increased retention of dissolved and suspended solids in the product, results in decreased fresh water consumption, and decreased wastewater volume.

By closing the process whitewater system in a fiberboard plant, it is possible to reduce the suspended solids in the raw waste load. As a first approximation, suspended solids concentration is almost independent of the total volume of wastewater per unit of fiberboard produced (Gran, 1972). The total discharge of suspended solids will thus be roughly proportional to the volume of wastewater.

The BOD raw waste load, on the other hand, is less influenced by a moderate closing of the process whitewater system due to the build-up of dissolved solids in the process whitewater system during recycle.

Operating data are availabe from plant 64, a SIS hardboard plant, which demonstrates the effect of plant close-up on BOD loads. Plant 64 began an extensive program to close its whitewater system in March 1976. The wastewater flow from the plant was reduced in steps from an average of 700,000 l/day (187,000 gal/day) in March 1976, to 26,500 l/day (7,000 gal/day) in February 1977. The corresponding BOD loads were reduced from 3,400 kg/day (7,500 lb/day) to 400 kg/day (900 lb/day). Figure VII-3 illustrates the relationship between BOD load and discharge volume for the plant during the close-up period. The most dramatic reduction in BOD load occurred in October 1976, when the plant achieved a reduction in flow of about 85 percent. BOD data reported by this plant is monitored at the discharge of two settling ponds; however, very little BOD removal is effected in these ponds.

FIGURE PLANT 64
FLOW VS. EFFLUENT BOD



DATA ARE FROM MARCH,1976 TO FEBRUARY 1977.

Figure VII - 3

The ability of an insulation board or hardboard plant to close its process whitewater system is highly dependent upon the type of board products produced. The increased dissolved solids retained in the board tend to migrate to the board surface during drying and/or pressing, increasing the risk of spot formation on the board sheets and sticking in the press.

Excessive degradation of board quality cannot be tolerated in decorative type insulation board, finished hardboard paneling, or certain types of exterior hardboard siding. Other problems associated with a high degree of process whitewater recycle are corrosion of pumps, plumbing, and equipment due to the decreased pH of recycled whitewater; plugging of shower sprays and decreased freeness (drainage characteristics) of stack due to solids build-up; and an elevation of temperature in the process whitewater system.

In order to achieve maximum closure, a plant must be willing to invest considerable capital, and be prepared to accept decreased production during the period of time that optimum plant operating conditions are being tested. The primary benefit to a plant which succeeds in closing its process whitewater system is effective pollution control without reliance on expensive end-of-pipe treatment.

Some of the measures which can be used to achieve close-up or maximum recycle of the process whitewater system are as follows:

1. Elimination of extraneous wastewater sources. Pump seal water can be reduced or eliminated by the use of recycled whitewater or by conversion to mechanically sealed pumps where possible. Chip wash water can be reduced by recycle following screening and sedimentation of grit. Housekeeping water use should be kept to an absolute minimum. High pressure sprays and/or dry cleaning methods should be used where possible.

2. Provision of sufficient whitewater equalization. Sufficient equalization capacity for control and containment of whitewater surges should be provided. Several plants employ large outdoor surge ponds for this purpose. Surge ponds also serve to control whitewater temperature. Several plants use heat exchangers for temperature control, and provide sufficient capacity for plant start-up and shut-down.

3. Clarification of whitewater. Several plants use gravity clarifiers to remove grit and settleable solids form the whitewater system. To use forming water for showers or pump seal water, it is necessary to remove the majority of fiber. Screens or filters are available for this purpose, and in some cases a "save-all" installation may be justified. "Save-alls" are used extensively in the pulp and paper industry. They can result in fiber concentrations of less than 0.20 pounds per 1,000 gallons of water, which makes the water suitable

for showers and pump seals. This type of device can also dramatically reduce the suspended solids leaving the mill in the raw effluent. The hardboard process can use either a flotation-type save-all or a drum-type unit. Fiber from the save-all can be returned to the process.

4. Extraction of concentrated wastewater. The soluble sugars and other dissolved materials released into the process whitewater during refining can be extracted by efficient countercurrent washing of the stock or by using a dewatering press. The concentrated whitewater can then be evaporated for recovery of an animal feed by-product. Use of this process allows greater recycle of the remaining whitewater, which is primarily leaner machine whitewater. Plants 42, 24, and 663 currently use stock washers to extract concentrated whitewater for subsequent evaporation to animal feed. Plant 663 has successfully demonstrated the capability of a dewatering press for the same purpose on one of its production lines. This plant was able to completely close the remaining process whitewater system following the press. Successful application of this extraction process depends on the use of an evaporator on the concentrated whitewater, otherwise the plant has succeeded only in concentrating its wastewater, which may have adverse effects on subsequent biological treatment. The high capital expense of such systems must be at least partially amortized by by-product sales. The economics of applying this system will vary from plant to plant, and must be evaluated on an individual basis. Some considerations will be: amount of material available for recovery; energy costs for liquor evaporation; proximity to market; and market price.

5. Corrosion control. The corrosiveness of the recycled process whitewater can be controlled with addition of caustic soda, lime, or other basic chemicals. Most plants practice chemical pH control to some extent. Corrosion-resistant pumps, piping, and tanks can be used to replace corroded equipment or for new construction.

6. Control of press sticking. Press sticking can be mitigated by washing the surface of the press plates or cauls more frequently, or by using release agents such as paraffin emulsions. Lowering the temperature of the hot press may also be effective.

Two thermo-mechanical refining insulation board plants have achieved complete close-up of process whitewater systems. Both plants produce structural grade board only. Plant 137 uses a save-all device to clarify the whitewater for further reuse. Plant 1111 uses external surge ponds for whitewater equalization and temperature control, as well as a gravity clarifier for solids control. Both plants indicated that extensive process experimentation and modification, during a period of one to two years, was required before the major process problems due to close-up were solved.

Plant 64, as previously discussed, is the sole hardboard plant which has approached full close-up. This plant produces primarily industrial grade hardboard and has encountered some quality control problems during the course of the close-up.

Plant 888 has achieved a nearly complete close-up by recycling the effluent from its biological treatment system into the plant for process water. Details of the internal modifications required to accommodate the treated effluent are not known.

A review of potential in-plant process modifications for both insulation board and hardboard plants indicates that some reductions in raw waste loading can be accomplished. Specific recommendations for in-plant modifications on a plant to plant basis require a detailed and thorough working knowledge of each plant. Such a detailed evaluation is beyond the scope of this study.

End-of-Pipe Treatment

Primary Treatment--Wood Preserving

Primary treatment is defined in this document as treatment applied to the wastewater prior to biological treatment.

Oil-Water Separation--Because of the deleterious effects that oil has on all subsequent steps in wastewater treatment, efficient oil-water separation is necessary for effective treatment in the wood preserving industry. Oil, whether free or in an emulsified form, accounts for a significant part of the oxygen demand of wood preserving effluents and serves as a carrier for concentrations of the priority pollutants such as PNA's and pentachlorophenol that far exceed their respective solubilities in oil-free water. In a real sense, control of oils is the key to wastewater management in the wood preserving industry.

Oil-water separators of the API type are extensively used by wood preserving plants and are the equipment of choice to impart the "primary oil separation" referred to in the proposed treatment regimes which follow. It is preceded and followed at many plants by a rough oil separation and secondary oil separation, respectively. The former operation occurs either in the blowdown tank or in a surge tank preceding the API separator. Secondary separation usually occurs in another API separator operated in series with the first, or it may be conducted in any vessel or lagoon where the detention time is sufficient to permit further separation of free oil. A few plants achieve almost complete removal of free oils by filtering the wastewater through an oil-absorbent medium. This practice is unnecessary if the wastewater is to be chemically flocculated.

The oil content of wastewater entering the blowdown tank may be as high as 10 percent, with 1 to 5 percent being a more normal range. Depending

on the efficiency of rough separation, the influent to the primary separator will have a free oil content ranging from less than 200 mg/l to several thousand mg/l. Removal efficiencies of 60 to 95 percent can be achieved, but the results obtained are effected by temperature, oil content, and separator design, especially as regards detention time. Data published by the American Petroleum Institute (API, 1959) show that 80 percent removal of free oils is normal in the petroleum industry. Secondary separation should remove up to 90 percent of the residual free oil, depending on the technique used.

Chemical flocculation--Because oil-water emulsions are not broken by mechanical oil-removal procedures, chemical flocculation is required to reduce the oil content of wastewaters containing emulsions to a satisfactory level. Lime, ferric chloride, various polyelectrolytes, and clays of several types are used in the industry for this purpose. Automatic metering pumps and mixing equipment have been installed at some plants to expedite the process, which is usually carried out on a batch basis. COD reductions of 30 to 80 percent or higher are achieved--primarily as a result of oil removal. Average COD removal is about 50 percent.

Influent oil concentration varies with the efficiency of mechanical oil separation and the amount of emulsified oil. The latter variable in turn is effected by type of preservative (either pentachlorophenol in petroleum, creosote, or a creosote solution of coal tar or petroleum) conditioning method used, and design of oil-transfer equipment. Pentachlorophenol preservative solutions cause more emulsion problems than creosote or its solutions, and plants that steam condition--especially those that employ open steaming--have more problems than plants that use the Boulton conditioning method. Plants that use low-pressure, high-volume oil transfer pumps have less trouble with emulsions than those that use high-pressure, low-volume equipment.

Typically, influent to the flocculation equipment from a creosote process will have an oil content of less than 500 mg/liter, while that from a pentachlorophenol process will have a value of 1000 mg/liter or higher. For example, analyses of samples taken from the separator outfalls at ten plants revealed average oil contents of 1,470 and 365 mg/liter for pentachlorophenol and creosote wastewater, respectively. The respective ranges of values were 540 to 2,640 mg/liter and 35 to 735 mg/ liter. Average separator effluents for three steaming plants sampled in conjunction with the present study gave oil and grease values of 1,690 and 935 mg/liter for pentachlorophenol and creosote separators, respectively.

Flocculated effluent generally has an oil content of less than 200 mg/liter and frequently less than 100 mg/liter. Before and after oil and grease values for several steaming plants visited in connection with the pretreatment standards were as follows:

Influent (mg/liter)	After Flocculation (mg/liter)
900	20
35	<10
24,450	90
810	125
1,380	70
334	230

Some of the exceptionally low values are due in part to wastewater dilution after flocculation.

Filtration--Many plants which flocculate wastewater subsequently filter it through sand beds to remove the sludge. When poorly conducted, this procedure is highly efficient in removing both the solids resulting from the process as well as some of the residual oil. The solids which accumulate on the bed are removed periodically along with the upper inch or so of sand.

A common mistake that renders filter beds almost useless is the application of incompletely flocculated wastewater. The residual oil retards percolation of the water through the bed, thus necessitating the replacement of the oil-saturated sand. This has happened frequently enough at some plants that the sand filters have been abandoned and a decantation process used instead. At many plants decantation is part of the flocculation system. Solids removal is expedited by use of vessels with cone-shaped bottoms. Frequently, the solids are allowed to accumulate from batch to batch, a practice which is reported to reduce the amount of flocculating agents required.

Removal of Metals from Wastewater--A method of metals removal recommended for wood preserving, but used to only a limited extent by that industry (Hyde, 1965), was adopted from the plating industry (Martin, 1973). This procedure is based on the fact that hexavalent chromium is the only metal (boron excepted) used by the industry that will not precipitate from solution at a neutral or alkaline pH. Thus, the first step in treating wastewaters containing this metal is to reduce it from the hexavalent to the trivalent form. The use of sulfur dioxide for this purpose has been reported on in detail by Chamberline and Day (1956). Chromium reduction proceeds most rapidly in acid solution. Therefore, the wastewater is acidified with sulfuric acid to a pH of 4 or less before introducing the sulfur dioxide. The latter chemical will itself lower the pH to the desired level, but is less expensive to use than the acid.

When the chromium has been reduced, the pH of the wastewater is increased to 8.5 or 9.0 to precipitate not only the trivalent chromium, but also the copper and zinc. If lime is used for the pH adjustment, fluorides and most of the arsenic will also be precipitated. Care must be taken not to raise the pH beyond 9.5, since trivalent chromium is slightly

soluble at higher values. Additional arsenic and most residual copper and chromium in solution can be precipitated by hydrogen sulfide gas or sodium sulfide. Ammonium and phosphate compounds are also reduced by this process.

The procedure is based on the well-known fact that most heavy metals are precipitated as relatively insoluble metal hydroxides at an alkaline pH. The theoretical solubilities of some of the hydroxides are quite low, ranging down to less than 0.01 mg/liter. However, theoretical levels are seldom achieved because of unfavorable settling properties of the precipitates, slow reaction rates, interference of other ions in solution, and other factors. Copper, zinc, and chromium can be reduced to levels substantially lower than 1.0 mg/liter by the above procedure. Fluorides have a theoretical solubility of 8.5 at a pH of 8.5 to 9.0 mg/liter, but residual concentrations on the order of 10 to 20 mg/liter are more usual because of slow settling of calcium fluoride. The use of additional lime, alum coagulation, and filtration through bone char are reported to reduce fluoride concentrations to 1.0 mg/liter or less.

The most difficult ion to reduce to acceptable concentrations levels is arsenic. Treatment of water containing arsenic with lime generally removes only about 85 percent of the metal. Removal rates in the range of 94 to 98 percent have been reported for filtration through ferric hydroxide. However, none of these methods is entirely satisfactory, particularly for arsenic concentrations above 20 mg/liter.

More encouraging results in arsenic removal, as well as the removal of other heavy metals, were recently reported by EPA (Technology Transfer, January, 1977). The study found that pretreatments of wastes with lime or ferric chloride or alum followed by carbon adsorption were highly effective. Ferric chloride pretreatment was the most effective for metals used in wood preserving. Reductions of chromium, copper, zinc, and arsenic following treatment with ferric chloride and carbon adsorption were, in order, 99.3, 96.0, 94.0, and 97.1 percent.

A detailed treatise on treatment technology for wastewater containing heavy metals was recently published in book form (Patterson, 1975). Methods of treatment for arsenic presented by the author are shown in Table VII-3.

Chemical precipitation and filtration employing ferric compounds and sulfides were at least as effective as lime precipitation, which, as indicated above, has been employed to a limited extent by the wood preserving industry. However, with one or two possible exceptions, none of the methods is as effective as the combination physical-chemical method described in the EPA report discussed above (Technology Transfer, January, 1977), particularly when initial concentration is taken into account. Chemical oxidation of arsenate to arsenite prior to coagulation treatment was reported to improve arsenic removal. Incomplete removal of the metal by coagulation treatments was believed by the author to be

Table VII-3. Summary of Arsenic Treatment Methods and Removals Achieved*

Treatment	Initial Arsenic (mg/l)	Final Arsenic (mg/l)	Percent Removal
Charcoal Filtration	0.2	0.06	70
Lime Softening	0.2	0.03	85
Precipitation with Lime plus Iron	---	0.05	--
Precipitation with Alum	0.35		85-92
Precipitation with Ferric Sulfate	0.31-0.35	0.003-0.006	98-99
Precipitation with Ferric Sulfate	25.0	5	80
Precipitation with Ferric Chloride	3.0	0.05	98
Precipitation with Ferric Chloride	0.58-0.90	0.0-0.13	81-100
Precipitation with Ferric Hydroxide	---		
Precipitation with Ferric Hydroxide	362.0	15-20	94-96
Ferric Sulfide Filter Bed	0.8	0.05	94
Precipitation with Sulfide	---	0.05	
Precipitation with Sulfide	132.0	26.4	80

* Adopted from Patterson, 1975.

caused by the formation of a stable complex with the precipitating metal. More complete removal of arsenite was assumed to indicate that arsenate forms the more stable complexes.

Among other methods of chemical precipitation, use of thioacetamide and dibromo-oxine is mentioned in the literature (Cadman, 1974). "Complete" recovery of chromium and zinc is claimed for the first-named chemical, and "100 percent" recovery of copper, zinc, and chromium is reported for dibromo-oxine.

Considering cost, no more efficient chemical method of removing hexavalent chromium and copper from solution than the standard method (reduction of chromium to trivalent form followed by lime precipitation of both metals) is revealed by the literature. However, to meet increasingly stringent effluent standards, some industries have turned to an ion exchange technique.

Cadman (1974) has reported excellent results in removing metals from wastewater using ion exchange. The resin, Chelex-100, removed "essentially" 100 percent of the zinc, copper, and chromium in his tests. Chitosan, Amberlite, and Permutit-S1005 were also reported to be highly effective. The Permutit resin removed 100 percent of the copper and zinc but only 10 percent of the chromium.

Primary Treatment--Insulation Board and Hardboard

Screening--Screens are used by many fiberboard plants to remove bark, wood chips, and foreign materials from the wastewater prior to further treatment. Screening equipment may consist of mechanically cleaned bar screens, vibrating screens, or sidehill screens. Screening serves to reduce wear and tear on treatment equipment, and also separate extraneous material from the wood fiber which is returned to the plant after primary settling in most insulation-board plants.

Primary Settling--Most insulation board plants and many hardboard plants use gravity type primary settling facilities to remove a major portion of the wood fibers from the raw wastewater. Primary sludge may be returned to the process for reuse, or it may be thickened and/or dewatered and disposed to a landfill. Common sludge handling devices include gravity thickeners and mechanical dewatering equipment.

Settling ponds are the most common primary settling facilities used in the industry; however, several plants are equipped with mechanical clarifiers. Suspended solids removals in primary settling facilities range from about 65 to 80 percent. Data from one plant demonstrated that 10 to 15 percent BOD removal was being achieved by the primary settling facility. One plant achieved 24 percent BOD removal in a mechanical primary settling tank through the use of polymers as a coagulant.

Secondary Treatment

Biological Treatments--Wastewater generated by the wood preserving, insulation board, and hardboard industries is amenable to biological treatment. A review of the literature on this subject follows.

Activated Sludge--Cooke and Graham (1965) performed laboratory scale studies on the biological degradation of phenolic wastes by the completed mixed activated sludge system. While many of the basic parameters needed for design were not presented, the final results were conclusive. The feed liquors contained phenols, thiocyanates, ammonia, and organic acids. Aeration varied from 8 to 50 hours. Influent concentration and percentage removal of phenol averaged 281 mg/l and 78 percent, respectively, at a volumetric loading of 144 to 1600 kg/100 cubic meters/day (9 to 100 lb/1000 cubic feet/day).

Badger and Jackman (1961), studying bacteriological oxidation of phenols in aerated reaction vessels on a continuous flow basis with a loading of approximately 1600 to 2400 kg/1000 cubic meters/day (100 to 150 lb of phenol/1000 cubic feet/day) and a MLSS of 2000 mg/l, found that with wastes containing up to 5000 mg/l phenol, a two-day retention period could produce removal efficiencies in excess of 90 percent. Because the investigators were working with a coke gasification plant waste, the liquor contained thiocyanates. Higher oxidation efficiencies could be achieved with a reduction of the thiocyanate in the waste. Gas chromatography indicated no phenolic end products of degradation with original waste being a mixture of 36 percent monohydric and 64 percent polyhydric phenols.

Pruessner and Mancini (1967) obtained a 99 percent oxidation efficiency for BOD in petrochemical wastes. Similarly, Coe (1952) reported reductions of both BOD and phenols of 95 percent from petroleum wastes in bench-scale tests of the activated sludge process. Optimum BOD loads of 2247 kilograms/1000 cubic meters per day (140 lb/1000 cubic feet per day) were obtained. Coke plant effluents were successfully treated by Ludberg and Nicks (1969) although some difficulty in start-up of the activated sludge system was experienced because of the high phenol content of the water.

The complete mixed, activated sludge process was employed to process a high phenolic wastewater from a coal-tar distilling plant in Ontario (American Wood Preservers Association, 1960). Initial phenol and COD concentrations of 500 and 6,000 mg/liter, respectively, were reduced in excess of 99 percent for phenols and 90 percent for COD.

Coal gas washing liquor was successfully treated by Nakashio (1969) using activated sludge at a loading rate of 0.116 kg of phenol/kg MLSS/day. An influent phenol concentration of 1200 mg/l was reduced by more than 99 percent in this year-long study. Similar phenol removal rates were obtained by Reid and Janson (1955) in treating wastewaters generated by the washing and decarbonization of aircraft engine parts. Other examples

of biological treatment of phenolic wastes include work by Putilena (1952, 1955) Meissner (1955) and Shukov, et al. (1957, 1959).

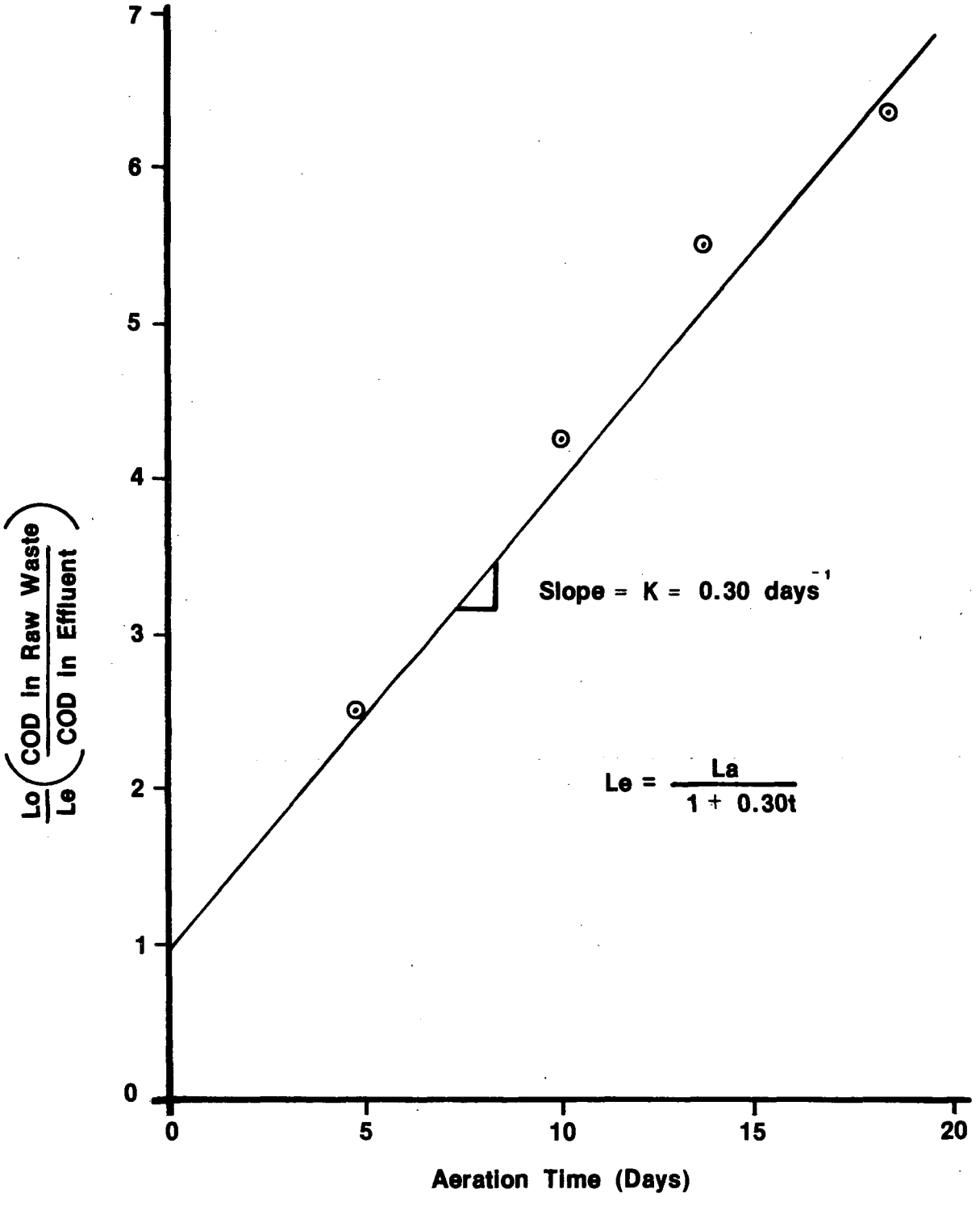
Of particular interest is a specific test on the biological treatment of coke plant wastes containing phenols and various organics. In a report of pilot and full scale studies performed by Kostenbader and Flacksteiner (1969), the complete mixed activated sludge process achieved greater than 99.8 percent oxidation efficiency of phenols. Successful results were achieved with phenol loadings of 0.86 kg phenol/kg MLSS/day with an equivalent BOD loading of 2 kg BOD/kg MLSS/day. In comparison, a typical activated sludge loading is 0.4 kg BOD/kg MLSS/day. Effluent concentrations of phenol from the pilot plant were 0.2 mg/l in contrast to influent concentrations of 3500 mg/l. Slight variations in process efficiency were encountered with varying temperatures and loading rates. Phosphoric acid was added to achieve a phosphorus-to-phenol ratio of 1:70. At the termination of pilot plant work, a similar large scale treatment plant processing of 424 cubic meters/day (112,000 gpd) was installed and resulted in an effluent containing less than 0.1 mg/l of phenol.

Dust and Thompson (1972) conducted bench-scale tests of complete mixed activated sludge treatment of creosote and pentachlorophenol wastewaters using 5-liter units and detention times of 5, 10, 15, and 20 days. The operational data collected at steady-state conditions of substrate removal for the creosote waste are shown in Table VII-4. A plot of these data showed that the treatability factor, K, was 0.30 $days^{-1}$ (Figure VII-4). The resulting design equation, with t expressed in days, is:

$$L_e = L_o/(1 + 0.30t)$$

A plot of percent COD removal versus detention time in the aerator based on the above equation, shown in Figure VII-5, indicates that an oxidation efficiency of about 90 percent can be expected with a detention time of 20 days in units of this type.

Dust and Thompson (1972) also attempted to determine the degree of biodegradability of pentachlorophenol waste. Cultures of bacteria prepared from soil removed from a drainage ditch containing pentachlorophenol waste were used to inoculate the treatment units. Feed to the units contained 10 mg/liter of pentachlorophenol and 2,400 mg/liter COD. For the two 5-liter units (A and B) the feed was 500 and 1000 ml/day and detention times were, in order, 10 and 5 days. Removal rates for pentachlorophenol and COD are given in Table VII-5. For the first 20 days, Unit A removed only 35 percent of the pentachlorophenol added to the unit. However, removal increased dramatically afterward and averaged 94 percent during the remaining 10 days of the study. Unit B consistently removed over 90 percent of the pentachlorophenol added. Beginning on the 46th day and continuing through the 51st day, pentachlorophenol loading was increased at two-day intervals to a maximum of about 59 mg/liter. Removal rates for the 3 two-day periods of increased loadings were 94,



Determination of Reaction Rate Constant for a Creosote Wastewater

Figure VII - 4

reported by Montes, Allen, and Schowell (1956) who obtained BOD reductions of 90 percent in a trickling filter using a 1:2 recycle ratio, and Dickerson and Laffey (1958), who obtained phenol and BOD reductions of 99.9 and 96.5 percent, respectively, in a trickling filter used to process refinery wastewater.

A combination biological waste-treatment system employing a trickling filter and an oxidation pond was reported on by Davies, Biehl, and Smith (1967). The filter, which was packed with a plastic medium, was used for a roughing treatment of 10.6 million liters (2.8 million gallons) of wastewater per day, with final treatment occurring in the oxidation pond. Removal rates of 95 percent for phenols and 60 percent for BOD were obtained in the filter, notwithstanding the fact that the pH of the influent averaged 9.5

A study of biological treatment of refinery wastewaters by Austin, Meehan, and Stockham (1954) employed a series of four trickling filters with each filter operating at a different recycle ratio. The waste contained 22 to 125 mg/l of oil which adversely affected BOD removal. However, phenol removal was uneffected by oil concentrations within the range studies.

Prather and Gaudy (1964) found that significant reductions of COD, BOD, and phenol concentrations in refinery wastewater were achieved by simple aeration treatments. They concluded that this phenomenon accounted for the high allowable loading rates for biological treatments such as trickling filtration.

The practicality of using trickling filters for secondary treatment of wastewaters from the wood preserving industry was explored by Thompson and Dust (1972). Creosote wastewater was applied at BOD loading rates of from 400 to 3050 kg/1000 cu m/day (25 to 190 lb/1000 cu ft/day) to a pilot unit containing a 6.4 meter (21 feet) filter bed of plastic media. The corresponding phenol loadings were 1.6 to 54.6 kg/1000 cu m/day (0.1 to 3.4 lb/1000 cu ft/day). Raw feed-to-recycle ratios varied from 1:7 to 1:28. Daily samples were analyzed over a period of seven months that included both winter and summer operating conditions. Because of wastewater characteristics at the particular plant cooperating in the study, the following pretreatment steps were necessary: (a) equalization of wastes; (b) primary treatment by coagulation for partial solids removal; (c) dilution of the wastewater to obtain BOD loading rates commensurate with the range of raw flow levels provided by the equipment; and (d) addition to the raw feed of supplementary nitrogen and phosphorus. Dilution ratios of 0 to 14 were used.

The efficiency of the system was essentially stable for BOD loadings of less than 1200 kg/1000 cu m/day (75 lb/1000 cu ft/day). The best removal rate was achieved when the hydraulic application rate was 2.85 l/min/m (0.07 gpm/sq ft) of raw waste and 40.7 l/min/m (1.0 gpm/sq ft) of recycled waste. The COD, BOD, and phenol removals obtained under these

conditions are given in Table VII-6. Table VII-7 shows the relationship between BOD loading rate and removal efficiency. BOD removal efficiency at loading rates of 1060 kg/1000 cu m/day (66 lb/1000 cu ft/day) was on the order of 92 percent, and was not improved at reduced loadings. Comparable values for phenols at loading rates of 19.3 kg/1000 cu m/day (1.2 pounds/1000 cu ft/day) were about 97 percent.

Since phenol concentrations were more readily reduced to levels compatible with existing standards than were BOD concentrations, the sizing of commercial units was based on BOD removal rates. Various combinations of filter-bed depths, tower diameters, and volumes of filter media that were calculated to provide a BOD removal rate of 90 percent for an influent having a BOD of 1500 mg/l are shown in Table VII-8 for a plant with a flow rate of 75,700 l/day (20,000 gpd).

Stabilization Ponds--The American Petroleum Institute's "Manual on Disposal of Refinery Wastes" (1960) refers to several industries that have successfully used oxidation ponds to treat phenolic wastes. Montes (1956) reported on results of field studies involving the treatment of petrochemical wastes using oxidation ponds. He obtained BOD reductions of 90 to 95 percent in ponds loaded at the rate of 84 kg of BOD per hectare per day (75 lb/acre/day).

Phenol concentrations of 990 mg/l in coke oven effluents were reduced to about 7 mg/l in field studies of oxidation ponds conducted by Biczyski and Suschka (1967). Similar results have been reported by Skogen (1967) for a refinery waste.

The literature contains operating data on only one pond used for treating wastewater from wood preserving operations (Crane, 1971; Gaudy, et al., 1965; Gaudy, 1971). The oxidation pond is used as part of a waste treatment system by Weyerhaeuser Company at its DeQueen, Arkansas, wood preserving plant. As originally designed and operated in the early 1960's, the DeQueen waste treatment system consisted of holding tanks into which water from the oil-recovery system flowed. From the holding tanks the water was sprayed into a terraced hillside from which it flowed into a mixing chamber adjacent to the pond. Here it was diluted 1:1 with creek water, fortified with ammonia and phosphates, and discharged into the pond proper. Retention time in the pond was 45 days. The quality of the effluent was quite variable, with phenol content ranging up to 40 mg/l. In 1966, the system was modified by installing a raceway containing a surface aerator and a settling basin in a portion of the pond. The discharge from the mixing chamber now enters a raceway where it is treated with a flocculating agent. The resulting floc collects in the settling basin. Detention time is 48 hours in the raceway and 18 hours in the settling basin from which the wastewater enters the pond proper.

These modifications in effect changed the treating system from an oxidation pond to a combination aerated lagoon and polishing pond, and the

Table VII-6. BOD, COD, and Phenol Loading and Removal Rates for Pilot Trickling Filter Processing A Creosote Wastewater[a]

Measurement	Characteristics		
	BOD	COD	Phenol
Raw Flow Rate l/min/sq m (gpm/sq ft)	2.85 (0.07)	2.85 (0.07)	2.85 (0.07)
Recycle Flow Rate l/min/sq m (gpm/sq ft)	40.7 (1.0)	40.7 (1.0)	40.7 (1.0)
Influent Concentration (mg/l)	1968	3105	31
Loading Rate gm/cu m/day	1075 (66.3)	1967 (121.3)	19.5 (1.2)
Effluent Concentration (mg/l)	137	709	< 1.0
Removal (%)	91.9	77.0	99+

[a] Based on work at the Mississippi Forest Products Laboratory as reported by Davies (1971)

Table VII-7. Relationship Between BOD Loading and Treatability for Pilot Trickling Filter Processing A Creosote Wastewater

BOD Loading kg/cu m	BOD Loading (lb/cu ft/day)	Removal (%)	Treatability[a] Factor
373	(23)	91	0.0301
421	(26)	95	0.0383
599	(37)	92	0.0458
859	(53)	93	0.0347
1069	(66)	92	0.0312
1231	(76)	82	0.0339
1377	(85)	80	0.0286
1863	(115)	75	0.0182
2527	(156)	62	0.0130

[a] Based on the equation:

$$\frac{Le}{Lo} = e^{KD/Q^{0.5}} \text{ (EPA, 1976)}$$

in which Le = BOD concentration of settled effluent, Lp = BOD of feed, Q_2 = hydraulic application rate of raw waste in gpm/sq ft D = depth of media in feet, and K = treatability factor (rate coefficient).

Table VII-8. Sizing of Trickling Filter for a Wood Preserving Plant

NOTE: Data are based on a flow rate of 75,700 liters per day (20,000 gallons per day) with filter influent BOD of 1,500 and effluent BOD of 150 mg/l.

Depth of Filter Bed m (ft)	Raw Flow l/min/sq m (gpm/sq ft) Filter Surface	Recycle Flow l/min/sq m (gpm/sq ft) Filter Surface	Filter Surface Area sq m (sq ft)	Tower dia sq m (sq ft)	Volume of Media cu m (cu ft)
3.26 (10.7)	0.774 (0.019)	29.7 (0.73)	65.8 (708)	9.14 (30.0)	213 (7617)
3.81 (12.5)	1.059 (0.206)	29.3 (0.72)	48.3 (520)	7.83 (25.7)	183 (6529)
4.36 (14.3)	1.385 (0.034)	28.9 (0.71)	37.0 (398)	6.86 (22.5)	160 (5724)
4.91 (16.1)	1.793 (0.044)	28.5 (0.70)	29.3 (315)	6.10 (20.0)	142 (5079)
5.46 (17.9)	2.200 (0.054)	28.1 (0.69)	23.7 (255)	5.49 (18.0)	128 (4572)
5.97 (19.6)	2.648 (0.065)	27.7 (0.68)	19.5 (210)	4.97 (16.3)	116 (4156)
6.52 (21.4)	3.178 (0.078)	27.3 (0.67)	16.4 (177)	4.57 (15.0)	107 (3810)

effect on the quality of the effluent was dramatic. Figure VII-6 shows the phenol content at the outfall of the pond before and after installation of the aerator. As shown by these data, phenol content decreased abruptly from an average of about 40 mg/l to 5 mg/l.

Even with the modifications described, the efficiency of the system remains seasonally dependent. Table VII-9 gives phenol and BOD values for the pond effluent by month for 1968 and 1970. The smaller fluctuations in these parameters in 1970 as compared with 1968 indicate a gradual improvement in the system.

Soil Irrigation--Several applications of wastewaters containing high phenol concentrations to soil irrigation have been reported. One such report by Fisher (1977) related the use of soil irrigation to treat wastewaters from a chemical plant that had the following characteristics:

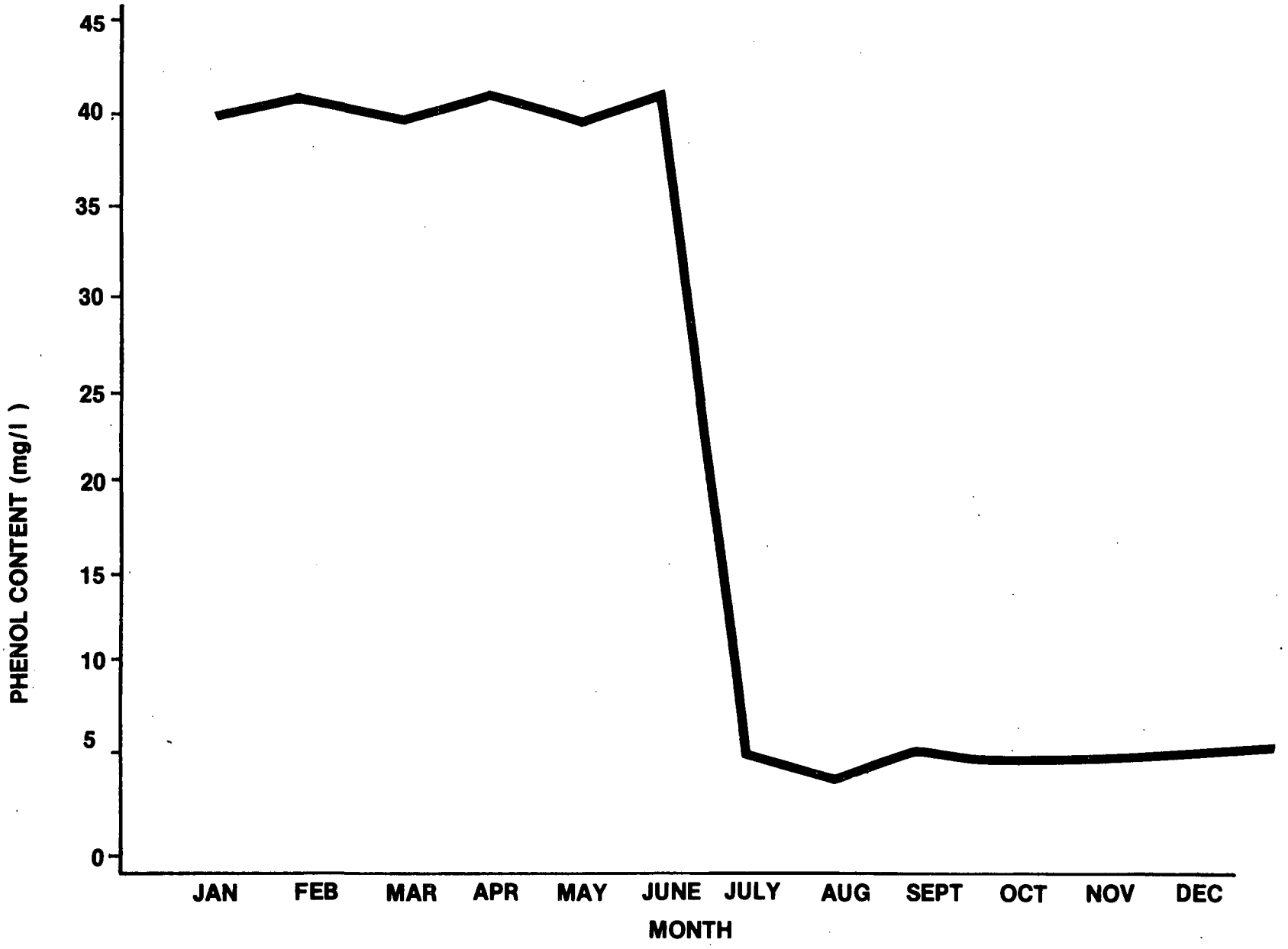
pH	9 to 10
Color	5,000 to 42,000 units
COD	1,600 to 5,000 mg/liter
BOD	800 to 2,000 mg/liter

Operating data from a 0.81 hectare (2 acre) field, when irrigated at a rate of 7570 liters (2,000 gal) per acre/day for a year, showed color removal of 88 to 99 percent and COD removal of 85 to 99 percent.

The same author reported on the use of soil irrigation to treat effluent from two tar plants that contained 7,000 to 15,000 mg/liter phenol and 20,000 to 54,000 mg/liter COD. The waste was applied to the field at a rate of about 20,000 liters (5000 gal) per day. Water leaving the area had COD and phenol concentrations of 60 and 1 mg/liter, respectively. Based on the lower influent concentration for each parameter, these values represent oxidation efficiencies of well over 99 percent for both phenol and COD.

Bench-scale treatment of coke plant effluent by soil irrigation was also studied by Fisher. Wastes containing BOD and phenol concentrations of 5,000 and 1,550 mg/liter, respectively, were reduced by 95+ and 99+ percent when percolated through 0.9 meters (36 inches) of soil. Fisher pointed out that less efficient removal was achieved with coke-plant effluents using the activated sludge processs, even when the waste was diluted with high-quality water prior to treatment. The effluent from the units had a color rating of 1,000 to 3,000 units, compared to 150 units for water that had been treated by soil irrigation.

Both laboratory and pilot scale field tests of soil-irrigation treatments of wood preserving wastewater were conducted by Dust and Thompson (1972). In the laboratory tests, 210 liter (55 gallon) drums containing a heavy clay soil 60 centimeters (24 inches) deep were loaded at rates of 32,800; 49,260; and 82,000 liters/hectare/day (3,500; 5,250; and



PHENOL CONTENT IN OXIDATION POND EFFLUENT BEFORE AND AFTER INSTALLATION IN JUNE 1966 OF AERATOR

Figure VII - 6

Table VII-9 Average Monthly Phenol and BOD Concentrations in Effluent from Oxidation Pond

Month	(mg/liter) 1968 Phenol	1968 BOD	1970 Phenol	1970 BOD
January	26	290	7	95
February	27	235	9	140
March	25	190	6	155
April	11	150	3	95
May	6	100	1	80
June	5	70	1	60
July	7	90	1	35
August	7	70	1	45
September	7	110	1	25
October	16	150	---	---
November	7	155	---	---
December	11	205	---	---

Source: Crane, 1971; Gaudy et al., 1965; Gaudy, 1971.

8,750 gallons/acre/day). Influent COD and phenol concentrations were 11,500 and 150 mg/liter, respectively. Sufficient nitrogen and phosphorus were added to the waste to provide a COD:N:P ratio of 100:5:1. Weekly effluent samples collected at the bottom of the drums were analyzed for COD and phenol.

Reductions of more than 99 percent in COD content of the wastewater were observed from the 1st week in the case of the two highest loadings and from the 4th week for the lowest loading. A breakthrough occurred during the 22nd week for the lowest loading rate and during the 4th week for the highest loading rate. The COD removal steadily decreased thereafter for the duration of the test. Phenol removal showed no such reduction, but instead remained high throughout the test. The average test results for the three loading rates are given in Table VII-10. Average phenol removal was 99+ percent. Removal of COD exceeded 99 percent prior to breakthrough and averaged over 85 percent during the last week of the test.

The field portion of Thompson and Dust's (1972) study was carried out on an 0.28-hectare (0.8-acre) plot prepared by grading to an approximately uniform slope and seeded to native grasses. Wood preserving wastewater from an equalization pond was applied to the field at the rate of 32,800 liters/hectare/day (3,500 gallons/acre/day) for a period of nine months. Average monthly influent COD and phenol concentrations ranged from 2,000 to 3,800 mg/liter and 235 to 900 mg/liter, respectively. Supplementary nitrogen and phosphorus were not added. Samples for analyses were collected weekly at soil depths of 0 (surface), 30, 60, and 120 centimeters (1, 2, and 4 feet).

The major biological reduction in COD and phenol content occurred at the surface and in the upper 30 centimeters (1 foot) of soil. A COD reduction of 55.0 percent was attributed to overland flow. The comparable reduction for phenol content was 55.4 percent (Table VII-11). COD reductions at the three soil depths, based on raw waste to the field, were 94.9, 95.3, and 97.4 percent, respectively, for the 30-, 60-, and 120-centimeter (1-, 2-, and 4-foot) depths. For phenols, the reductions were, in order, 98.9, 99.2, and 99.6 percent.

Philipp (1971) reported on the land disposal of insulation board wastewater at the Celotex Corporation plant in L'Anse, Michigan. Following in-plant filtering for fiber recovery, the wastewater was pumped to a 0.4 ha settling pond and then to two holding ponds, the first having a volume of about 100,000 cu m and the second about 378,500 cu m. All wastewater was retained from late October through April. During the period May to October, the effluent from the second holding pond was pumped to the 40.5 ha spray field.

The spray field was located on a sand of high permeability and with a depth of 2 to 4 m. An underdrainage system was installed at a depth of

Table VII-10. Results of Laboratory Tests of Soil Irrigation Method of Wastewater Treatment*.

Loading Rates (Liter/ha/day)	Length of Test (Week)	Average and COD Removal to Breakthrough	COD REMOVAL Last Week of Test %	Phenol Average % Removal (All Weeks)
32,800 (3,500)**	31	99.1 (22 wks)	85.8	98.5
49,260 (5,250)	13	99.6	99.2	99.7
82,000 (8,750)	14	99.0 (4 wks)	84.3	99.7

* Creosote wastewater containing 11,500 mg/liter of COD and 150 mg/liter of phenol was used.
** Loading rates in parentheses in gallons/acres/day.

Source: Thompson and Dust, 1972.

Table VII-11. Reduction of COD and Phenol Content in Wastewater Treated by Soil Irrigation.*

Month	Raw Waste	Soil Depth (centimeters) 0	30	60	120
		COD (mg/liter)			
July	2,235	1,400	--	--	66
August	2,030	1,150	--	--	64
September	2,355	1,410	--	--	90
October	1,780	960	150	--	61
November	2,060	1,150	170	170	46
December	3,810	670	72	91	58
January	2,230	940	121	127	64
February	2,420	580	144	92	64
March	2,460	810	101	102	68
April	2,980	2,410	126	--	76
Average % Removal (weighted)		55.0	94.9	95.3	97.4
		Phenol (mg/liter)			
July	235	186	--	--	1.8
August	512	268	--	--	0.0
September	923	433	--	--	0.0
October	310	150	4.6	--	2.8
November	234	86	7.7	3.8	0.0
December	327	6	1.8	9.0	3.8
January	236	70	1.9	3.8	0.0
February	246	111	4.9	2.3	1.8
March	277	77	2.3	1.9	1.3
April	236	172	1.9	0.0	0.8
Average % Removal (weighted)		55.4	98.9	99.2	99.6

* Adapted from Thompson and Dust (1972).

1.5 m. The entire area was originally cleared and then seeded with Reed Canary grass.

The discharge from the insulation board plant averaged 22 l/sec with a BOD concentration prior to spray irrigation of 1,150 mg/l.

Although Philipp reported no data as such, he stated that the efficiency of the system for removing BOD, as measured from the influent to the field to the effluent of the underdrainage system, was in excess of 99 percent.

Amberg (cir. 1964) reported on waste treatment measures at the Baltimore Division of Crown Zellerbach Corporation. An aerated lagoon with an oxygen supply of 2,620 kg/day (5,770 lb/day) was used to treat whitewater with a design BOD load of 2,780 kg/day (6,120 lb/day). The lagoon was uniformly mixed and had an average dissolved oxygen concentration of 2.9 mg/l.

Suspended solids increased across the lagoon as a result of biological floc formation, but could be readily removed by subsequent sedimentation. The final effluent averaged 87 mg/l suspended solids during the three days of the study.

The overall plant efficiency for BOD removal was 94 percent, producing a final effluent with an average BOD concentration of 60 mg/l.

Quirk (1969) reported on a pilot plant study of aerated stabilization of boxboard wastewater. Detention times ranged from 0.5 to 0.6 days. The study indicated that full-scale performance, with nutrient addition, could achieve a 90 percent reduction of BOD with a detention time of 4 days.

In-Place Biological Treatment in the Wood Preserving Industry--The data presented in the literature show that the conventional wastewater parameters--COD, total phenols, oil and grease, and suspended solids--can be reduced to acceptable levels by treatment regimes that include biological treatment. Furthermore, verification data collected during this study indicate a high degree of removal of the organic priority pollutants of specific interest from biological treatments.

Considerably less data on pentachlorophenol removal rates are available for industrial installations than for other phenolic pollutants. The reason for this is that there is no standard method for analyzing for this chemical, and the methods available to the average plant (e.g., the safranin method) are notoriously inaccurate. Moreover, neither the effluent guidelines nor most EPA discharge permits or state standards require separate monitoring for pentachlorophenol. There is, therefore, an information gap that can be filled only in part by data from studies previously discussed.

Approximately 10 percent of the wood preserving plants have biological treatment facilities. A listing of these plants is presented in Table VII-12. Based on data supplied by the data collection portfolios, the breakdown of these facilities by type is as follows:

Trickling filter	1
Activated sludge	3
Aerated lagoon	10
Soil irrigation	8

Not included in this tabulation are several plants that use oxidation ponds alone. While it is true that some plants do obtain effective wastewater treatment with oxidation ponds, this term has come into such misuse that any body of water, including sumps, may at one time or another be described as an oxidation pond.

The characteristics of the influent to a biological treatment unit vary with the type and effectiveness of pretreatment and amount of dilution water added to the process waste. With regard to the latter point, a few plants mix process waste with coil condensate, boiler blowdown, etc., after flocculation and before biological treatment. For this reason, it is difficult to compute treatment efficiency on a consistent basis.

Raw and treated wastewater characteristics for several plants for which data are available are given in Table VII-13. Average efficiency of the treatment systems for the five plants for which both raw and treated wastewater parameters are available is as follows:

Parameter	Efficiency (%)
COD	94.8
Phenols	>98.2
O & G	>90.5

Average pollution loadings at the plant outfalls, expressed as kg/1000 cu m of production, are given below for the seven plants:

Parameter	Discharge (kg/1000 cu m)
COD	33.7
Phenols	0.048
O & G	3.21

These data show that current BAT standards can be met by treatment regimes that include biological treatments. The complete treatment system used at each of the seven plants listed in Table VII-13 are described below:

Table VII-12. Plants that Employ Biological Treatments as Part of their Waste Management Program[1].

Plant No.	Type of Process
240	Activated sludge (Boulton)
412	Activated sludge + oxidation ponds + soil irrigation
855	Activated sludge + oxidation ponds + soil irrigation
717	Aerated lagoon
185	Aerated lagoons + soil irrigation
637	Aerated lagoon + soil irrigation
745	3 aerated lagoons + soil irrigation
495	Aerated lagoons + oxidation ponds
112	Aerated lagoon--3 in series
974	Aerated lagoons
517	Aerated lagoons (2) + soil irrigation
139	Aerated lagoons
199	Aerated lagoon + settling lagoon
862	Oxidation lagoons
681	Oxidation ponds + soil irrigation
599	Oxidation ponds (6 in series) + soil irrigation
177	Oxidation ponds
740	Soil irrigation
553	Soil irrigation
216	Soil irrigation
665	Soil irrigation
411	Soil irrigation
331	Soil irrigation after spray pond
300	Soil irrigation

[1]Biological treatment as defined here includes soil irrigation.

Table VII-13. Raw and Treated Wastewater Parameters and Pollution Loads Per Unit of Production for Seven Exemplary Plants in the Steaming Subcategory

Plant No.	Raw Waste (mg/l)			Treated Waste (mg/l)			Discharge Load (kg/1000 cu m)		
	COD	Phenol	O&G	COD	Phenol	O&G	COD	Phenol	O&G
495	--	--	--	25	.036	<10	5.29	<0.016	<2.08
637	1750	4.6	145	50	<0.2	<10	8.82	<0.032	1.76
412	2135	161	--	65	<.02	--	8.66	<0.016	--
185	9150	25	1300	170	<.2	<10	37.7	<0.048	<2.24
517	5490	17.6	576	235	.65	15	53.5	0.144b	3.37
331	1685	60.2	171	165	.013	15	70.2	<0.016	6.41b
199	1430	482.2	35	100	.12	<10	59.3	0.064	<5.93b

Flow and Production Data

Plant No.	Flow (liters/day)	Production (1000 cu m/day)
495	53,000	0.25
637	30,000	0.17
412	41,000	0.31
185	38,000	0.17
517	27,000	0.12
331	125,000	0.29
199	95,000	0.16

a--Based on 1974 data.
b--Note that an oil content of 10 mg/liter, which some authorities report is the lowest value that can be measured with precision, exceeds the current BAT guidelines for one of the plants.

Plant 495

Rough oil-water separation---primary oil-water separation---equalization lagoon---aerated lagoon (compressed air)[1]---oxidation pond---aerated lagoon---oxidation pond---oxidation pond---discharge (none for two years).

[1]Packaged bacteria added daily.

Plant 637

Rough oil-water separation---primary oil-water separation---flocculation---aerated tank (75,000 liter capacity)---aerated lagoon---spray evaporation as required---discharge as required.

Plant 412

Rough oil-water separation---primary oil-water separation---equalization basin---dual activated sludge treatment---three oxidation ponds in series---soil irrigation.

Plant 331

Rough oil-water separation---primary oil-water separation---aerated lagoon---aerated lagoon---aerated lagoon---soil irrigation---aerated lagoon---recycle as needed.

Plant 517

Rough oil-water separation---primary oil-water separation---aerated lagoon---aerated lagoon---soil irrigation---oxidation (collecting) pond---recycle as needed.

Plant 185

Rough oil-water separation---primary oil-water separation---flocculation---aerated lagoon---oxidation pond---aerated lagoon---spray evaporation (2 units).

Plant 199

Rough oil-water separation---primary oil-water separation (dual system)---flocculation---sand filtration---aerated lagoon---oxidation pond---POTW.

Multiphase biological treatment, in combination with appropriate primary treatment, may be required to meet current BAT guidelines.

A summary of raw and final waste loadings of Polynuclear Aromatics for five wood preserving plants sampled during the verification sampling program is presented in Table VII-14.

Table VII-14. Raw and Final Waste Loadings for Polynuclear Aromatics*

Plant Code		Raw and Final Effluent Loadings, kg/cu m (lb/1,000 cu ft)												
		1	2	3	4	5	6	7	8	9	10	11	12	13
310	Raw Waste	.15 (.0093)	.093 (.0058)	.10 (.0064)	.016 (.001)	---	---	.0022 (.00014)	.026 (.0016)	.099 (.0062)	.21 (.013)	.11 (.0066)	.21 (.013)	.067 (.0042)
	Final Effluent	.099 (.0062)	.013 (.0008)	.015 (.00093)	< .0011 < (.000066)	---	---	< .0011 < (.000066)	< .011 < (.000066)	.0075 (.00047)	.0059 (.00037)	.0058 (.00036)	.0059 (.00037)	.0085 (.00053)
312	Raw Waste	.11 (.0069)	.069 (.0043)	.22 (.014)	.0062 (.00039)	< .0012 < (.000077)	.0022 (.00014)	.0022 (.00014)	.0067 (.00042)	.051 (.0032)	.26 (.016)	.091 (.0057)	.26 (.016)	.45 (.028)
	Final Effluent	< .0012 < (.000017)	.0012 (.000017)	.0012 (.000017)	.0012 (.000017)	.0012 (.000017)	.0012 (.000017)	.0012 (.000017)	.0012 (.000017)	.0012 (.000017)	.0012 (.000017)	.0012 (.000017)	.0012 (.000017)	.0012 (.000017)
314	Raw Waste	.18 (.011)	.15 (.0093)	.11 (.0066)	.014 (.0009)	---	---	---	.0008 (.0005)	.11 (.0067)	.72 (.045)	.27 (.017)	.88 (.055)	.16 (.01)
	Final Effluent	.03 (.0019)	.003 (.00019)	.24 (.015)	< .003 < (.00019)	---	---	---	< .003 < (.00019)	< .042 < (.0026)	.018 (.0011)	.011 (.00071)	.018 (.0011)	< .003 < (.00019)
316	Raw Waste	.5 (.031)	.29 (.018)	.19 (.012)	.042 (.0026)	---	---	---	.045 (.0028)	.29 (.018)	1.4 (.087)	.5 (.031)	1.4 (.087)	.24 (.015)
	Final Effluent	.12 (.0074)	.059 (.0037)	.018 (.0011)	< .0054 < (.00034)	---	---	---	< .0054 < (.00034)	.098 (.0061)	.22 (.014)	.16 (.0098)	.22 (.014)	.042 (.0026)
318	Raw Waste	.37 (.023)	.037 (.0023)	.46 (.0029)	.0051 (.00032)	---	---	---	.0032 (.0002)	.27 (.017)	.19 (.012)	.11 (.0066)	.19 (.012)	.026 (.0016)
	Final Effluent	.0078 (.00049)	.012 (.00077)	.012 (.00077)	< .0013 < (.000082)	---	---	---	< .0013 < (.000082)	.0078 (.00049)	.08 (.005)	.0029 (.00018)	.008 (.0005)	.0038 (.00024)

* See Table V-9 for names of poly nuclear aromatics corresponding to numbers 1 through 13.

Combined sample obtained after effluents from creosote and PCP separator are completely mixed.
Data obtained during verification sampling program.

Biological Treatment in the Insulation Board Industry

Plant 55 produces structural and decorative insulation board. The plant has reduced its raw waste flow from 13,250 kl/day (3.5 MGD) to less than 5,678 kl/day (1.5 MGD) by modification of the pulping process, reuse of process water, and recycle of treated effluent. The wastewater is screened for removal of gross solids. The wastewater then goes to two parallel primary clarifiers followed by an activated sludge system. Discharge from the biological system is either recycled to the plant or discharged to a creek. Sludge resulting from primary clarification and n excess sludge from secondary clarification are thickened, vacuum filtered, and reused in the process. Historical data in the data collectio portfolio shows the system provides overall BOD removal of 98 percent and a suspended solids removal of 93 percent. Effluent waste loadings are presented in Table VII-15. Effluent BOD and TSS concentrations are 34.1 mg/l and 323.7 mg/l, respectively.

Plant 125 produces structural and decorative insulation board. Its process wastewater (combined with vacuum seal water, treated septic tank effluent, and stormwater runoff) is routed to a primary clarifier. Sludge drawn from the primary clarifier is recycled to the manufacturing process. Overflow from the clarifier goes to an aerated lagoon. Secondary clarification follows, and the waste secondary sludge is recycled to the process. The treated effluent is collected in a sump for reuse in the process. The excess treated effluent is discharged to receiving waters. From historical data obtained in the data collection portfolio, and data obtained during the verification sampling program, this system exhibits a 15 percent reduction in BOD and a 10 percent increase in solids level. Effluent loadings are presented in Table VII-15. BOD and TSS effluent concentrations are 1081.8 mg/l and 911.3 mg/l, respectively.

Plant 127 produces ceiling tiles and panels, sheathing, and mineral wool fiber insulation board. Process water from the insulation board plant receives primary sedimentation. Primary sludge is returned to the process. The wastewater is then either reused in the insulation board process for stock dilution and shower water, or used as makeup water for the mineral wool fiber plant. The raw wastewater from the mineral wool plant enters the treatment system, which consists of a primary clarifier, an aerated lagoon, and a secondary clarifier. Sludge from the primary and secondary clarifier is dewatered, either in a settling pond or a vacuum filter, and hauled to a disposal site. Approximately 1514 l/min (400 gpm) of the treated wastewater from the secondary clarifier is discharged to a POTW, while approximately 757 l/min (200 gpm) is recycled to a fresh water tank for use as makeup water in both the insulation and mineral wool fiber plants. Historical data obtained from the data collection portfolio indicate average treated effluent concentrations of 7.74 mg/l BOD and 77.4 mg/l TSS.

Plant 123 has no treatment or pretreatment facilities. Excess process wastewater, combined with pump seal water and sanitary wastewater, are discharged directly to a POTW. Plant personnel indicated in the data collection portfolio that suspended solids removal equipment is being considered to reduce current loads to the POTW.

Table VII-15. Insulation Board Treated Effluent Characteristics (Annual Average).

Plant Number	Production		Flow		BOD		TSS	
	kkg/day	(TPD)	kl/kkg	(kgal)/(ton)	kg/kkg	(lbs)/(ton)	kg/kkg	(lbs)/(ton)
Mechanical Pulping and Refining								
931	201	(220)	2.96	(0.71)	1.05	(2.10)	1.15	(2.30)
125	139	(153)	1.88	(0.45)	2.03	(4.06)	1.71	(3.42)
555	471	(517)	10.5	(2.53)	0.36	(0.72)	3.42	(6.83)
531	246	(270)	1.02	(0.24)	0.07	(0.14)	0.16	(0.32)
Thermo Mechanical Pulping and Refining and/or Hardboard Production at Same Facility								
373†	605	(665)††	51.3	(12.3)	4.06	(8.12)	12.3	(24.5)
1071	359	(395)††	21.9	(5.26)	2.15	(4.31)	.94	(1.88)

†Data are taken before paper wastewater is added.
††Includes both insulation board and hardboard production.

Plant 931 produces structural and decorative insulation board. The plant collects its process wastewater in a whitewater storage tank, recycles a portion of the wastewater where needed, and sends the remaining portion to the treatment system which consists of an equalization tank, a floc-clarifier, and an aerated lagoon. Polymer addition in the clarifier is used to aid settling. Fiber recovered in the clarifier is recycled to the process. Data obtained from the verification sampling program show removal efficiencies in the floc-clarifier of 24 percent BOD and 79 percent TSS. A portion of the clarifier overflow is recycled to the process and the remaining wastewater enters the aerated lagoon, where it is retained 30.4 days before discharge to a POTW. Solids levels increase in the aerated lagoon from an average influent loading of 0.71 kg/kkg (1.42 lb/ton) to an effluent loading of 1.15 kg/kkg (2.30 lbs/ton). Overall removal efficiency at the system is 82 percent for BOD and 60 percent for suspended solids. The treated waste loadings for this plant are presented in Table VII-15. Effluent BOD and TSS concentrations are 354.6 mg/l and 388.4 mg/l, respectively.

Plant 531 is a self-contained discharger and uses treated wastewater to spray-irrigate a 2.3 hectare (5.6 acre) field. Whitewater enters the treatment system at two points: an aerated lagoon and an evaporation pond. Water from the evaporation pond is routed to the aerated lagoon.

Waste loadings from the lagoon are 1.27 kg/kkg (2.54 lb/ton) BOD and 46 kg/kkg (92 lb/ton) TSS. The lagoon removes 89 percent of the BOD. Solids levels increase during mixing. From the aerated lagoon, the wastewater is sent to a primary clarifier, where polymer and alum aid in settling and pH adjustment. The supernatant from the clarifier is directed to a holding pond. Sludge from the clarifier is thickened in a flotation unit and hauled daily to a cinder dump. Water separated from the sludge enters the holding pond of the spray irrigation system. Total efficiency of the system, prior to spray irrigation, is 95 percent BOD removal and 65 percent solids removal. Effluent waste loadings from data supplied by the plant are presented in Table VII-15.

Plant 989, which produces decorative and mineral wool insulation board, is a self-contained discharger with spray irrigation as the ultimate means of wastewater disposal. The process wastewater from the plant enters a series of three settling ponds with a total capacity of 587 million liters (155 million gallons). The ponds retain the wastewater up to a period of six months, after which it is sprayed onto a 30 hectare (80 acre) field of Reed Canary grass. The spray irrigation system operates 180 days per year at a rate of 6435 kl/day (1.7 MGD). No historical data were obtained from the plant.

Plant 1111 produces structural insulation board. Process whitewater is completely recycled and the plant has no external treatment system.

Plant 695 has no wastewater treatment facilities. Wastewater from the thermo-mechanical pulping and refining of insulation board is collected in a whitewater chest. A portion is recycled to the process and the

remaining wastewater is discharged to a POTW. No monitoring practices for flow or other parameters exist.

Plant 231 uses thermo-mechanical pulping and refining to produce structural and decorative insulation board. The process wastewater is screened for removal of gross solids prior to being collected and is either recycled to the process or discharged with no further treatment to a POTW. Annual effluent concentrations for 1976 were 4125.9 mg/l BOD and 2121.4 mg/l TSS.

Plant 137 produces structural insulation board. There are no wastewater treatment facilities, as no process wastewater is discharged. All process whitewater is recirculated to a sump. Sump waters are screened, stored in a clarified whitewater chest, and recycled to the process.

A summary of the influent and effluent waste loads for insulation board plants is presented in Table VII-16. Treatment efficiencies are calculated for the plants which supplied both influent and effluent data.

Raw and treated effluent loadings of total phenols for four insulation board plants are presented in Table VII-17. Raw and treated effluent loadings of heavy metals for four insulation board plants are presented in Table VII-18.

Biological Treatment in the Wet Process Hardboard Industry

Plant 24 produces S1S and S2S hardboard for such uses as paneling, doorskins, siding and concrete formboard. Process wastewaters are collected in a sewer. Cooling, seal, boiler blowdown surface runoff, and condensate from the distillation process are combined in a separate storm sewer. After screening, primary clarification, and flow equalization of each waste stream, the two streams are combined prior to biological treatment. Solids removed during screening are landfilled. Solids from primary clarification are either landfilled or dewatered and burned in mill boilers. After the two waste streams are combined, they are routed to a biological system consisting of two contact stabilization activated sludge systems operating in parallel, followed by an aerated lagoon. The activated sludge from the secondary clarifiers is pumped to two stabilization basins, reaerated for sludge stabilization, and returned to the contact basins. Waste sludge is either recycled to the production units or landfilled. BOD removal calculated from historical data for the contact stabilization system is 78 percent. Suspended solids removal is 70 percent. BOD and TSS effluent concentrations from the contact stabilization system are 435.5 mg/l and 157 mg/l, respectively.

After secondary clarification the wastewater is routed to an aerated lagoon and is discharged after approximately 6 days detention time to old impoundment ponds. A portion of the lagoon effluent is reused as log flume make-up water. Treated effluent is discharged from the holding ponds to a creek. Treated concentrations calculated from 1976 historical data are 102 mg/l BOD and 120 mg/l TSS. Effluent waste loadings are presented in Table VII-19a.

Table VII-16. Insulation Board Annual Average Raw and Treated Waste Characteristics.

Plant Code	BOD, kg/Kkg (lb/ton) Raw Waste	Treated Effluent	Percent Reduction	TSS, kg/Kkg (lb/ton) Raw Waste	Treated Effluent	Percent Reduction
Mechanical Pulping and Refining Insulation Board						
931*	5.70 (11.4)	1.05 (2.10)	82%	3.34 (6.67)	1.15 (2.30)	66%
123	5.95 (11.9)	--	--	4.67 (9.33)	--	--
555	21.6 (43.2)	0.361(0.72)	98%	47.1 (94.1)	3.42 (6.83)	93%
531	1.27 (2.59)	0.07 (0.14)	95%	0.46 (0.92)	0.16 (0.32)	65%
125*	2.39 (4.78)	2.03 (4.06)	15%	1.55 (3.11)	1.71 (3.42)	+10% increase
Thermo-Mechanical Pulping and Refining and/or Hardboard Production at Same Facility						
231	33.6 (67.1)	--	--	17.3 (34.5)	--	--
373	29.8 (59.5)	4.06 (8.12)	86%	28.6 (57.1)	12.3 (24.5)	57%
1071	43.2 (86.3)	2.15 (4.31)	95%	-- --	.94 (1.88)	--

* Raw waste are calculated from verification sampling data.

Table VII-17. Raw and Treated Effluent Loadings and Percent Reduction for Total Phenols Insulation Board.

Plant Code	Raw Waste[1] kg/Kkg	Raw Waste[1] Load lb/ton	Treated Waste[2] kg/Kkg	Treated Waste[2] Load lb/ton	% Reduction
555	0.00095	0.0019	0.00010	.00021	89%
231	0.0024	.0048		---	---
931	0.00040	.00079	0.00008	.00015	81%
125	0.0022	.0045	0.00014	.00029	94%

1 Data obtained during the verification sampling program.
2 Average daily waste flow and production data for 1976 supplied by plants in response to data collection portfolio were used to calculate waste loadings.

Table VII-18. Raw and Treated Effluent Loadings and Percent Reduction for Insulation Board Metals.

D R A F T

Plant No.	Be	Cd	Cu	Pb	Ni	Zn	Sb	As	Se	Ag	Tl	Cr	Hg
Plant No. 931													
Raw Waste Load (kg/Kkg)	.0000042	.0000028	.0019	.000006	.0008	.003	.0000021	.000013	.000014	.0000021	.0000028	.000006	.000028
(lb/ton)	(.0000083)	(.0000056)	(.0037)	(.000011)	(.0016)	(.005)	(.0000042)	(.000025)	(.000027)	(.0000042)	(.0000056)	(.000011)	(.0000042)
Treated Waste Load (kg/Kkg)	.0000021	.0000035	.0009	.000006	.0006	.0014	.000018	.000006	.000007	.0000021	.000008	.000022	.00000042)
(lb/ton)	(.0000042)	(.0000069)	(.0018)	(.000011)	(.0011)	(.0028)	(.000035)	(.000011)	(.000013)	(.0000042)	(.000015)	(.000044)	(.00000083)
% Reduction	49%	+ 23%	51%	0%	31%	44%	+733%	56%	52%	0%	+ 167%	+ 300%	80%
Plant No. 231													
Raw Waste Load (kg/Kkg)	.000007	.000008	.0023	.00017	.00085	.0042	.000025	.000027	.000035	.0000049	.0000041	.00006	.000041
(lb/ton)	(.000014)	(.000016)	(.0046)	(.00034)	(.0017)	(.0084)	(.000049)	(.000054)	(.00007)	(.0000098)	(.0000082)	(.00012)	(.000082)
Treated Waste Load (kg/Kkg)	.000012	.000013	.0020	.00021	.0009	.0480	.000021	.000013	.000025	.000017	.0000041	.00020	.00013
(lb/ton)	(.000024)	(.000026)	(.0040)	(.00041)	(.0018)	(.0095)	(.000042)	(.000026)	(.000049)	(.000033)	(.0000082)	(.00040)	(.00026)
% Reduction	+ 71%	+ 62%	13%	+ 20%	5%	+ 13%	14%	52%	30%	+ 236%	0%	+ 233%	+ 217%
Plant No. 125													
Raw Waste Load (kg/Kkg)	.00001	.00001	.000041	.000027	.00025	.005	.000014	.00006	.00007	.00001	.000017	.00047	.000021
(lb/ton)	(.00002)	(.00002)	(.000082)	(.000053)	(.00049)	(.01)	(.000027)	(.00012)	(.00014)	(.00002)	(.000033)	(.00094)	(.000041)
Treated Waste Load (kg/Kkg)	.000001	.000001	.00018	.0000038	.000013	.00017	.0000028	.000006	.0000044	.0000013	.0000013	.000006	.0000019
(lb/ton)	(.0000019)	(.0000019)	(.00035)	(.0000075)	(.000026)	(.00033)	(.0000056)	(.000012)	(.0000087)	(.0000025)	(.0000025)	(.000011)	(.0000038)
% Reduction	90%	90%	+ 326%	85%	94%	96%	79%	90%	93%	88%	92%	98%	91%
Plant No. 555													
Raw Waste Load (kg/Kkg)	.0000055	.0000055	.0036	.000055	.00009	.006	.000022	.000017	.000035	.000005	.0000065	.00012	.00008
(lb/ton)	(.000011)	(.000011)	(.0072)	(.00011)	(.00018)	(.012)	(.000044)	(.000034)	(.00007)	(.000011)	(.000013)	(.00023)	(.00016)
Treated Waste Load (kg/Kkg)	.000006	.000006	.0012	.000008	.000037	.0008	.000048	.00002	.000032	.000007	.000008	.00009	.0000007
(lb/ton)	(.000011)	(.000011)	(.0023)	(.000016)	(.000074)	(.0016)	(.000095)	(.00004)	(.000063)	(.000013)	(.000016)	(.00017)	(.0000013)
% Reduction	0%	0%	68%	85%	58%	86%	+ 115%	+ 17%	10%	+ 18%	+ 23%	26%	99%

Plant 42, which produces S1S and S2S hardboard, collects all process wastewaters and directs the flow in one of two streams to the wastewater treatment facility. The two streams are designated as strong and weak. The strong wastewater stream (which contains condensate from the evaporation of process whitewater for animal feed) enters two activated sludge units operating in parallel. Waste sludge is aerobically digested and pumped to two humus ponds. Water decanted from the humus ponds enters the weak wastewater system. After clarification, the strong wastewater is combined with the weak wastewater and enters the weak treatment system. The weak system consists of an aerated lagoon, an oxidation and settling pond, and two storage ponds. The wastewater is subsequently routed to either spray irrigation or discharge, depending on the season of the year. Between October 1 and May 14, the effluent from the treatment facility is usually recycled to the process or discharged to the river. From May 15 through September 30, the mill directs the treated effluent to a number of storage ponds. The stored treated effluent is either discharged to spray irrigation fields or recycled to the manufacturing process. During 1976, because of drought conditions, the plant was not allowed to discharge to the river for the major part of the year, and effluent was discharged to the irrigation field. Effluent loadings are presented in Table VII-19a.

Plant 606 produces S1S hardboard which is used for exterior siding. The process water is first screened to remove gross solids which are landfilled. The wastewater then enters two settling ponds used alternately. Sludge from these ponds is dredged as required and landfilled. The wastewater flows to the two stage biological treatment system, consisting of an activated sludge system and a second stage aerated lagoon. The practice of recycling a portion of the waste sludge from the secondary clarifier is under evaluation. Overflow from the clarifier enters a second stage aerated lagoon. Treated effluent from this lagoon is currently being reused in the process. Excess treated effluent is discharged to the river. Historical data indicates an overall treatment effiency of 83 percent BOD removal and 24 percent TSS removal. Effluent BOD and TSS concentrations are 681.7 mg/l and 546.8 mg/l, respectively. Effluent waste loadings are presented in Table VII-19a.

Plant 248, which produces S2S hardboard, collects all plant wastewaters into one sewer prior to any treatment. The treatment system consists of a primary aerated pond (Hinde Aqua Air Pond), two stage biological treatment, and secondary storage and/or settling. Waste-water is retained in the Hinde Aqua Air pond for approximately 2.5 days. The primary function of this system is flow and biological equalization, as no BOD or TSS reduction is achieved. After nutrient addition and pH adjustment, wastewaster enters the first stage of biological treatment which consists of two Infilco Aero Accelators. Each Aero Accelator has an aeration compartment and a clarification zone. Biological solids from the clarifier zone are recycled to the aeration compartment. Waste sludge is detained in a surge tank and spray irrigated. The wastewater is routed from the

Table VII-19a. S1S Hardboard Treated Effluent Characteristics (Annual Average).

Plant Number	Production		Flow		BOD		TSS	
	$\frac{kkg}{day}$	(TPD)	$\frac{kl}{kkg}$	$\frac{(kgal)}{(ton)}$	$\frac{kg}{kkg}$	$\frac{(lbs)}{(ton)}$	$\frac{kg}{kkg}$	$\frac{(lbs)}{(ton)}$
S1S Hardboard								
444	88.7	(97.5)	46.6	(11.2)*	9.00	(18.0)*	17.1	(34.1)*
606	194	(213)	7.38	1.78	5.05	(10.1)	4.05	(8.10)
824**	117	(129)	8.82	(2.12)	6.85	(13.7)	10.1	(20.2)
	113.8	(125.0)	8.82	(2.12)	1.30	(2.59)	4.31	(8.62)
888	91.9	(101)	14.0	(3.36)	28.0	(56.0)	27.1	(54.1)
42	343	(377)	4.16	(1.00)	0.13	(0.26)	0.12	(0.24)
24	1446	(1589)	9.40	(2.26)	.97	(1.93)	1.14	(2.27)
64***	111	(122)	4.24	(1.02)	18.5	(36.9)	1.59	(3.18)
	111	(122)	.62	(0.15)	5.10	(10.2)	.59	(1.17)
262****	83.6	(91.9)	17.1	(4.12)	4.72	(9.43)	11.1	(22.2)
	83.6	(91.9)	11.0	(2.65)	2.24	(4.48)	5.30	(10.6)

* Hardboard and paper waste water streams are comingled.
** First row represents total year's data (January to December, 1976). Second row represents data from July through December, 1976.
*** First row represents data from January through December, 1976. Second row represents data from October, 1976 through February, 1977.
*** First row represents data from January to December, 1976. Second row represents data from June to December, 1976.

Table VII-19b. S2S Hardboard Treated Effluent Characteristics (Annual Average).

Plant Number	Production		Flow		BOD		TSS	
	kkg/day	(TPD)	kl/kkg	(kgal)/(ton)	kg/kkg	(lbs)/(ton)	kg/kkg	(lbs)/(ton)
S2S Hardboard								
248	210	(231)	18.3	(4.39)	4.44	(8.88)	4.11 5.90+	(8.22) (11.80)
1071	359	(395)++	21.9	(5.26)	2.15	(4.31)	.94	(1.88)
373+++	605	(665)	51.3	(12.3)	4.06	(8.12)	12.3	(24.5)
428++++	346	(381)	24.1	(5.8)	12.5	(25.0)	21.0	(42.0)

\+ Treated waste load adjusted from non-standard method to standard method.
++ Includes both insulation and hardboard production.
+++ Data are taken before paper wastewater is added. Includes both insulation and hardboard production.
++++ 1975 data.

Accelators to the secondary stage of biological treatment consisting of two aerated lagoons in series. The retention time in each lagoon is approximately 2.5 days. After final biological treatment the wastewater flows into one of two 22.7 million liter (6 million gallon) facultative lagoons. The lagoons are used alternately to minimize the effects of any thermal inversions. Solids are removed from each basin during the periods it is not in use. Treated effluent is discharged to the river.

From historical data obtained in the data collection portfolio, this system exhibits an overall efficiency of 93 percent BOD removal and 74 percent TSS removal. Effluent concentrations are 242.5 mg/l BOD and 224.4 mg/l TSS. Treated effluent loadings are shown in Table VII-19b. The above values are based on a non-standard analytical method for TSS. A study was conducted during April and May of 1977, to determine the correlation between the TSS as measured by the non-standard method used by the plant, and TSS as measured by Standard Methods. Twenty-nine final effluent samples were collected by the plant over a 29-day period. The samples were split at the plant with one fraction analyzed by the plant using the non-standard method, and one fraction sent by air freight to ESE's Gainesville laboratory for analysis. The results of the study for final effluent are presented in Table VII-20. The least squares linear correlation between the data is shown in Figure VII-7.

The annual average daily treated waste load reported by the plant was converted to concentration using the annual average daily flow and production, adjusted using the least squares linear correlation, and converted back to an adjusted treated waste load. The resulting adjusted treated waste load is 5.9 kg/kkg (11.8 lb/ton). The adjusted final effluent TSS concentration is 323 mg/l.

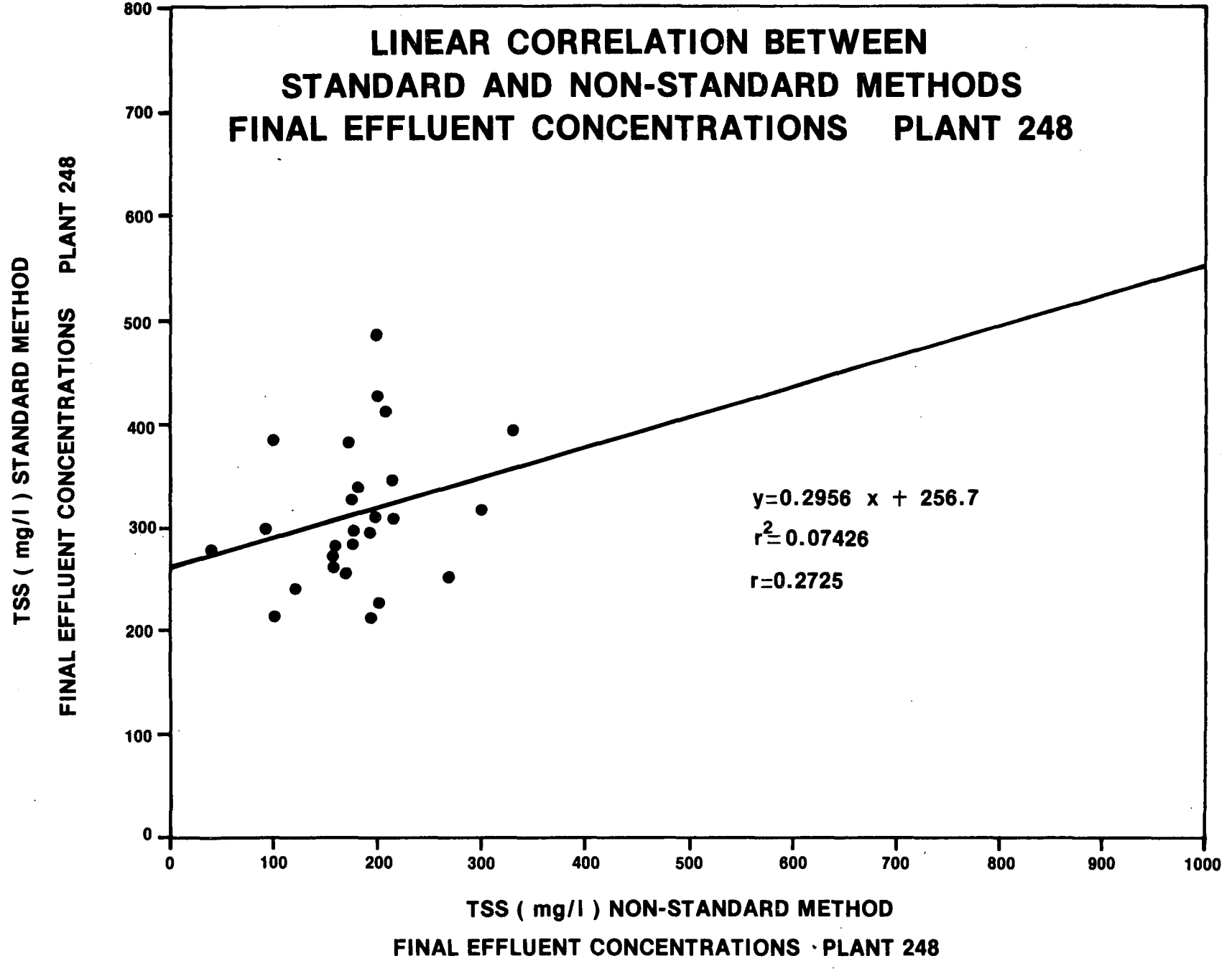
Plant 444 produces S1S hardboard and specialty paper products. The wastewaters from the two processes are comingled with cooling waters and directed to the treatment system. The plant indicated in its data collection portfolio that piping modifications were to be completed by June 1977, and that after these modifications the cooling waters will not enter the wastewater stream. The treatment system consists of two primary settling ponds, which can operate either in series or parallel, an aerated lagoon, and a secondary settling pond. The primary settling ponds are decanted and the sludge is pumped to a drying area and landfilled. Secondary sludge is pumped and landfilled. Historical data obtained from the data collection portfolio indicate effluent concentrations of 192.7 mg/l BOD and 365. mg/l TSS. Overall efficiency removals in the biological system (aerated lagoon and secondary settling pond) is 72 percent for BOD. The solids level increased 147 percent. Effluent waste loadings are presented in Table VII-19a.

Plant 262 produces S1S hardboard. The non contaminated fresh water is collected and discharged directly to the river. All excess plant whitewater is processed through the treatment facility. The wastewater is first screened for removal of gross solids and returned to the process.

Table VII-20. Standard and Non-Standard Methods Comparison, Final Effluent Concentrations, Plant 248.

1977 Dates	TSS (mg/l) Final Effluent	
	Standard Method	Non-Standard Method
4/21	280	160
4/22	345	210
4/23	300	90
4/24	390	330
4/25	320	300
4/26	310	220
4/27	220	190
4/28	380	170
4/29	250	170
4/30	260	160
5/1	220	100
5/2	280	180
5/3	230	200
5/4	250	270
5/5	290	180
5/6	290	190
5/7	310	220
5/8	270	160
5/9	310	200
5/10	240	120
5/11	340	180
5/12	280	40
5/13	430	200
5/14	480	200
5/15	330	170
5/16	310	210
5/17	420	210
5/18	370	100
5/19	240*	890*
Mean	311	183

* These values were omitted from the calculations.


LINEAR CORRELATION BETWEEN
STANDARD AND NON-STANDARD METHODS
FINAL EFFLUENT CONCENTRATIONS PLANT 248
y=0.2956 x + 256.7
r²=0.07426
r=0.2725
TSS (mg/l) STANDARD METHOD
FINAL EFFLUENT CONCENTRATIONS PLANT 248
TSS (mg/l) NON-STANDARD METHOD
FINAL EFFLUENT CONCENTRATIONS · PLANT 248
0
100
200
300
400
500
600
700
800
900
1000

re VII - 7

The wastewater then enters a primary settling pond, where it is retained for 4 days before entering the biological treatment system. Nutrients are added prior to an aerated lagoon. After a two-day retention period in the aerated lagoon, the wastewater enters a secondary settling pond and is discharged to the river. Sludge from the settling ponds and aerated lagoon is dredged as necessary and landfilled.

The annual average efficiency of this system is 84 percent BOD removal and a 10 percent increase in solids levels. In-process modifications completed in June 1976, however, significantly affected the efficiency of the treatment system from June through December, 1976. The system achieved BOD removal of 91 percent and TSS removal of 48 percent. Treated waste loads are presented in Table VII-19a.

Plant 28, which produces S1S hardboard, collects all process wastewater in a system of channels, gravity sewers, and force mains. The wastewater flows into a collection and equalization tank and is pumped to a lime neutralization tank, then to a POTW. Historical effluent data indicate effluent BOD and TSS concentrations of 3526.3 mg/l and 863.9 mg/l, respectively.

Plant 824, which produces S1S hardboard, significantly altered its biological treatment system during 1976 by expanding the facilities. The treatment system presently consists of a pair of two-stage biological treatment facilities operating in parallel. Each system consists of two aerated lagoons operating in series followed by a settling pond.

The first aerated lagoon has a capacity of 15.1 million liters (4 million gallons) and is followed by a second aerated lagoon with a 5.7 million liter (1.5 million gallon) capacity. Nutrients are added to the lagoons and lime is added for pH adjustment prior to the settling ponds. Cooling water is combined with the process wastewater from the settling ponds before final discharge to the river. Modifications to the treatment system were completed in July, 1976. From historical data for 1976 the annual average effluent concentrations of BOD and TSS were 773.4 mg/l and 1140.3 mg/l, respectively. The system exhibited overall efficiencies of 81 percent BOD removal and 55 percent TSS removal. Since the completion of the modifications in July, the average effluent concentrations were 141.9 mg/l BOD and 472.4 mg/l BOD. The new system achieves 96 percent BOD removal and 81 percent TSS removal. Effluent waste loadings are presented in Table VII-19a.

Plant 428 produces S1S and S2S hardboard which is used in tile board, furniture, and merchandising display panels. Wastewater is pumped to an effluent holding tank and then to a primary clarifier with a detention time of three hours. Sludge, consisting mainly of wood fiber, is continuously removed from the clarifier, dewatered, and either burned in a power boiler or landfilled. The water removed from the sludge is recycled back to the primary clarifier. Clarified effluent flows to the secondary treatment system consisting of a settling pond and two aerated

lagoons in series. Primary treated effluent is held one day in the settling pond and then flows to the first aerated lagoon, where nutrients are added. Average theoretical detention in each basin is 17 days. The first basin was designed to maintain the totally mixed system. In the 308 data collection portfolio, plant 428 maintains that 70 to 80 percent of the BOD load is removed in the first basin. The water flows by gravity to the second aerated lagoon, the second half of which is a quiescent zone to allow the biological solids to settle. Treated effluent is discharged from the second aerated lagoon to receiving waters. Data from 1975 show overall efficiency of the system is 89 percent BOD removal and 3 percent TSS removal. Effluent concentrations are 516.8 mg/l BOD and 868.2 mg/l TSS. Effluent loadings are presented in Table VII-19b (1975 data).

Plant 888 produces S1S hardboard for use in siding and industrial furniture. The plant also operates a veneer plant sawmill. Process waters from the hardboard and veneer plant are comingled and directed to the treatment facility which consists of two primary settling ponds in series followed by an activated sludge system.Detention time in the primary settling ponds is approximately nine days. Solids are removed annually by decanting the basins. Nutrients are added as the wastewater enters the activated sludge system, consisting of an aerated lagoon and secondary clarifier. Sludge is recycled from the clarifier to the aeration basin at approximately 568 l/min (150 gpm). Waste sludge enters a small aerobic digester and is pumped to an irrigation field. After biological treatment the treated wastewater flows into two post storage basins and is recycled to the manufacturing process.

Historical data obtained in the 308 data collection portfolio indicate a 62 percent BOD removal and an increase in TSS of 61 percent. Concentrations of the treated effluent are 2005.4 mg/l BOD and 1934.7 mg/l TSS. Effluent waste loadings are presented in Table VII-19a.

Plant 288 produces S2S hardboard for use in building siding and thermo mechanically pulped and refined insulation board. The plant uses a combination of biological and physical wastewater treatment. All wastewaters other than groundwood whitewater are discharged to a sump. The groundwood whitewater is directed to a newly constructed wood molasses plant. The wastewater from the sump has previously been directed either to an oxidation pond or to a primary clarifier; however, the state regulatory agency has ordered the plant to discontinue use of the oxidation pond. At the time the contractor visited the plant in late 1976, a portion of the wastewater was still directed to the oxidation pond and discharged to the river. The plant plans to discontinue use of the pond by routing all highly concentrated wastewaters to the molasses plant and the remaining wastewater to the existing clarifier or directly to a holding tank. Sludge from the clarifier is recycled to the plant, and the overflow wastewater is directed to the holding tank. The effluent from the holding tank is spray irrigated onto a field. Runoff from the field is collected and discharged to the river.

Plant 373, which produces S2S hardboard and hermo-mechanically pulped and refined insulation board, collects all process wastewater in a main sewer and directs the water to the treatment system. The treatment system consists of a series of hydrosieves, a rotating biological surface (RBS) biological treatment, and a secondary clarifier. The solids removed by the hydrosieves are recycled to the process. The liquid flows to a holding tank, where a portion is either returned to the refiners, used in repulping, or reused in the forming machines. The remaining flow enters the biological treatment system and nutrients are added. The wastewater then flows to a secondary clarifier where paper mill effluent is conbined with the hardboard and insulation board treated effluent. Secondary sludge is landfilled. The final effluent is discharged to the river.

Historical data obtained in the data collection portfolio indicate 32 percent BOD removal and 60 percent TSS removal from primary treatment (hydrosieves). The RBS treatment system showed a 78 percent reduction in BOD and an 8 percent increase in TSS. A mechanical failure at the RBS system prompted investigation for a proper treatment system. At the time the data collection portfolio was received, pilot studies were being conducted to determine the best method of treatment. Effluent loadings are presented in Table VII-19b.

Plant 64 produces S1S hardboard. The treatment system consists of two settling ponds in series. Process wastewater is collected in a sump and directed to the ponds which have a theoretical retention time of ten days before discharge to receiving waters. Effluent loadings are presented in Table VII-19a.

Plant 22 produces S2S hardboard and thermo-mechanically pulped and refined insulation board. The hardboard is used for paneling or cabinets. The insulation board is used for ceiling tiles or sheathing. Plant effluent, after screening to remove gross solids, enters a three-day capacity holding pond. The wastewater then flows to two settling ponds operating in parallel. After settling, the water enters a storage pond. Discharge from the storage pond is pumped to irrigation fields. No monitoring of wastewater is practiced at this plant.

Plant 666 produces S2S hardboard, thermo-mechanically pulped and refined insulation board, and mineral wool fiber. Mineral wool fiber is produced at a separate manufacturing facility. Wastewaters from the mineral wood fiber plant are discharged to two settling ponds operating in parallel. The hardboard and insulation board wastewaters are combined with the settling pond effluent and discharged to a POTW.

Plant 1071 produces thermo-mechanically pulped and refined insulation board, fiberboard, and S2S hardboard. The hardboard is primarily used for exterior siding. The wastewater from the insulation and hardboard product lines are collected in a sump, screened, and directed to a

primary clarifier. Clarifier underflow is recycled to the process. The solids are pumped over a Bauer hydrosieve, recovered, and recycled to the process. Water may bypass the clarifier and flow directly to settling basins. Water then flows to a 24.3 hectare (60 acre) holding pond, used for flow equalization, and subsequently discharges to a series of four aerated lagoons. The discharge from the fourth aerated lagoon is split between two oxidation ponds. Effluent from the two oxidation ponds are comingled and discharged to the river.

Historical data show 95 percent BOD removal and effluent concentrations of 98.1 mg/l BOD and 42.8 mg/l TSS. Waste loadings are presented in Table VII-19b.

A summary of the influent and effluent waste loads for thirteen wet process hardboard plants is presented in Table VII-21a and Table VII-21b. Treatment efficiencies are calculated for the plants which supplied both influent and effluent data in the data collection portfolio.

Raw and treated effluent loadings of total phenols for six hardboard plants is presented in Table 22. Raw and treated effluent loadings of heavy metals for six hardboard plants is presented in Table 23.

Tertiary Treatments

Candidate tertiary treatment technologies for wood preserving include membrane systems, activated carbon adsorption, chemical oxidation, and evaporation. Candidate tertiary treatment technologies for insulation board and hardboard are chemically assisted coagulation of secondary effluent and direct filtration of secondary effluent.

Membrane Systems--This term refers to both ultrafiltration, which is employed primarily to remove suspended and emulsified materials in wastewater, and to reverse osmosis (RO), which removes all or part of the dissolved substances, depending upon the molecular species involved, and virtually all of the suspended substances. Both technologies are currently used as part of the wastewater treatment system of many diverse industries (Lin and Lawson, 1973; Goldsmith, et al., 1973; Stadnisky, 1974) and have potential appplication in the wood preserving industry for oil removed.

Ultrafiltration treatment of oily waste basically involves passing the waste under a pressure of 2.1 to 3.6 atm (30 to 50 psi) over a membrane cast onto the inside of a porous fiberglass tube. The water phase of the waste is forced through the membrane and discarded, reused, or further processed by other means. The oil and other solids not in solution remain in the tube. The process in effect concentrates the waste. Volume reductions on the order of 90 to 96 percent have been reported (Goldsmith, et al., 1973; Stadnisky, 1974).

Results obtained in pilot- and full-scale operations of ultrafiltration systems have been mixed. Goldsmith, et al. (1973), operated a pilot unit continuously (24 hours per day) for six weeks processing waste emulsions containing 1 to 3 percent oil. The permeate from the system, which was 95 percent of the original volume, contained 212 mg/liter

Table VII-21a . Hardboard Annual Average Raw and Treated Waste Characteristics.

Plant Code	BOD, kg/Kkg (lb/ton) Raw Waste	Treated Effluent	Percent Reduction	TSS, kg/Kkg (lb/ton) Raw Waste	Treated Effluent	Percent Reduction
S1S Hardboard						
444	32.7 (65.4)	9.00 (18.0)	72%	6.90 (13.8)	17.1 (34.1)	147% increase
28	37.4 (74.7)	--	--	9.15 (18.3)	--	--
606	29.3 (58.6)	5.05 (10.1)	83%	12.4 (24.8)	4.05 (8.10)	67%
824*	35.6 (71.2)	6.85 (13.7)	81%	22.5 (44.9)	10.1 (20.2)	55%
	35.6 (71.2)	1.30 (2.59)	96%	22.5 (44.9)	4.31 (8.62)	81%
888	68.7 (137.3)	28.0 (56.0)	59%	16.8 (33.5)	27.1 (54.1)	+61% increase
262**	30.1 (60.1)	4.72 (9.43)	84%	10.1 (20.2)	11.1 (22.2)	+10% increase
	26.3 (52.5)	2.24 (4.48)	91%	10.1 (20.1)	5.30(10.6)	48%
42	1.9 (3.8)	0.13 (0.26)	93%	0.56 (1.15)	0.12 (0.24)	79%
24	21.9 (43.8)	0.97 (1.93)	96%	5.85 (11.7)	1.14 (2.27)	81%
64***	--	18.5 (36.9)	--	--	1.59 (3.18)	--
	--	5.05 (10.2)	--	--	1.59 (1.17)	--

Table VII-21b. Hardboard Annual Average Raw and Treated Waste Characteristics (continued).

Plant Code	BOD, kg/Kkg (lb/ton) Raw Waste	Treated Effluent	Percent Reduction	TSS, kg/Kkg (lb/ton) Raw Waste	Treated Effluent	Percent Reduction
S2S Hardboard						
248	66.3 (132.6)	4.5 (8.9)	93%	15.9 (31.8) 14.1 (28.2)†	4.11 (8.22) 5.90 (11.8)†	74% 58%†
1071	43.2 (86.3)	2.15 (4.31)	95%	--	.94 (1.88)	--
373	29.8 (59.5)	4.06 (8.12)	86%	28.6 (57.1)	12.3 (24.5)	57%
428††	116 (232)	12.5 (25.0)	89%	21.6 (43.2)	21.0 (42.0)	3%

* First row represents data from January through December, 1976; second row represents data from July through December, 1976.
** First row represents data from January through December, 1976; second row represents data from June through December, 1976.
*** First row represents data from January through December, 1976; second row represents data from October, 1976, through February, 1977.
† Solids data adjusted from non-standard method to standard method.
†† 1975 data.

Table VII-22. Raw and Treated Effluent Loadings and Percent Reduction for Total Phenols Hardboard.

Plant Code	Raw Waste[1] kg/Kkg	Raw Waste[1] Load lb/ton	Treated Waste[2] kg/Kkg	Treated Waste[2] Load lb/ton	% Reduction
262	0.005	.01	0.00030	.00059	94%
42	0.01	.02	0.00015	.0003	98%
24	0.003	.006	---	---	---
824	0.055	.11	0.00046	.00092	99%
28	---	---	0.003	.006	---
22	0.0015	.003	0.0028	.0055	+83%
428*	---	---	0.0005	.001	---

1 Data obtained during verification sampling program.
2 Average daily waste flow and production data for 1976 supplied by plants in response to data collection portfolio were used to calculate waste loadings.

* Data are 1976 historical data supplied by plant in response to data collection portfolio.

Table VII-23. Raw and Treated Effluent Loadings and Percent Reduction for Hardboard Metals.

DRAFT

Plant No.	Be	Cd	Cu	Pb	Ni	Zn	Sb	As	Se	Ag	Tl	Cr	Hg
824													
Raw Waste Load (kg/Kkg)	.000006	.00029	.0039	.00006	.0024	.009	.0002	.000012	.000018	.000006	.000013	.00029	.000018
(lb/ton)	(.000012)	(.00057)	(.0078)	(.00012)	(.0047)	(.017)	(.00003)	(.000023)	(.000035)	(.000012)	(.000026)	(.00058)	(.000035)
Treated Waste Load (kg/Kkg)	.0000045	.0000045	.0014	.00002	.0002	.0025	.0000085	.00002	.000006	.0000005	.000007	.000006	.000018
(lb/ton)	(.000009)	(.000009)	(.0028)	(.00004)	(.0004)	(.0049)	(.00017)	(.00004)	(.000012)	(.000001)	(.000014)	(.00011)	(.000035)
% Reduction	25%	98%	64%	67%	92%	72%	96%	+73% increase	33%	92%	46%	98%	0%
248													
Raw Waste Load (kg/Kkg)	.000013	.00006	.014	.00012	.0018	.0048	.00008	.000026	.00002	.00018	.000013	.00019	.0000013
(lb/ton)	(.000025)	(.000012)	(.027)	(.00024)	(.0035)	(.0096)	(.00015)	(.000051)	(.00004)	(.00035)	(.000025)	(.00037)	(.0000025)
Treated Waste Load (kg/Kkg)	.000009	.000037	.009	.000037	.00033	.0008	.000009	.000024	.000019	.000085	.000013	.000043	.000037
(lb/ton)	(.000018)	(.000074)	(.017)	(.000074)	(.00066)	(.0016)	(.000018)	(.000048)	(.000037)	(.00017)	(.000025)	(.000085)	(.000074)
% Reduction	31%	38%	36%	69%	82%	83%	89%	8%	8%	53%	0%	77%	+283% increase
42													
Raw Waste Load (kg/Kkg)	.000008	.000007	.00044	.0008	.0008	.003	.00008	.000016	.00005	.000007	.000013	.0001	.0000027
(lb/ton)	(.000016)	(.000013)	(.00088)	(.0015)	(.00015)	(.005)	(.00015)	(.000032)	(.0001)	(.000013)	(.000026)	(.0019)	(.0000053)
Treated Waste Load (kg/Kkg)	.0000028	.000008	.000017	.000033	.000024	.00026	.00001	.000007	.00002	.0000033	.0000023	.000024	.0000011
(lb/ton)	(.0000056)	(.000016)	(.00033)	(.000065)	(.000047)	(.00052)	(.000020)	(.000014)	(.000039)	(.0000066)	(.0000045)	(.000047)	(.0000022)
% Reduction	65%	+14% increase	96%	96%	97%	91%	87%	56%	60%	53%	82%	76%	59%
28													
Raw Waste Load (kg/Kkg)	.000005	.000005	.0011	.00002	.00006	.024	.000024	.000014	.000024	.000005	.000005	.00009	.000011
(lb/ton)	(.00001)	(.0001)	(.0021)	(.00004)	(.00012)	(.048)	(.000048)	(.000027)	(.000048)	(.00001)	(.00001)	(.00017)	(.000021)
Treated Waste Load (kg/Kkg)													
(lb/ton)													
% Reduction													
262													
Raw Waste Load (kg/Kkg)	.000009	.000009	.009	.000035	.00006	.014	.000009	.000017	.00006	.000009	.000009	.000017	.00031
(lb/ton)	(.000017)	(.000017)	(.017)	(.000069)	(.00011)	(.027)	(.000017)	(.000034)	(.00011)	(.000017)	(.000017)	(.000034)	(.00062)
Treated Waste Load (kg/Kkg)	.000009	.000009	.004	.000026	.000035	.0066	.000009	.000017	.00047	.000009	.000009	.000035	.00007
(lb/ton)	(.000017)	(.000017)	(.0079)	(.000052)	(.000069)	(.013)	(.000017)	(.000034)	(.000093)	(.000017)	(.000017)	(.000069)	(.00014)
% Reduction	0%	0%	56%	26%	42%	53%	0%	0%	15%	0%	0%	+103% increase	77%
24													
Raw Waste Load (kg/Kkg)	.000007	.000007	.0033	.000042	.00012	.007	.0001	.000015	.000023	.000009	.000009	.006	.000022
(lb/ton)	(.000013)	(.000013)	(.0065)	(.000083)	(.00023)	(.014)	(.0002)	(.00003)	(.000045)	(.000017)	(.000017)	(.011)	(.000043)
Treated Waste Load (kg/Kkg)	.0000048	.0000048	.0000048	.000036	.00006	.0019	.000011	.0000004	.000019	.00006	.000008	.00082	.0000004
(lb/ton)	(.0000096)	(.0000096)	(.0000096)	(.000071)	(.00011)	(.0038)	(.000023)	(.0000009)	(.000038)	(.00011)	(.000016)	(.0016)	(.0000007)
% Reduction	31%	31%	99%	14%	50%	73%	89%	97%	17%	+547% increase	11%	86%	98%

ether extractables--primarily water-soluble surfactants. A 15,140 l/day (4,000 gpd) system installed based on the pilot plant data produced a permeate containing 25 mg/liter ether extractables. No significant reduction in flux rate with time was observed in either the pilot- or full-scale operation.

Ultrafiltration tests of a pentachlorophenol wastewater were conducted by Abcor, Inc., in cooperation with the Mississippi Forest Products Laboratory (1974). The samples contained 2,160 mg/liter oil and had a total solids concentration of 3,900 mg/liter. Flow rate through the system was 95 l/min (25 gpm) at a pressure of 3.3 atm (48 psi). A 26-fold volumetric concentration, representing a volume reduction of 96.2 percent, was achieved. Two membrane types were tested. Both showed a flux decline on the order of 55 to 60 percent with increasing volumetric concentration. A detergent flush of the system was found to be necessary at the end of each run to restore the normal flux values of 35 l/sq m/day (35 gal/sq ft/day). Oil content of the permeate was 55 mg/liter. While this value represents a reduction of over 97 percent, it does not meet the requirements for stream discharge. COD was reduced 73 percent.

The principal of RO is similar to that of ultrafiltration. However, higher hydraulic pressures, 27.2 to 40.8 atm (400 to 600 psi), are employed and the membranes are semipermeable and are manufactured to achieve rejection of various molecular sizes. Efficiency varies, but rejection of various salts in excess of 99 percent have been reported (Merten and Bray, 1966). For organic chemicals, rejection appears to be a function of molecular size and shape. Increases in chain length and branching are reported to increase rejection (Durvel and Helfgott, 1975). Phenols are removed to the extent of only about 20 percent by cellulose acetate membranes, while polyethylenimine membranes increase this percentage to 70 but achieve a lower flux rate (Fang and Chian, 1975). In case studies that have been cited, RO was found to be competitive with conventional waste treatment systems only when extremely high levels of treatment were required (Kremen, 1975).

Removals of 83 percent TOC and 96 percent TDS were reported for RO in which cellulose acetate membranes at 40.8 atm (600 psi) were used (Boen and Jahannsen, 1974). Flux rates in this work of 129 to 136 l/sq m/day (34 to 36 gal/sq ft/day) were achieved. However, in other work, pretreatment by carbon adsorption or sand filtration was found to be necessary to prevent membrane fouling (Rozelle, 1973). Work by the Institute of Paper Chemistry (Morris, et al., 1972) indicates that membrane fouling by suspended solids or large molecular weight organics can be controlled in part by appropriate pretreatment, periodic pressure pulsations, and washing of the membrane surfaces. In this and other work (Wiley, et al., 1972), it was concluded that RO is effective in concentrating dilute papermill waste and produces a clarified water that can be recycled for process purposes.

Recycling of process wastewater, following ultrafiltration and RO treatment, is the objective of a treatment installation currently being constructed by Pacific Wood Treating Corporation, Ridgefield, Washington (1976). The concentrated waste will be incinerated and the permeate from the system used for boiler feed water. The system, which is expected to cost $200,000, is scheduled to start operating in April, 1977. An EPA grant has been requested to provide funds for system evaluation when the project goes on stream.

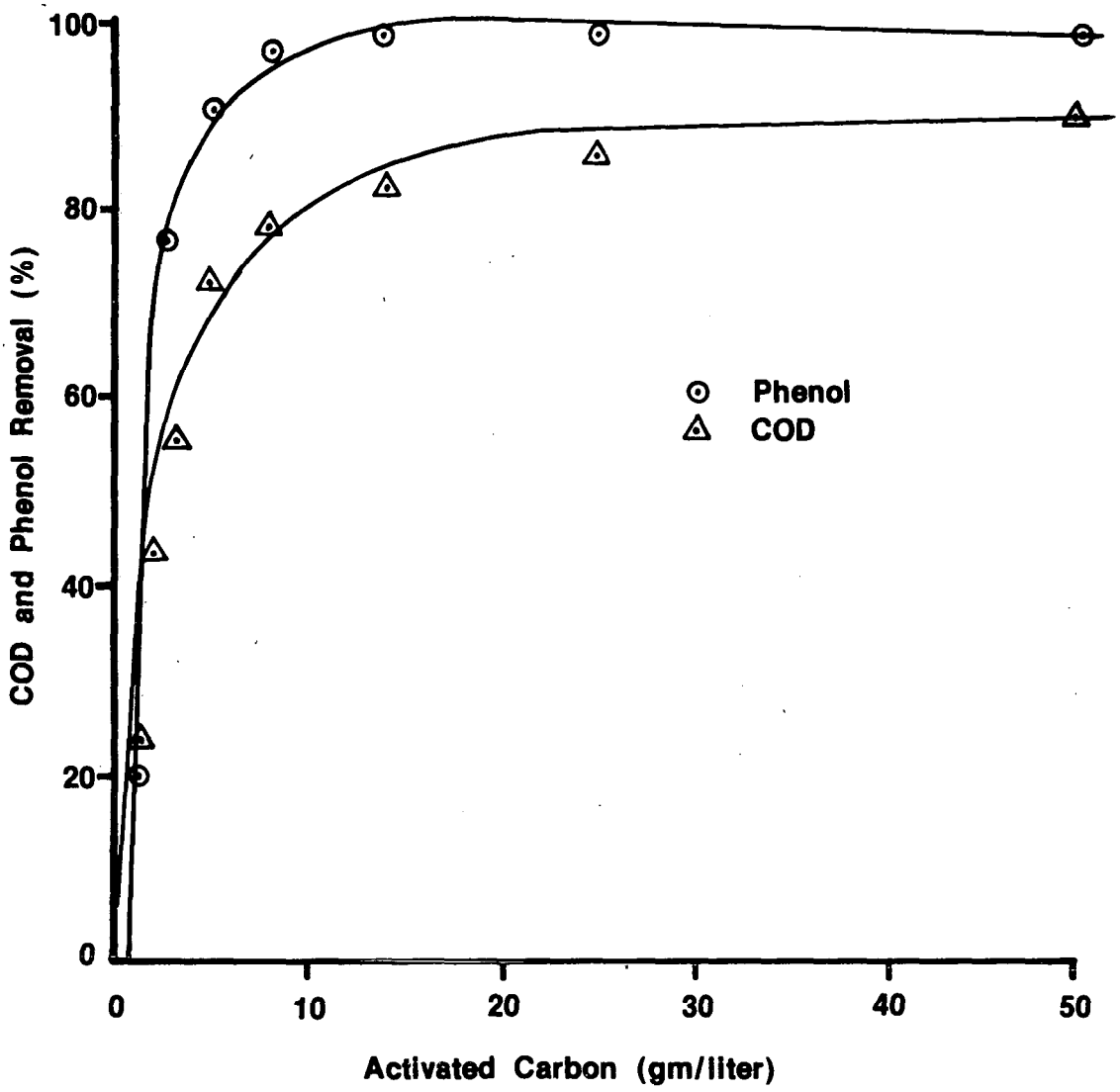
Data on the use of RO with wood preserving wastewater was provided by the cooperative work between Abcor, Inc., and the Mississippi Forest Products Laboratory referred to above (1974). In this work, the permeate from the UF system was processed further in an RO unit. Severe pressure drop across the system indicated that fouling of the membranes occurred. However, module rejection remained consistent throughout the run. Permeate from the system had an oil content of 17 mg/liter, down from 55 mg/liter, and the COD was reduced by 73 percent. Total oil removal and COD reductions in both the UF and RO systems were 99 percent and 92 percent, respectively.

Carbon Adsorption--The efficacy of activated carbon in wastewater treatment has been "rediscovered" by dozens of scientists and engineers in recent years, and it would appear that most have recorded their findings in various scientific journals. Relatively few of these articles are relevant to the timber industry.

To date, there is no known wood preserving, insulation board, or hardboard plant that uses activated carbon adsorption as part of its wastewater treatment program. However, the South Orange, New Jersey, plant of Atlantic Creosoting Company has engaged an engineering firm to study the possible use of activated carbon to treat water from a wet scrubber installed as part of an odor-control system (Straubing).

Results of carbon adsorption studies conducted by Thompson and Dust (1972) on a creosote wastewater are shown in Figure VII-8. Granular carbon was used with a contact time of 24 hours. The wastewater was flocculated with ferric chloride and its pH adjusted to 4.0 prior to exposure to the carbon. As shown in the figure, 96 percent of the phenols and 80 percent of the COD were removed from the wastewater at a carbon dosage of 8 g/liter. The loading rate dropped off sharply at that point, and no further increases in phenol removal and only small increases in COD removal occurred by increasing carbon dosage to 50 gm/liter. Similar results were obtained in tests using pentachlorophenol wastewater.

Results of adsorption isotherms that were run on pentachlorophenol wastewater and other samples of creosote wastewater followed a pattern similar to that shown in Figure VII-8. In some instances a residual content of phenolic compounds remained in wastewater after a contact period of 24 hours with the highest dosage of activated carbon employed, while in



Relationship Between Weight of Activated Carbon Added and Removal of COD and Phenols from a Creosote Wastewater

Figure VII - 8

other instances all of the phenols were removed. Loading rates of 0.16 kilograms of phenol and 1.2 kilograms of COD per kilogram of carbon were typical, but much lower rates were obtained with some wastewaters.

Adsorption isotherms have been developed for wood preserving wastes from several plants to determine the economic feasibility of employing activated carbon in lieu of conventional secondary treatments. The wastewater used for this purpose was usually pretreated by flocculation and filtration to remove oils. Theoretical carbon usage rates obtained from the isotherms ranged from 85 to almost 454 kg per 3,785 liters (1,000 pounds per 1,000 gallons) of wastewater. However, values as low as 0.6 kg per 3,785 liters (1.4 pound per 1,000 gallons)--e.g., the waste from Atlantic Creosoting Company mentioned above--have been found. Because of its source, this waste was not typical of that from a wood preserving plant, although both COD and phenols--4,000 and 600 mg/liter--were high. It differed in the quality of oil-water separation with few exceptions; however, the experience has been that, while activated carbon does an excellent job in removing phenolic compounds, other organics, principally water- soluble wood sugars, greatly increase carbon exhaustion rates.

Use of activated carbon to treat wastewater from a plant producing herbicides was described by Henshaw (1971). With the exception of wood sugars, this waste was similar to wood preserving effluents, especially in terms of COD (3,600 mg/liter) and phenolic materials (210 mg/liter). Raw wastewater was piped directly to a carbon adsorber and the carbon was regenerated thermally. Flow rate and loading rate were not revealed, but the effluent from the system had a phenol content of 1 mg/liter. Cost of the treatment was reported to be about $0.36 per 3,785 liters (1,000 gallons).

The effect of high organic content on carbon usage rate is well known in industry. Recent work to develop adsorption isotherms for 220 wastewater samples representing 75 SIC categories showed a strong relationship between carbon usage rate and organic content of the samples, as measured by TOC (Hager, 1974). Usage rates as high as 681 kg per 3,785 liters (1,500 pounds per 1,000 gallons) were reported for wastewater samples from the organic chemicals industry. For petroleum refining, the values ranged from 0.1 to 64 kg per liter (0.2 to 141 pounds per gallon), depending upon the TOC of the waste.

Use of activated carbon in wastewater treatment in oil refineries is common (Paulson, 1972; Dejohn and Adams, 1975; Baker, 1976; Scaramelli and DiGiano, 1975). Because this industry is related to wood preserving in terms of wastewater characteristics, a few of the more pertinent articles dealing with activated carbon treatment of refinery wastewater are summarized here.

Workers dealing with treatment process methodology emphasized the necessity of pretreatment of activated carbon column influent (Suhr and Culp, 1974). Based on these reports suspended solids in amounts exceeding 50

mg/liter should be removed. Oil and grease in concentrations above 10 mg/liter should likewise not be applied directly to carbon. Both materials cause head loss and can reduce adsorption efficiency by coating the carbon particles. This is apparently more critical in the case of oil and grease than for suspended solids.

Common pretreatment processes used by the industry include chemical clarification, oil flotation, and filtration. Adjustments in pH are frequently made to enhance adsorption efficiency. An acid pH has been shown to be best for phenols and other weak acids. Flow equalization is, of course, necessary for most treatment processes.

Efficiency of adsorption varies among molecular species. In a study of 93 petrochemicals commonly found in that industry's wastewater, adsorption was found to increase with molecular weight and decrease with polarity, solubility, and branching (Scaramelli and DiGiano, 1975). However, molecules possessing three or more carbons apparently respond favorably to adsorption treatments (Hager, 1974).

Dejohn and Adams (1975) studied the relative efficiency of lignite and bituminous coal carbons and concluded that the former is better for refinery wastes because it contains more surface area in the 20 to 500 Å pores.

Several authors have discussed the economics of carbon adsorption. Paulson (1972) stated that direct operating costs based on BOD removal from refinery wastewater range between 4.8 and 10.9 cents per 1,000 gallons for primary effluents and between 5.3 and 9.4 cents per 1,000 gallons for secondary effluents. These estimates were based on a carbon usage rate of 9.9 pounds per 1,000 gallons. Typical treatment facilities for a primary effluents were listed as follows by this author:

Chemical clarifiers	Backwash holding tanks
Coagulant and polymer feeders	Backwash water storage tanks
Pump stations	Carbon reactivation facilities
Carbon adsorbers	Sludge handling facilities

The system for secondary effluent would include these items:

- Pump stations
- Carbon adsorbers
- Backwash holding tank
- Backwash storage tank
- Carbon regeneration facilities

Much higher operating costs for carbon systems have been reported by Rosfjord, et al. (1976). Costs of $0.40 to $6.00 per pound of phenols removed were cited. The efficiency of the carbon regeneration facilities were listed as an important consideration in computing operating costs. Recovery of chemicals, particularly phenols, from carbon beds by either

reactive or solvent methods was reported to be less costly than thermal regeneration.

According to Hutchins (1975), it is most economical to discard carbon at usage rates lower than 159 to 182 kg (350 to 400 pounds) per day and to thermally regenerate at higher usage rates.

Limited data on activated carbon treatment of wood preserving waste strongly indicate that the process is not economically viable when applied as a secondary treatment. The high cost of carbon adsorption when employed in this capacity is due primarily to the presence of high wood sugar levels in the effluents from this industry. Use of the process as a tertiary treatment following biological oxidation--assuming a high oxidation efficiency of the sugars--is probably economically viable.

Adsorption by Other Media--Polymeric adsorbents have been recommended for use under conditions similar to those where carbon adsorption is indicated (Stevens and Kerner, 1975). Advantages cited for these materials include efficient removal of both polar and nonpolar molecules from wastewater, ability to tailor-make an adsorbent for a particular contaminant, small energy inputs for regeneration compared to carbon, and lower cost compared to carbon where carbon depletion rates are greater than 2.3 kg per 3,785 liters (5 pounds per 1,000 gallons). Data on efficiency of polymeric adsorbents were not presented.

Clay minerals, such as attapulgite clay, have been recommended for use in removing certain organics and heavy metals from wastewater (Morton and Sawyer, 1976).

Chemical Oxidation

Chlorine--The use of chlorine and hypochlorites as a treatment to oxidize phenol-based chemicals in wastewater is widely covered in the literature. A review of this literature, with emphasis on the employment of chlorine in treating wood preserving wastewaters, was presented in a recent EPA document (1973).

The continued use of chlorine as an oxidizing agent for phenols is in question for at least two reasons. There is, first of all, a concern over recent supply problems and the increasing cost of the chemical (Rosfjord, et al., 1976). Secondly, chlorine treatments of phenolic wastes form mono-, di-, and trichlorophenols which persist unless sufficient dosages are used to rupture the benzene ring (EPA, 1973). It is probably true that low-level chlorine treatments of these wastes are worse than no treatment at all because of the formation of such compounds.

For these and possibly other reasons, attention has been focused on other oxidizing agents equally as capable as chlorine of oxidizing phenolic compounds without creating these additional problems.

Potassium Permanganate--This is a strong oxidizing agent that is being marketed as a replacement for phenol. One vendor (Carus Chemical Company, 1971) claims that the chemical "cleaves the aromatic carbon ring of the phenol and destroys it" and then degrades the aliphatic chain thus created to innocuous compounds. Stoicheometrically, 7.13 kg of $KMnO_4$ are required to oxidize one kilogram of phenol. According to Rosfjord, et al. (1976), however, ring cleavage occurs at ratios of about 7 to 1. A higher ratio is required to reduce the residual organics to CO_2 and H_2O.

As in the case of chlorine (EPA, 1973), the presence of oxidizable materials other than phenols in wastewater greatly increases the amount of $KMnO_4$ required to oxidize a given amount of phenols. In the trade literature cited above, it was stated that $10 worth of $KMnO_4$ was required to treat 3,785 liters (1,000 gallons) of foundry waste containing 60 to 100 mg/ liter of phenols. Eighty milligrams per liter of phenols in 3,785 liters (1,000 gallons) is equivalent to 0.3 kg (0.67 pounds). At a 7:1 ratio, the treatment should have cost $2.35. The actual ratio was 30:1 and the cost was about $15 per 0.454 kilograms (one pound) of phenol removed. The latter figure agrees with one vendor's data, which indicated a cost of $0.15 per mg/liter of phenol per 3,785 liters (1,000 gallons) of wastewater.

Limited studies conducted by the Mississippi Forest Products Laboratory revealed no cost advantage of $KMnO_4$ over chlorine in treating wood preserving wastewater. The high content of oxidizable materials other than phenol in this type of waste consumes so much of the chemical that massive doses are required to eliminate the phenols.

Hydrogen Peroxide--This is a powerful oxidizing agent, the efficacy of which is apparently enhanced by the presence of ferrous sulfate which acts as a catalyst. Reductions in phenol content of 99.9 percent (in wastewater containing 500 mg/liter) have been reported for H_2O_2 when applied in a 2:1 ratio (Anonymous, 1975). A reaction time of 5 minutes was required. Ferrous sulfate concentrations of 0.1 to 0.3 percent were used. COD concentration was reduced to 760 mg/liter from 1,105 mg/liter.

According to Eisenhauer (1964), the reaction involves the intermediate formation of catechol and hydroquinone, which are oxidized by the ferric ion to quinones. As is the case with other oxidizing agents, the degree of substitution on the phenol molecule affects the rate of reaction. Substituents in the ortho and para positions reduced the reaction rate the most, and complete substitution (e.g., pentachlorophenol) prevented the reaction from taking place. Solution pH had a significant effect on

the efficiency of the treatment. Optimum pH was in the range of 3.0 to 4.0, with efficiency decreasing rapidly at both higher and lower values.

Treatments of industrial wastes were reported by Eisenhauer to require higher levels of H_2O_2 than simple phenol solutions because of the presence of other oxidizable materials. In fact, the ratio of H_2O_2 to phenols required varied directly with COD above the level contributed by the phenol itself. At all ratios studied with industrial wastes, phenol levels dropped rapidly during the early part of the reaction period, then remained unchanged thereafter. For some types of wastes, the addition of high concentrations of H_2O_2, up to molar ratios of 16:1, did not cause significant further decreases in phenol content. Similar results have been reported for wood preserving wastewater treated with chlorine (EPA, 1973). Prechlorination of wastes with high COD contents reduced the amount of H_2O_2 required in some cases, but not in others.

Hydrogen peroxide has not been used on a commercial scale to treat wastewater from the wood preserving industry or, based on the available literature, wastewaters from related industries. The cost of the chemical is such that a relatively high phenol removal efficiency must ensue to justify its use. The available evidence suggests that, in common with other oxidizing compounds, organics other than phenol consume so much of the reagent as to render the treatment impractical. Its use in a tertiary treating capacity may be practical, depending upon the residual COD of the treated effluent.

Ozone--Ozone has been studied extensively as a possible treatment for industrial wastewaters (Evans, 1972; Eisenhauer, 1970; Niegowski, 1956). No practical success has attended these efforts. The literature reveals only one example in the U.S. of the application of ozone to treat an industrial waste. Boeing Corporation is reported to have operated a 6.8 kg/hour ozonator to treat cyanide and phenolic wastes (McLain, 1973). Worldwide, the situation is similar. The literature mentions a plant in France and one in Canada, both of which use ozone to treat cyanide and phenolic wastes from biologically treated effluents. Conversely, there have been numerous pilot plant studies of the application of ozone for industrial wastes, and ozone is widely used in Europe, especially France, to treat domestic water supplies. Pilot studies to assess the feasibility of using ozone to treat domestic wastes have been sponsored by EPA (Wynn, et al., 1973).

The problem is one of economics. Eisenhauer (1970) concluded from his work that the ozonization of phenol to CO_2 and H_2 cannot be achieved economically. By contrast, Niegowski (1953) reported that in pilot plant tests of ozone, chlorine, and chlorine dioxide, ozone was demonstrated to be the most economical treatment for phenols.

No example of the use of ozone to treat timber products wastewater appears in the literature. However, one wood preserving plant installed a small ozone generator and directed the gas into a large lagoon. The treatment had no measurable effect on wastewater quality.

Incineration--The ultimate method of oxidation is, of course, incineration. At least two U.S. wood preserving plants and one in Canada have installed and operated wastewater incinerators prior to the energy crisis. At least one of the U.S. plants is still operating this equipment. Unofficial reports place operating costs in excess of $50 per 3,785 liters (1,000 gallons) at this plant. Successful use of incinerators by other industries have been based on concentrating the wastes to an organic content of at least 50 percent. At this concentration, the wastes can be incinerated without auxiliary fuel (Hyde, 1965).

Evaporation--Some applications of evaporation are both economical and effective, while others are not. Evaporation methods that require the use of process steam to achieve the required rate of evaporation are highly expensive. On the other hand, methods that depend on simple surface evaporation from lagoons may be economical but are not effective, since most such installations are located in regions where rainfall exceeds lake evaporation by 25 to 51 centimeters per year.

The most effective and economical method employs one or more evaporation lagoons equipped with spray equipment. By proper sizing of the lagoons to account for seasonal differences in both rainfall and evaporation, a zero discharge of process wastewater can be achieved. Actually, such installations serve a dual purpose. In addition to evaporating all or most of a plant's effluent, they also function in much the same fashion as an aerated lagoon. Significant reductions in conventional wastewater parameters are achieved with only a minimal accumulation of sludge.

Chemically Assisted Coagulation--Chemically assisted clarification, as defined in this document, is the use of coagulants or coagulant aids to increase the settleability of biological suspended solids in the clarifier of the biological treatment system. This technology is particularly applicable to the fiberboard industry, as this industry relies heavily on biological treatment for end-of-pipe pollution control. Removal of biological suspended solids from secondary treatment facilities is the single most critical problem for this industry in achieving the goals set forth in the Act.

The mechanisms by which a coagulant aids the precipitation of colloidal matter, such as biological suspended solids, are discussed at length in an AWWA Committee Report (1971), "State of the Art of Coagulation." The chemicals generally used to increase removals of fine and colloidal particles in conjunction with this technology are the metal salts of aluminum and iron, as well as synthetic organic polymers.

When metal salts are used, hydrolysis products are formed which destabilize colloidal particles by a complex series of chemical and physical interactions. Polyelectrolytes are extended-chain polymers of high molecular weight. Particles are adsorbed at sites along the chains of these polymers which interlock to form a physical bridge, thereby destabilizing the sorbed particles.

Chemically assisted coagulation may be used as an additional treatment process applied to the effluent of the secondary clarifier of the biological treatment system. This requires separate mixing, flocculation, and settling facilities, and a considerable capital investment. A recent study performed for the EPA (E.C. Jordan Co., 1977) on chemically assisted clarification demonstrated that increased suspended solids removal may be obtained when applying CAC as an integral part of the biological system. The advantage to this application is that capital and operating costs are kept at a minimum. Mixing takes place using the natural turbulence inherent in the latter stages of the biological system, and settling occurs in the biological secondary clarifier.

Insulation board plant 555 and S1S hardboard plant 824 reported the use of polyelectrolytes to increase solids removal in the biological secondary clarifiers of their respective treatment systems. Plant 824 adds the polyelectrolyte at the influent weir of the final settling pond; little mixing is achieved by application of the polymer at this point. The annual average daily TSS effluent concentration of this plant for the last four months of 1976 (following completion of upgraded treatment facilities) was about 488 mg/l. This represents an 81 percent reduction in TSS in the total system.

Plant 555 adds polyelectrolyte in the aeration basin of the activated sludge unit, achieving better mixing than plant 824.

The annual average daily TSS concentration of the final effluent is about 320 mg/l, which represents a 93 percent reduction in TSS. Both plants noted increased TSS removals using the polyelectrolyte, however no comparable data are available to quantify the amount of TSS reduction due to polymer addition.

Selection of the proper coagulant, point of addition, and optimum dose for this technology can be approximated in the laboratory using jar test procedures. Since the capital cost is minimum, in-plant studies can be easily conducted to optimize operating characteristics for maximum effectiveness.

Granular Media Filtration--Granular media filtration as a tertiary process for control of biological suspended solids, is receiving growing attention in the pulp and paper, food processing, textile, and oil refining industries. It is a physical/electrical/chemical process consisting of: (1) transport of the particles from the suspension to the

media; and (2) contact with and adhesion to the media or other solids previously absorbed on the media.

There are currently no hardboard or insulation board plants using granular filtration; however, several applications of this technology exist in the pulp and paper industry.

The National Council for Air and Stream Improvement conducted a pilot study to investigate the effectiveness of three manufactured granular media filters in removing suspended solids, BOD, and turbidity from papermaking secondary effluents (NCASI, 1973). The three filter systems were studied for TSS and BOD removals when filtering the effluent from an integrated bleached kraft mill and a boxboard mill. The report summarized the study findings by stating that all three units could reduce suspended solids concentrations and turbidity by 25 to 50 percent when chemicals were not used. Reductions of greater than 90 percent were possible with chemical addition.

A recent study performed for EPA on the Direct Filtration and Chemically Assisted Clarification of Biologically Treated Pulp and Paper Industry Westewater concluded that, based on actual plant operating data, direct filtration systems can be designed with chemical addition to achieve, on average, at least 50 percent reduction in filter effluent TSS concentration, with maximum removals of 80 to 90 percent.

It should be noted that influent suspended solids characteristics are an important factor in determining filter performance. Biological treated effluent from the insulation board and hardboard industries differs greatly from that of the pulp and paper industry. Pilot plant studies are needed to properly design a wastewater filter for any specific application. Actual plant operating data will also be required to effectively estimate actual TSS removals for the insulation board and hardboard industries.

Best Demonstrated Technology

Wood Preserving--The wastewater treatment systems at the wood preserving plants presented below exhibit best demonstrated technology for the wood preserving organic chemicals subcategories.

Plants with Multi-Stage Biological Treatment

Plant: 665

Subcategory: Steaming (Self-contained)

Preservatives: Creosote

Production: 413 cubic meters/day

Wastewater Volume: 41,600 liters/day

Wastewater Treatment:

1. Primary and secondary oil separation
2. Flocculation
3. Series of two solar oxidation ponds
4. Soil irrigation

Wastewater Quality (mg/liter):

	COD	Phenols	O&G	pH
Raw	--	--	--	--
Treated	250	0.29	<10	--

Plant: 495

Subcategory: Steaming (Direct discharge)

Preservatives: Creosote and pentachlorophenol

Production: 6,510 cubic meters/month

Wastewater Volume: 53,000 liters/day

Wastewater Treatment:

1. Oil-water separator--dual system
2. Equalization lagoon
3. Solar oxidation--2 lagoons in series
4. Aerated lagoon
5. Solar oxidation--2 lagoons in series

Wastewater Quality (mg/liter):

	COD	Phenols	O&G	PCP*
Raw	2485**	57.6**	476**	158
Treated	20	.03	<10	1.0

* Based on verification sampling program data.
** Based on 1974 data.

Plant: 599

Subcategory: Steaming (Vapor drying; self-contained)

Preservatives: Creosote

Production: 311 cubic meters/day (Design)

Wastewater Volume: 45,400 liters/day

Wastewater Treatment:

1. Primary and secondary oil-water separation
2. Solar oxidation ponds (3)
3. Aerated lagoon
4. Solar oxidation ponds (2)
5. Spray irrigation

Wastewater Quality (mg/liter):

	COD	Phenols	O&G
Raw*	1415	122	110
Treated	<20*	<2	<10*

* Based on 1973 data.

Plant: 855

Subcategory: Steaming (Self-contained)

Preservatives: Creosote and pentachlorophenol

Production: 537 cubic meters/day

Wastewater Volume: 35,200 liters/day

Wastewater Treatment:

1. Oil-water separator--separate system for each preservative
2. Equalization pond
3. Activated sludge treatment
4. Two-lagoon, "solar-oxidation" system
5. Spray irrigation

Wastewater Quality (mg/liter):

	COD	Phenols	O&G	PCP
Raw	3010	237.5	475	22.3
Treated	118	.048	40	.231

Plant: 185

Subcategory: Steaming (Self-contained)

Preservatives: Creosote and pentachlorophenol

Production: 170 cubic meters/day

Wastewater Volume: 37,900 liters/day

Wastewater Treatment:

1. Oil-water, gravity-type separation
2. Flocculation
3. Aerated lagoon
4. Settling pond
5. Spray evaporation lagoon
6. Holding lagoon

Wastewater Quality (mg/liter):

	COD	Phenols	O&G
Raw	9150	25	1300
Point 5	170	<0.2	<10

Plant: 412

Subcategory: Steaming (Vapor drying; self-contained)

Preservatives: Creosote

Production: 366 cubic meters/day

Wastewater Volume: 41,600 liters/day

Wastewater Treatment:

1. Oil-water separator
2. Equalization
3. Activated sludge treatment (dual aeration chambers)
4. Clarification
5. Lagoon system--85 days detention time
6. Spray irrigation field

Wastewater Quality* (mg/liter):

	COD	Phenols	O&G
Raw	2135	161	--
Treated**	65	<.02	<10

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* Based on 1974 data.
** Outfall of third lagoon prior to discharge to irrigation field.

Plant: 331

Subcategory: Steaming (Self-contained)

Preservatives: Creosote, pentachlorophenol, and CCA

Production: 292 cubic meters/day

Wastewater Volume: 125,000 liters/day

Wastewater Treatment:

1. Oil-water separation
2. Aerated lagoons--3 in series
3. Soil irrigation
4. Catch basin for recycling discharge from irrigation field to boiler, vacuum pumps, etc.

Wastewater Quality (mg/liter):

	COD	Phenols	O&G
Raw	1685	60.2	170
Treated	165	.013	15

Plant: 517

Subcategory: Steaming (Self-contained)

Preservatives: Creosote and pentachlorophenol

Production: 118 cubic meters/day

Wastewater Volume: 27,300 liters/day

Wastewater Treatment:

1. Oil-water separator
2. Aerated lagoons--2 in series equipped with spray nozzles
3. Spray irrigation
4. Catch basin for spray field runoff
5. Recycle of catch basin water as boiler water

Wastewater Quality (mg/liter):

	COD	Phenols	O&G
Raw	5491	17.6	576
Treated	235	0.65	15

Plants With Single-Stage Biological Treatment

Plant: 777

Subcategory: Steaming (Direct discharge)

Preservatives: Creosote and pentachlorophenol

Production: 1,980 cubic meters/month

Wastewater Volume: Unknown

Wastewater Treatment:

1. Oil-water separator
2. Flocculation
3. Sand filtration
4. Aerated lagoon
5. Discharge as required

Wastewater Quality (mg/liter):

	COD	Phenols	O&G
Raw	--	--	--
Treated	25	0.26	<10

Plant: 199

Subcategory: Steaming (Vapor drying; POTW)

Preservatives: Creosote

Production: 4050 cubic meters/month

Wastewater Volume: 94,600 liters/day

Wastewater Treatment:

1. Oil-water separation
2. Flocculation
3. Filtration
4. Aerated lagoon
5. Clarification
6. Discharge to POTW as required

Wastewater Quality (mg/liter):

	COD	Phenols	O&G
Raw	1430	482.2	35
Treated	100	.12	<10

Plant: 637

Subcategory: Steaming (Direct discharge)

Preservatives: Creosote and pentachlorophenol

Production: 170 cubic meters/day

Wastewater Volume: 30,300 liters/day

Wastewater Treatment:

1. Dual oil-water separators
2. Equalization lagoon
3. Chemical flocculation
4. Aerated lagoon equipped with spray evaporation equipment
5. Settling pond
6. Discharge as required

Wastewater Quality (mg/liter):

	COD	Phenols	O&G	pH
Raw (?)	1750	4.6	145	--
Treated	50	<0.2	<10	--

Plants With Flocculation

Plant: 450

Subcategory: Steaming (POTW)

Preservatives: Creosote, pentachlorophenol, and CCA

Production: 2410 cubic meters/month

Wastewater Volume: 11,400 liters/day

Wastewater Treatment:

1. Oil-water separation--separate system for each preservative
2. pH adjustment
3. Flocculation
4. Chlorination
5. Sand filtration
6. Equalization
7. Discharge to POTW as required

Wastewater Quality* (mg/liter):

	COD	Phenols	PCP	O&G	pH
Raw	6500	80	540	340	--
Treated	4866	0.20	15	15	8.0

* Based on 1976 pretreatment data.

Examples of plants that have no discharge of process wastewater are presented below. All wastewater from these plants are either recycled or evaporated via a cooling tower.

Plant: 203

Subcategory: Boulton (Self-contained)

Preservatives: Creosote, pentachlorophenol, ACA, and FR

Production: 5580 cubic meters/month

Wastewater Volume: Not applicable

Wastewater Treatment:

1. Primary and secondary oil separation
2. Recycle via cooling tower equipped with heat exchanger to evaporate excess water as required
3. Salt processes have zero discharge; all wastewater recycled

Wastewater Quality:
Not applicable

Plant: 111

Subcategory: Boulton (Self-contained)

Preservatives: Creosote and pentachlorophenol

Production: 1610 cubic meters/month

Wastewater Volume: Not applicable

Wastewater Treatment:

1. Primary and secondary oil-water separation
2. Part of wastewater recycled via process cooling tower. Remainder is evaporated in a cooling tower equipped with heat exchanger built especially for this purpose.

Wastewater Quality: Not applicable

Plant: 333

Subcategory: Wood preserving (zero discharge)

Preservatives: CCA and FR

Production: 18,800 fbm/day

Wastewater Volume: Not applicable

Wastewater Treatment:

No treatment is required. All wastewater is collected and recycled as makeup solutions for CCA and FR.

Wastewater Quality: Not applicable

Based on the results demonstrated by the above plants, the final effluent concentrations presented in Table VII-24 represent best demonstrated technology. The concentration of fugitive metals in organic chemical wood preservingplants is extremely variable from plant to plant, depending on such factors as preservatives employed, waste management practices, and rainfall. Concentrations of fugitive metals in plant wastewater are estimated based on data collected since 1973.

As reported in the discussion of chemical flocculation earlier in this section, flocculated effluent frequently has an oil and grease concentration of less than 100 mg/l. Therefore 100 mg/l is used as the expected concentration for this parameter after flocculation. Extremely low concentrations as that demonstrated by exemplary plant 450 are usually a result of dilution after flocculation.

Although not currently demonstrated in the industry, activated carbon adsorption following biological treatment and titration may be expected to remove 95 percent of total phenols (including PCP), 80 percent of the COD, and oil and grease concentrations to a limit of 10 mg/l, the limit of detection for this parameter.

Table VII-24. Best Demonstrated Final Effluent Concentrations, Wood Preserving Organic Chemicals Subcategory (mg/l).

Treatment System	COD	Phenol	O&G	PCP	PNA's (Total)	Cu	Cr	As	Zn
Multi-Stage Biological Treatment	75-100	0.04	<10	1.0	0.5	4.0	1.5	1.0	2.0
Single-Stage Biological Treatment	100	0.12	<10	5.0	1.0	4.0	1.5	1.0	2.0
Flocculation	5,000	0.2	100	12.0	1.5	4.0	1.5	1.0	2.0

Insulation Board

The wastewater treatment system at insulation board Plant 127 exhibits the lowest treated effluent concentrations of all plants in the insulation board mechanical pulping and refining subcategory. Annual average daily concentrations are 7.7 mg/l for BOD and 77.4 mg/l for TSS. The raw wastewater going to the treatment system is not characteristic of wood fiber insulation board, however. Wood fiber insulation board raw wastewater is used for process water in the plant's mineral wool fiber plant prior to being discharged to the treatment system. For the above reason, the wastewater treatment system at Plant 127 cannot be considered with other insulation board treatment systems.

The wastewater treatment system at insulation board Plant 555 in the mechanical pulping and refining subcategory demonstrates exemplary performance. Treatment units consist of bar screens, two parallel mechanical clarifiers, and a single stage activated sludge system followed by polymer assisted secondary clarification. Primary and waste secondary sludge are conditioned in a gravity thickener, followed by a vacuum filter. Dewatered sludge is stored and returned to the plant for reuse in the process.

The annual average daily raw waste loads for Plant 555 are 21.6 kg/kkg (43.2 lb/ton) for BOD, 47.0 kg/kkg (94.1 lb/ton) for TSS, and 0.00095 kg/kkg (0.0019 lb/ton) for total phenols. BOD and TSS raw waste loads are substantially higher than other plants in the subcategory. Annual average daily treated effluent waste loads are 0.36 kg/kkg (0.72 lb/ton) for BOD, 3.42 kg/kkg (6.83 lb/ton) for TSS, and 0.00010 kg/kkg (0.00021 lb/ton) for total phenols. Annual average daily treated effluent concentrations are 34.1 mg/l for BOD, 324 mg/l for TSS, and 0.010 mg/l for total phenols. It is estimated that 10 percent additional solids are removed from the secondary effluent by the addition of polyelectrolyte prior to clarification. The adjusted secondary effluent without the chemically assisted clarification would then be 360 mg/l. The high solids concentrations in the effluent are due to the difficulty in settling the biological solids produced in secondary treatment, a problem common to all fiberboard plants.

The amount of biological solids produced in secondary treatment systems is a function of the amount of BOD removed. The treatment system removes 98 percent of the raw BOD. Solids removal efficiency, based on raw waste solids load, is 93 percent. It is felt, however, that treatment efficiencies for suspended solids are not a reliable indicator of treatment plant performance since they do not account for biological solids produced in the secondary treatment systems.

Best demonstrated treatment for the insulation board, mechanical pulping and refining subcategory, based on final effluent concentrations and an annual average daily effluent flow of 10.5 kl/kkg (2.53 kgal/ton) demonstrated by Plant 555 is 0.36 kg/kkg (0.72 lb/ton) for BOD, 3.8 kg/kkg (7.6 lb/ton) for TSS, and 0.00010 kg/kkg (0.00021 lb/ton) for total phenols.

Application of chemically assisted clarification, as demonstrated by this plant,, will reduce the treated waste load for TSS to an annual daily average of 3.4 kg/kkg (6.8 lb/ton).

Application of granular media filtration technology is expected to reduce the effluent suspended solids concentration 35 percent, resulting in a final effluent TSS of 2.5 kg/kkg (4.9 lb/ton).

As previously discussed, none of the insulation board plants which produce solely insulation board by thermo-mechanical pulping and refining is a direct discharger, and it follows that there are no treatment systems upon which to base best demonstrated technology. Annual average daily raw wastewater characteristics of the one thermo-mechanical plant which does produce solely insulation board are 33.6 kg/kkg (67.1 lb/ton) BOD, 17.3 kg/kkg (34.5 lb/ton) TSS, and 0.0024 kg/kkg (0.004 lb/ton) total phenols. This raw waste load is similar to the average raw waste load for S1S hardboard plants, which is 33.8 kg/kkg (67.6 lb/ton) BOD, 14.2 kg/kkg (28.3 lb/ton) TSS, and 0.019 kg/kkg (0.038 lb/ton) total phenols, and there is no reason to expect average annual daily treated effluent concentrations from a properly designed biological treatment system for thermo-mechanical insulation board to be different from those for S1S hardboard. S1S hardboard treated effluents, as presented later in this section, are 150 mg/l BOD, 350 mg/l TSS, and 0.052 mg/l total phenols.

Based on an annual daily average effluent flow of 8.11 kl/kkg (1.95 kgal/ton) and an average production of 193 kkg/day (212 tons/day), the best demonstrated treated effluent waste load is 1.2 kg/kkg (2.4 lb/ton) BOD, 2.8 kg/kkg (5.7 lb/ton) TSS, and 0.00042 kg/kkg (0.00084 lb/ton) total phenols.

Application of chemically assisted clarification technology is expected to result in a 10 percent reduction in suspended solids. This would result in a treated effluent TSS load of 2.5 kg/kkg (5.0 lb/ton).

Application of granular media filter technology is expected to result in a 35 percent reduction in suspended solids. This would result in a treated effluent TSS load of 1.8 kg/kkg (3.7 lb/ton).

Due to the extremely low levels of heavy metals in the raw and final effluents of the insulation board industry, best demonstrated treatment plant performance technology is not defined for heavy metals. Table VII-18 presents the raw and treated waste loads of heavy metals for four insulation board plants. In general, reduction of heavy metals of about 50 percent or more are common for biological treatment systems. Data in Table VII-18 support this estimate.

Wet Process Hardboard

The wastewater treatment system at Plant 24 exhibits the lowest treated effluent concentrations of all the S1S hardboard plants. BOD and TSS effluent concentrations from the contact stabilization activated sludge system are 435.5 and 157 mg/l, respectively.

Following secondary clarification the wastewater is routed to an aerated lagoon and is discharged after approximately 6 days detention time to old impoundment ponds. Treated effluent is discharged from the holding ponds to a creek. Treated concentrations calculated from 1976 historical data are 102 mg/l BOD and 120 mg/l TSS.

Plant 24 evaporates much of its strong wastewater to produce an animal feed by-product, and the wastewater treated in the contact stabilization system includes large amounts of cooling, pump seal, and stormwater runoff, as well as boiler blowdown. For these reasons, this plant cannot be considered characteristic of the S1S hardboard segment.

Plant 444 achieves treated effluents concentrations of 193 and 365 mg/l for BOD and TSS respectively. This plant produces paper products at the same facility, and the wastewaters are combined before treatment. For this reason, Plant 444 cannot be considered characteristic of the S1S segment.

The wastewater treatment facility at Plant 824 consists of two, two-stage aerated lagoons followed by two settling ponds, only one of which is continuously on-stream. Modifications to this system were completed in July 1976. Upon completion of the modifications, the average daily effluent concentrations have been 142 mg/l for BOD and 472, mg/l for TSS. Verification sampling performed at the plant found the treated effluent concentration of total phenols to be 0.05 mg/l.

Although this plant adds a polyelectrolyte to the secondary settling pond, very little mixing is achieved. The treatment system at plant 824 is not achieving the effluent solids concentrations which can be expected from a plant that is properly designed and operated. S2S Plant 248 achieves an adjusted final effluent of 323 mg/l TSS from a similar settling pond arrangement. Insulation board Plant 555 obtains an adjusted final effluent of 360 mg/l TSS with a mechanical clarifier and much higher solids loadings.

A final effluent suspended solids concentration of 350 mg/l can be achieved by a well designed and operated secondary settling facility, as demonstrated by Plants 248 and 555. If 350 mg/l is use to calculate the suspended solids load from Plant 824, the resulting treated effluent loadings are 1.3 kg/Kkg (2.6 lb/ton) for BOD, 3.1 kg/Kkg (6.2 lb/ton) for TSS, and 0.00046 kg/Kkg (0.00092 lb/ton) for total phenols.

Application of chemically assisted clarification, with proper mixing facilities, with an expected reduction in suspended solids of 10 percent, will result in a treated effluent TSS load of 2.8 kg/Kkg (5.6 lb/ton).

Application of granular media filtration, with an expected reduction in solids of 35 percent, will result in a treated effluent TSS load of 2.0 kg/Kkg (4.0 lb/ton).

S2S/Insulation Board Plant 1071 exhibits the lowest effluent concentrations of any S2S hardboard producing plant. BOD and TSS annual average daily concentrations are 98.1 mg/l and 42.8 mg/l, respectively. However, this plant cannot be considered characteristic of the S2S subcategory for two reasons: 1) insulation board wastewater is completely mixed with S2S wastewater, and 2) land availability for this plant is such that treatment consists of a 24.3 hectare (60 acre) holding pond, followed by a series of four aerated lagoons, followed by two oxidation ponds.

Plant 248 provides solely S2S hardboard. Its treatment system, which represents best demonstrated technology, consists of a primary aerated pond (Hinde Aqua Air Pond), two-stage biological treatment, secondary storage and/or settling. Wastewater is retained in the Hinde Aqua Air pond for approximately 2.5 days. The primary function of this system is flow and biological equalization, as no BOD or TSS reduction is achieved. After nutrient addition and pH adjustment, wastewater enters the first stage of biological treatment which consists of two Infilco Aero Accelators. Each Aero Accelator has an aeration compartment and a clarification zone. Biological solids from the clarifier zone are recycled to the aeration compartment. Waste sludge is detained in a surge tank and spray irrigated. The wastewater is routed from the Accelators to the secondary stage of biological treatment consisting of two aerated lagoons in series. The retention time in each lagoon is approximately 2.5 days. After final biological treatment the wastewater flows into one of two 22.7 million liter (6 million gallon) facultative lagoons. The lagoons are used alternately to minimize the effects of any thermal inversions. Solids are removed from each basin during the periods it is not in use. Treated effluent is discharged to the river.

The annual average daily BOD concentration achieved by Plant 248 is 242.5 mg/l. The TSS concentration, adjusted to Standard Methods as previously described in this section, is 323 mg/l. The total phenols concentration of the effluent is 0.016 mg/l as sampled during the verification sampling program. This value is uncharacteristically low for fiberboard plants which use thermo-mechaincal pulping and refining. The phenols effluent concentration of S1S Plant 824, 0.05 mg/l, is more characteristic and will be used in calculating the treated effluent phenols waste load for Plant 248.

Final effluent annual average daily treated waste loads for Plant 248, representative of best demonstrated technology for the S2S subcategory, are 2.2 kg/Kkg (4.3 lb/ton) for BOD, 5.9 kg/Kkg (11.8 lb/ton) for TSS and 0.0009 kg/Kkg (0.0018 lb/ton) for phenols.

Application of chemically assisted clarification, with an expected suspended solids reduction of 10 percent, will result in a treated effluent TSS load of 5.3 kg/Kkg (10.6 lb/ton).

Application of granular media filtration, with an expected suspended solids reduction of 35 percent, will result in a treated effluent load of 3.8 kg/Kkg (7.7 lb/ton).

Due to the extremely low levels of heavy metals in the raw and final effluents of the hardboard industry, best demonstrated technology treatment plant performance is not defined for heavy metals. Table VII-23 presents the raw and treated waste loads of heavy metals for six hardboard plants. In general, reduction of heavy metals of about 50 percent or more are common for biological treatment systems. Data in Table VII-23 support this estimate.

Candidate Treatment Technologies

Wood Preserving

Direct discharge--Two basic treatment technology options are proposed for plants that discharge directly to the environment. Option 1 uses carbon adsorption in a tertiary treatment sequence following conventional biological secondary treatment. The technical validity of this treatment regime rests on the assumption that the primary treatment phases will reduce oil content to a level compatible with biological treatment, and that the efficiency of the biological treatment will be such that after clarification or filtration the effluent to the carbon unit will have a COD of less than 300 mg/liter.

Option 2 uses as a tertiary treatment biological oxidation to achieve essentially the same result as carbon adsorption in Option 1. The redundancy required in the biological treatment phase is not well defined by information at hand. However, in terms of conventional parameters, it is evident from Table VII-13 that satisfactory results can be achieved by multi-stage biological treatment.

The third technology option proposed for plants with a direct discharge is identical to Option 2 except that superimposed on it is the technology required to remove metal contaminants from the wastewater. If lime alone or lime in combination with a polyelectrolyte is used in Step 2, additional treatment (Steps 4 to 6) may not be necessary for removal of all metals except chromium. However, because of the substantial solubility of hexavalent chromium, its presence in the wastewater will require the full sequence of treatment steps shown.

Indirect discharge--Proposed technology in the Draft Development Document for Pretreatment Standards basically consists of the treatment sequence shown in Option 1 for indirect dischargers. This option gives due recognition to what is perceived to be the intent of the Act with respect to industry utilization of the POTW.

Option 3 is identical to Option 1 except that, as above, the technology for removing fugitive metals from wastewater prior to discharge to the POTW is included.

Option 2 is proposed in recognition of the fact that a higher level of treatment technology is employed by several plants that utilize the POTW. This option is similar to Option 2 for direct dischargers in that it provides redundancy in the biological-oxidation phase, with the POTW included in the tertiary treatment sequence.

Sufficient data are not available today to judge whether an on-site secondary treatment is required to ensure that the priority organic

pollutants do not pass through the POTW to the environment. Experience gained by the wood preserving industry over the past 30 years, however, clearly shows that this level of treatment is not required to protect the POTW. There is no record of an upset having been caused by wood preserving discharges, notwithstanding the fact that 17 percent of the U.S. plants now utilize the POTW.

Self-contained discharge--The three options presuppose two distinct wastewater management objectives. Options 1 and 2 are suggested for plants that choose to dispose of their wastewater, while Option 3 is for plants that choose to recycle it. The technologies represented by all three options are in current use at one or more plants and are self-explanatory. It should be noted, however, that most plants that dispose of their waste by evaporation, as shown in Option 2, do not provide flocculation.

Proposed Treatment Technology

Direct Discharge

Option 1 (Oily Wastewater Only)

Step	Description
1	Oil-water separation
2	Flocculation
3	Filtration
4	Single-stage biological treatment
5	Clarification or rapid sand filtration
6	Activated-carbon adsorption
7	Discharge or recycle as required

Option 2 (Oily Wastewater Only)

Step	Description
1	Oil-water separation
2	Flocculation
3	Filtration
4	Multi-stage, biological treatment
5	Clarification
6	Discharge as required

Option 3 (Oily Wastewater with Fugitive Metals)

Step	Description
1	Oil-water separation
2	Flocculation

3	Filtration
4	pH adjustment with H_2SO_4
5	Chromium reduction
6	pH adjustment with $Ca(OH)_2$
7	Multi-stage biological treatment
8	Clarification
9	Discharge as required

Indirect Discharge

Option 1 (Oily Wastewater Only)

Step	Description
1	Oil-water separation
2	Flocculation
3	Filtration
4	pH adjustment
5	Discharge to POTW

Option 2 (Oily Wastewater Only)

Step	Description
1	Oil-water separation
2	Flocculation
3	Filtration
4	Single-stage biological treatment
5	Clarification
6	Discharge to POTW

Option 3 (Oily Wastewater with Fugitive Metals)

Step	Description
1	Oil-water separation
2	Flocculation
3	Filtration
4	pH adjustment with H_2SO_4
5	Chromium reduction
6	pH adjustment with $Ca(OH)_4$
7	Filtration
8	Discharge to POTW

Self-Contained Discharge

Option 1

Step	Description
1	Oil-water separation
2	Flocculation

3	Filtration
4	Soil irrigation

Option 2

Step	Description
1	Oil-water separation
2	Flocculation
3	Filtration
4	Spray-pond or cooling tower evaporation

Option 3

Step	Description
1	Oil-water separation
2	Flocculation
3	Filtration
4	Single-stage biological treatment
5	Soil irrigation
6	Run-off collection
7	Recycle as required

Insulation Board and Hardboard

Four basic technology alternatives are proposed for insulation board and hardboard. Alternative A consists of primary clarification, followed by a two-stage activated sludge system, including secondary clarification. For the insulation board mechanical pulping subcategory, single stage activated sludge is proposed. The choice of a one- or two-stage system is primarily one of economics rather than treatment effectiveness. When properly designed and operated, a single stage unit will perform equally as well as a two-stage unit. For larger waste loadings, two-stage systems are more economical.

Alternative B includes Alternative A with the addition of polymers as coagulant aids just prior to the outfall of the aeration basin. Preliminary data transferred from the pulp and paper industry indicate a minimum of 10 percent solids reduction provided sufficient mixing is achieved and the clarifier is properly designed.

Alternative C includes Alternative A with the addition of dual media filtration. Preliminary data transferred from the pulp and paper industry indicates that 35 percent solids reduction can be expected from such a system. It should be noted that filtration as a tertiary treatment is not currently in use in the fiberboard industry. Pilot plant testing of this sytem will be required prior to application of this alternative.

Alternative D is applicable to plants with sufficient land availability. It consists of a two-stage aerated lagoon as an alternative to activated sludge treatment.

Alternative E is again limited to plants with sufficient land availability and appropriate climactic conditions. This alternative consists of a roughing lagoon/holding pond followed by spray irrigation. Several plants are successfully applying this technology to completely self-contain all process wastewater.

Pretreatment technology is not presented from the insulation board and hardboard industries due to the long-standing, demonstrated treatability of their raw wastewaters. Several insulation board and hardboard indirect dischargers provide varying levels of pretreatment prior to discharge to a POTW, as discussed earlier in this section. The purpose of this pretreatment is to reduce the waste load to the POTW, and thus lower sewer charges. Figures VII-9 through VII-22 graphically depict the candidate technologies. Tables VII-25 through VII-29 present the annual average daily final effluent waste loads that can be expected from each of the candidate technologies.

In order to allow an assessment of the economic impact of guidelines, model treatment systems have been developed.

Since the model systems are for subcategories consisting of numerous plants located throughout the United States, they are by necessity generalized. Whenever a treatment system is to be designed for a particular industrial operation, the design should be preceded by a characterization of the wastewater of the specific plant and by pilot plant studies in order to provide an optimum system for the given process.

Specific assumptions for each unit operation of the model treatment systems are as follows:

1. Monitoring Station--An installation to sample and measure the flow of treated wastewater prior to discharge to a receiving water or POTW. Flow is measured by a Parshall flume and recorded on a strip chart. Flow proportioned samples are pumped to the control house. Controls and sample pumps are under cover.

CANDIDATE TREATMENT TECHNOLOGY

ALTERNATIVE A

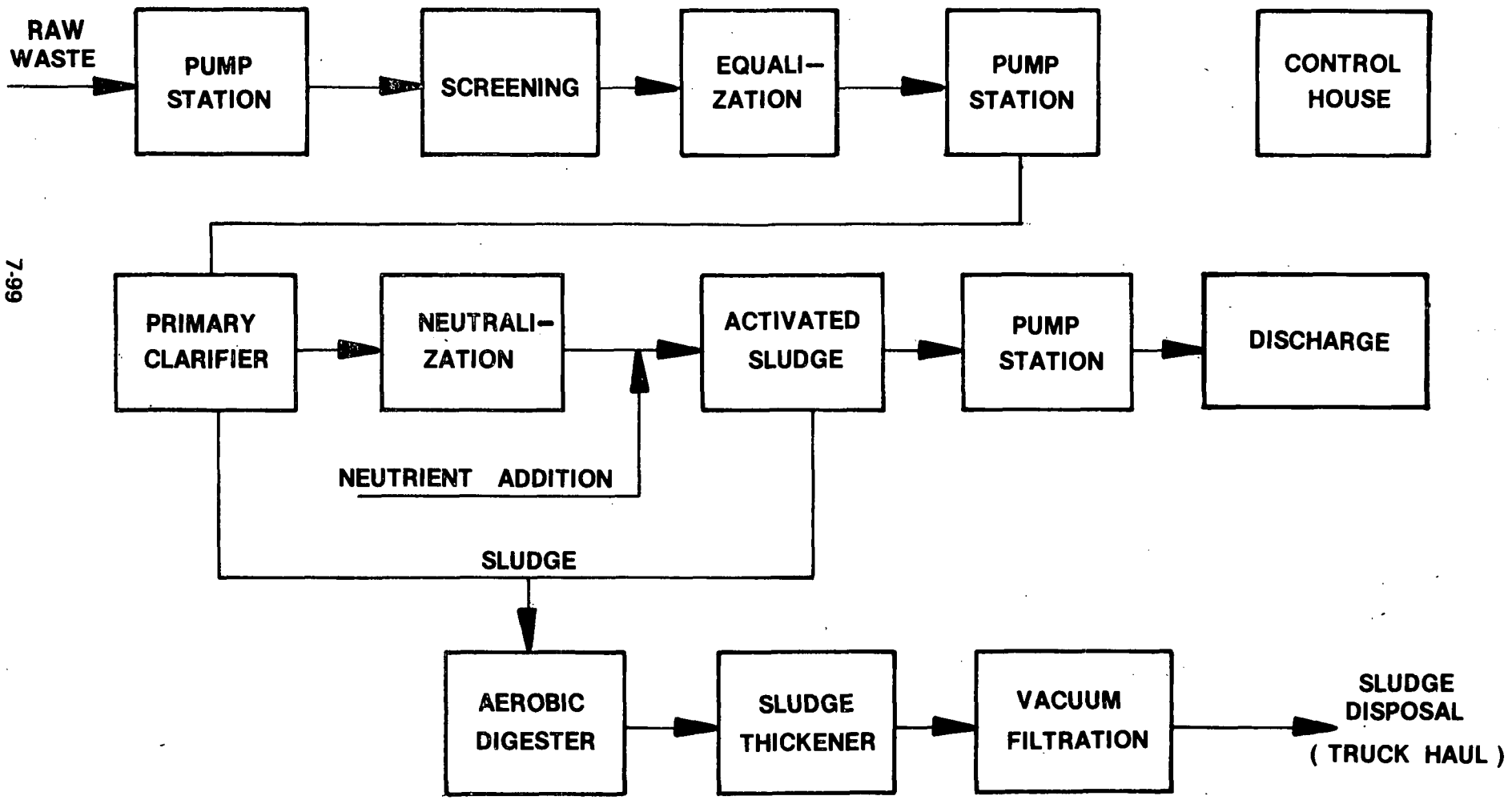

FIGURE VII-9

CANDIDATE TREATMENT TECHNOLOGY

ALTERNATIVE B

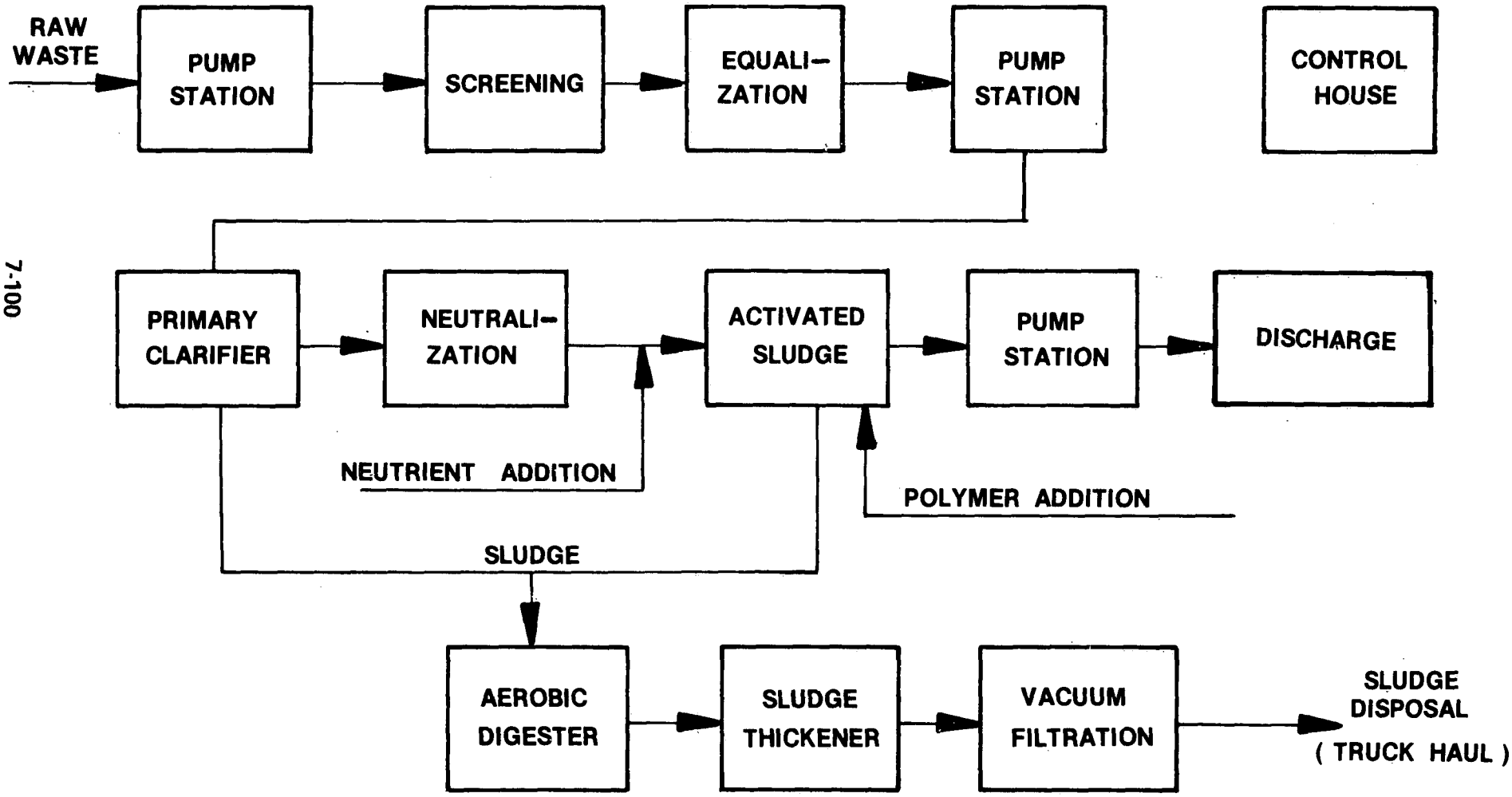

FIGURE VII-10

Candidate Treatment Technology

ALTERNATIVE C

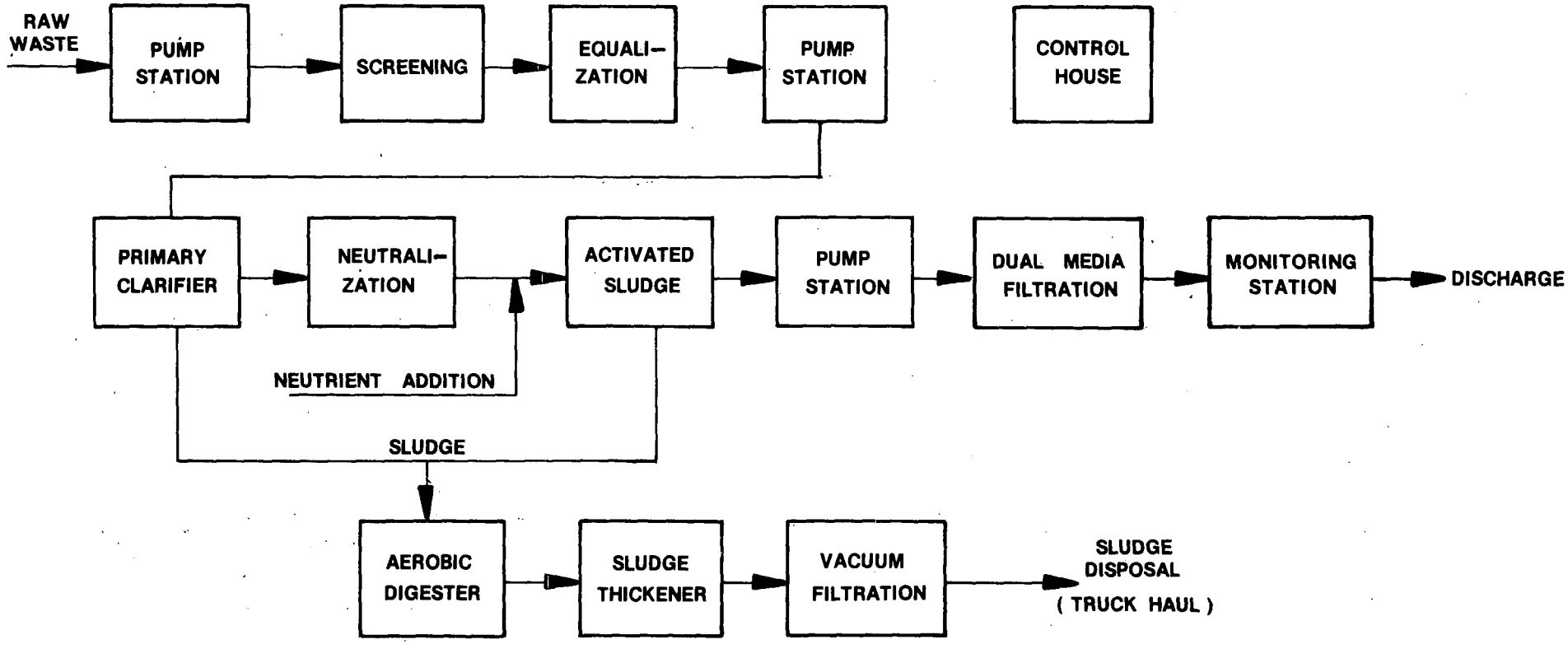

FIGURE VII-11

Candidate Treatment Technology

ALTERNATIVE D

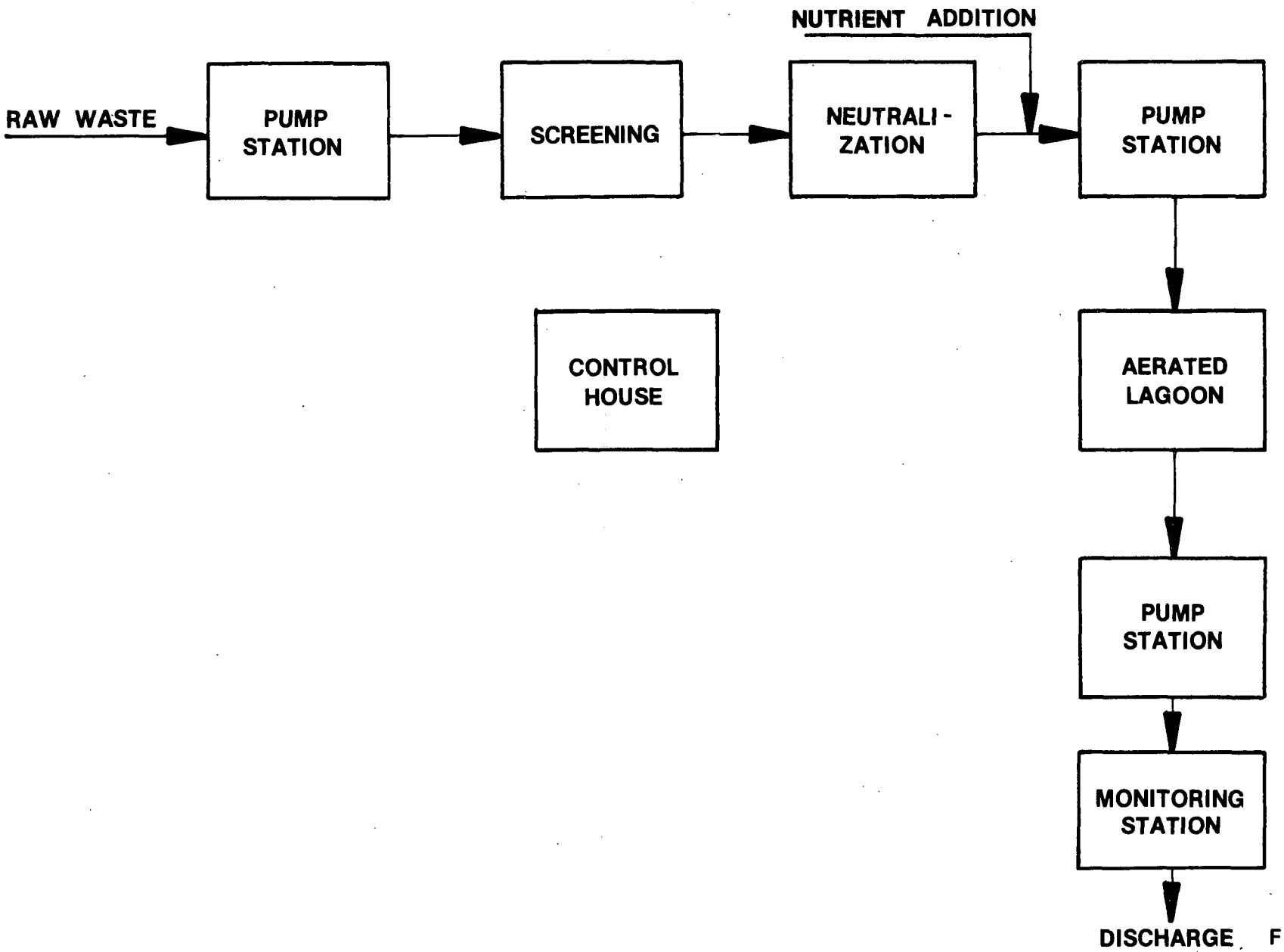

FIGURE VII-12

Candidate Treatment Technology

ALTERNATIVE E

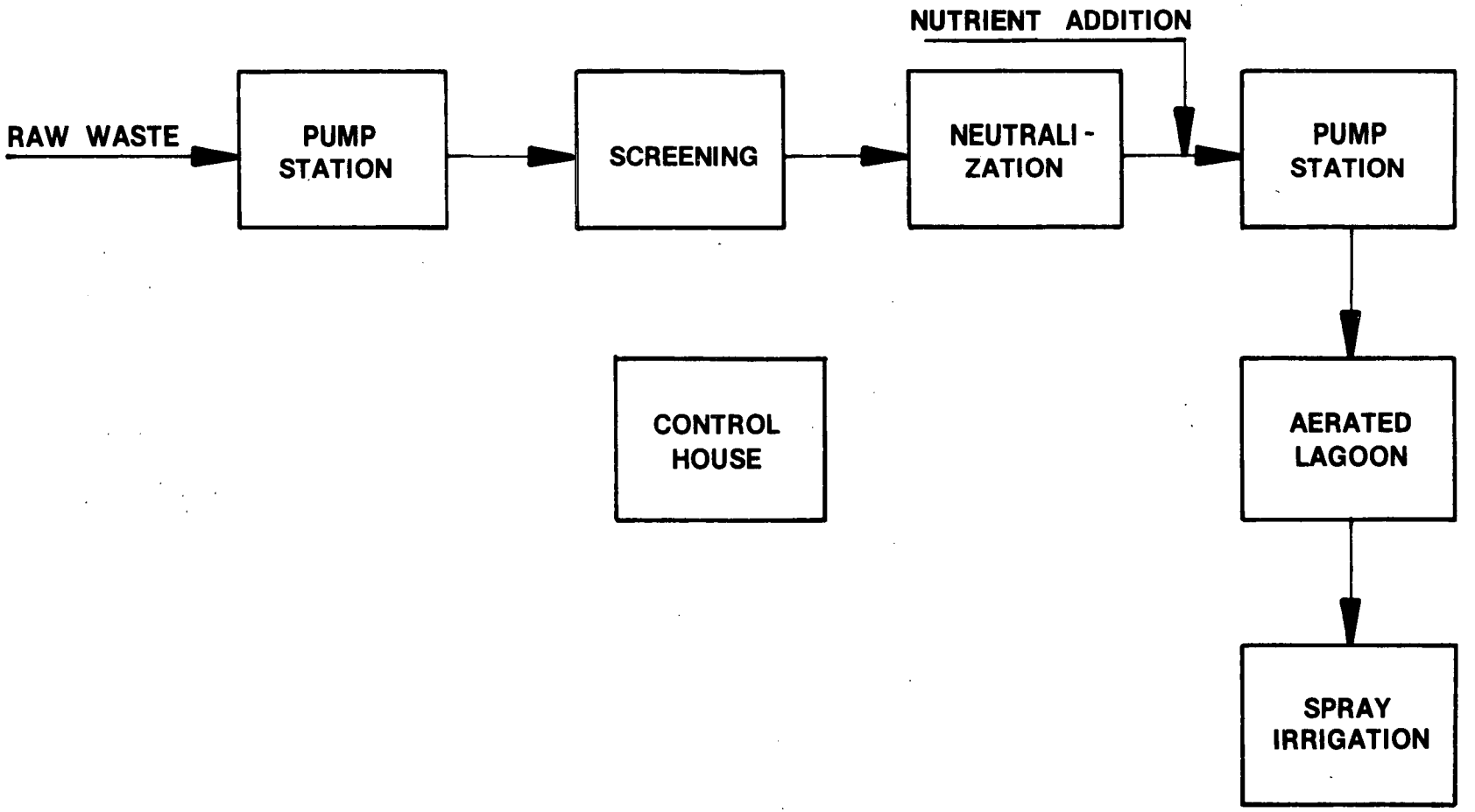

FIGURE VII-13

Candidate Treatment Technology
Wood Preserving

Indirect Discharge

Option 1 (Oily Wastewater Only)

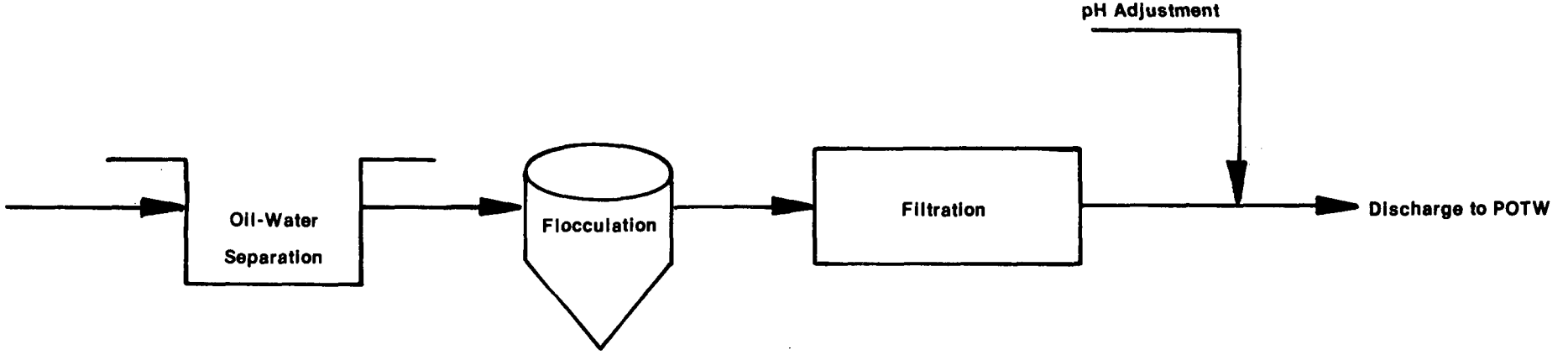

FIGURE VII-14

Candidate Treatment Technology
Wood Preserving

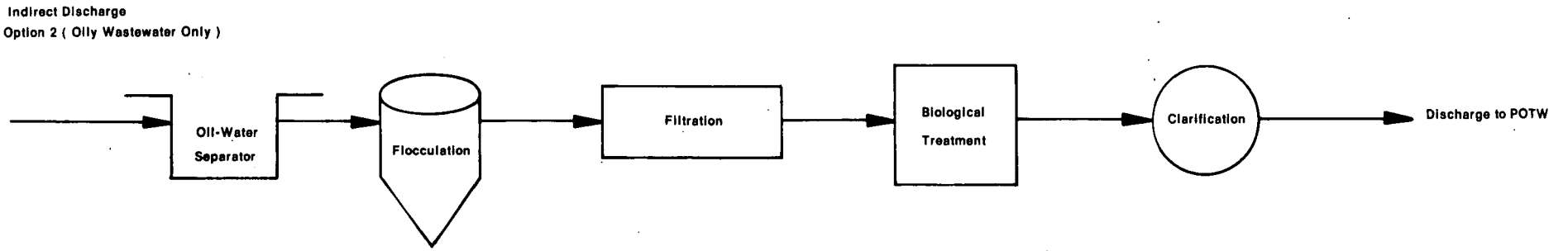

FIGURE VII-15

Candidate Treatment Technology
Wood Preserving

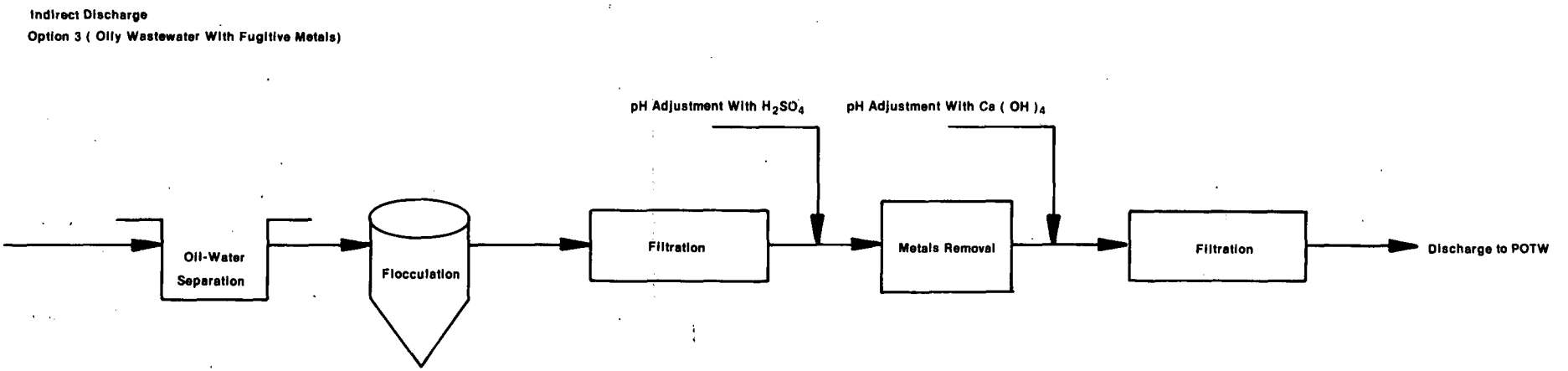

FIGURE VII-16

Candidate Treatment Technology
Wood Preserving

Self-Contained Discharge Option 1

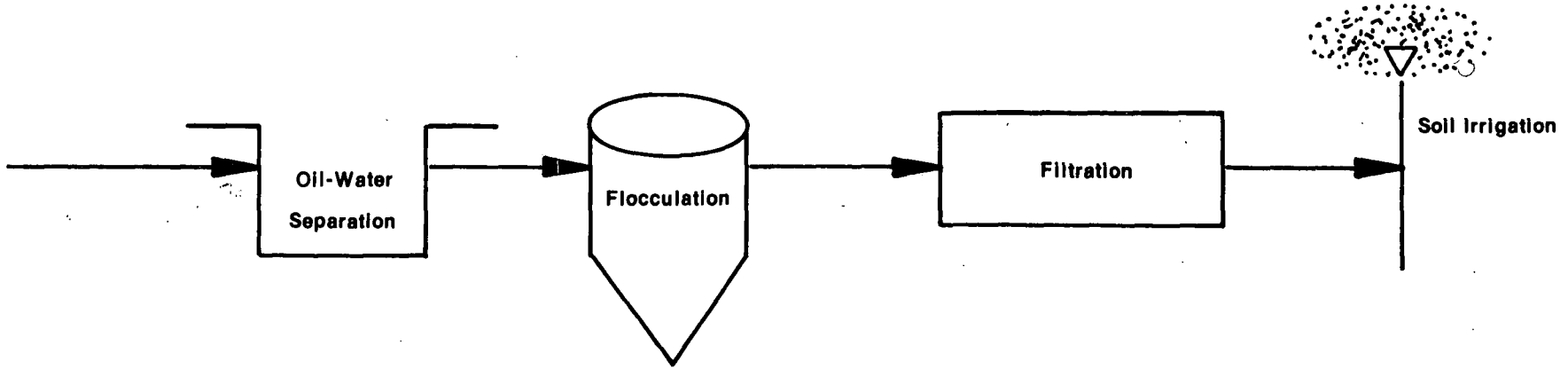

FIGURE VII-17

Candidate Treatment Technology
Wood Preserving

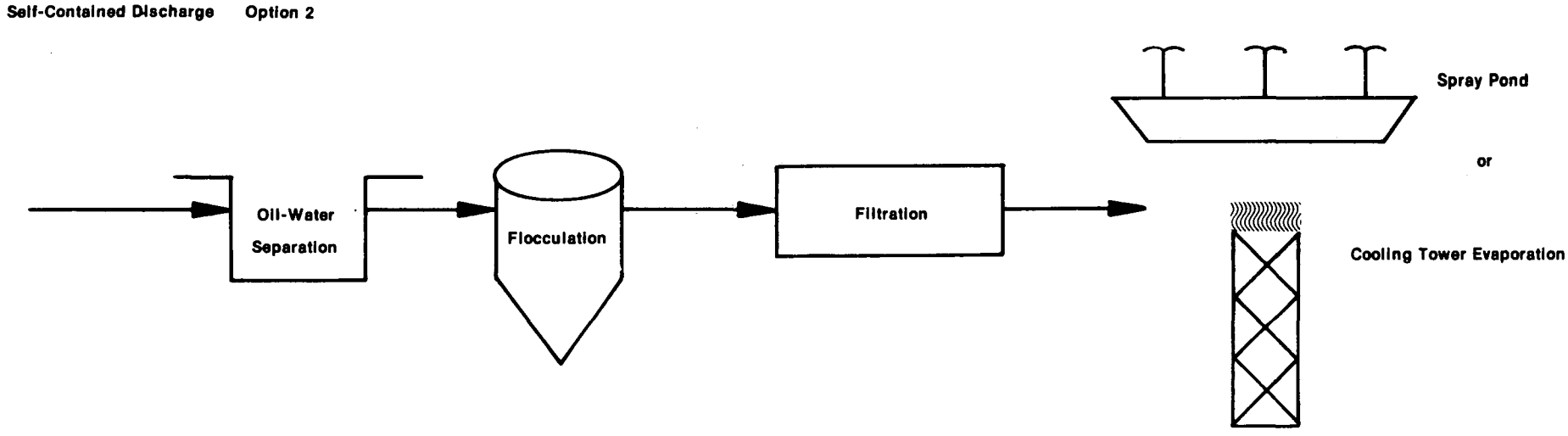

FIGURE VII-18

Candidate Treatment Technology
Wood Preserving

Self-Contained Discharge Option 3

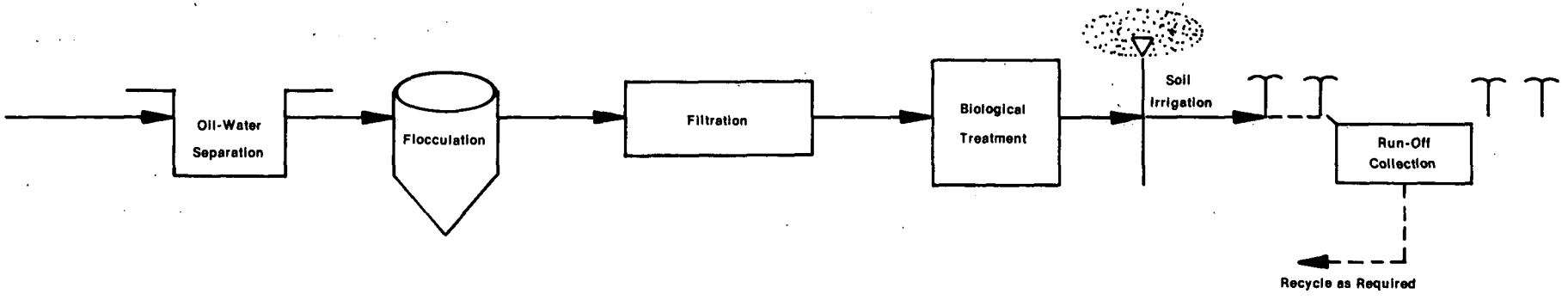

FIGURE VII-19

Candidate Treatment Technology
Wood Preserving

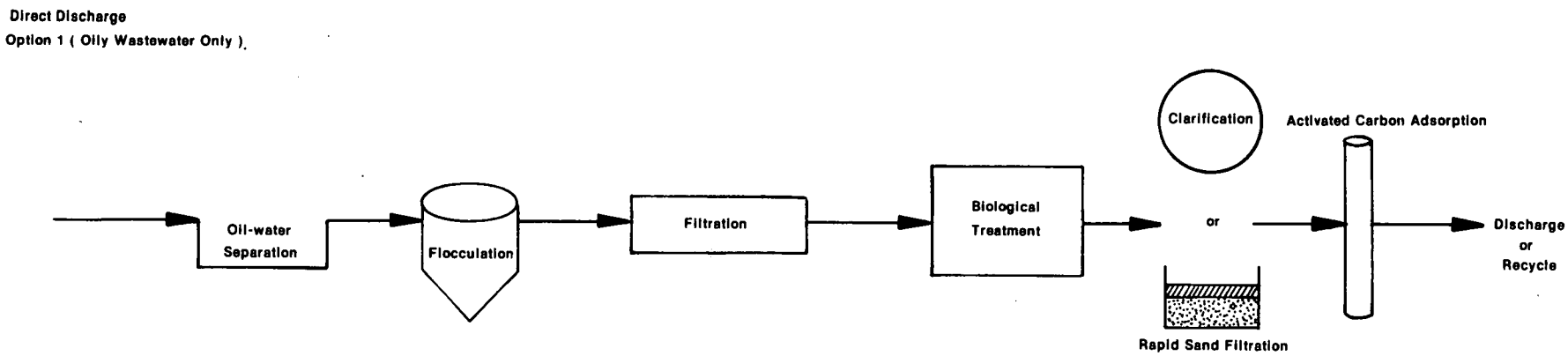

FIGURE VII-20

Candidate Treatment Technology
Wood Preserving

Direct Discharge
Option 2 (Oily Wastewater Only)

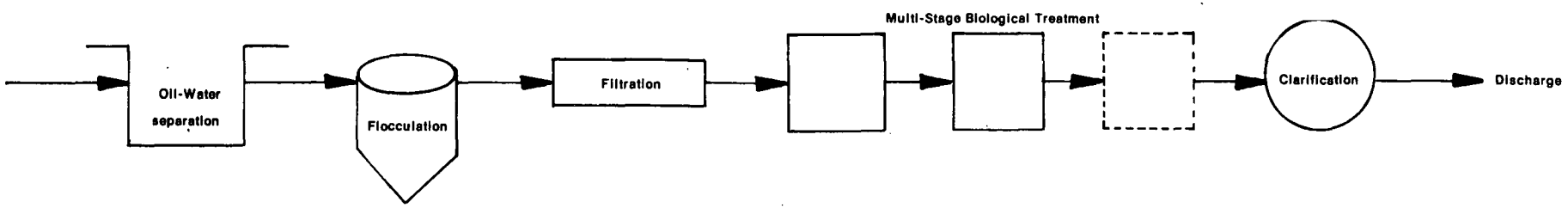

FIGURE VII-21

Candidate Treatment Technology
Wood Preserving

Direct Discharge
Option 3 (Oily Wastewater With Fugitive Metals)

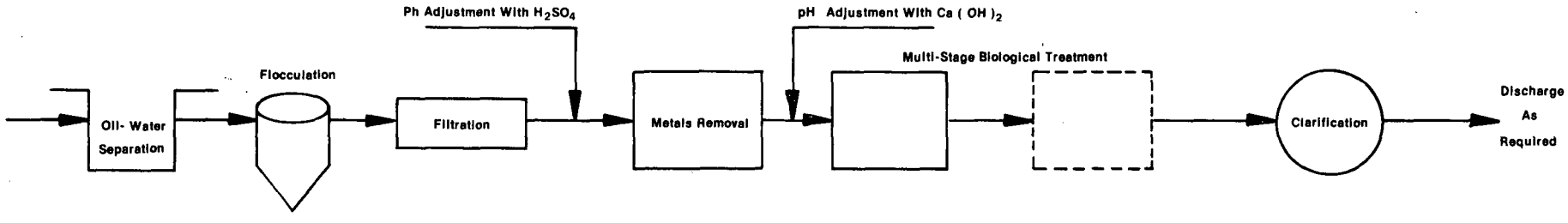

FIGURE VII-22

Table VII-25. Annual Average Final Effluent Waste Loads Achievable by Candidate Technologies, kg/1,000 cu m (lbs/1,000 cu ft), Wood Preserving Organic Chemicals Subcategories.

Candidate Treatment Technology	COD	Phenol	O&G	PCP	PNA's (Total)	Cu	Cr	As	Zn
Direct Discharge									
Option 1									
Single Stage Biological Activated Carbon	5.4 (0.34)	0.0017 (0.00010)	2.8 (0.17)	0.020 (0.0043)	0.056 (0.0034)	0.056 (0.0035)	0.021 (0.0013)	0.014 (0.00085)	0.028 (0.0018)
Option 2									
Multi-Stage Biological	27.0 (1.7)	0.011 (0.00070)	2.79 (0.17)	0.28 (0.017)	0.14 (0.0087)	1.1 (0.070)	0.42 (0.026)	0.28 (0.017)	0.57 (0.035)
Option 3									
Multi-Stage Biological Metal Reduction	27.0 (1.7)	0.011 (0.00070)	2.8 (0.17)	0.28 (0.017)	0.14 (0.0087)	0.014 (0.00087)	0.014 (0.00087)	0.014 (0.00087)	0.014 (0.00087)
Indirect Discharge									
Option 1									
Flocculation	1400.0 (87.0)	0.056 (0.0035)	2.8 (1.7)	3.3 (0.21)	0.42 (0.026)	1.1 (0.070)	0.42 (0.026)	0.27 (0.017)	0.56 (0.035)
Option 2									
Single-Stage Biolgical	28.0 (1.7)	0.033 (0.002)	2.8 (0.17)	1.4 (0.087)	0.279 (0.0174)	1.1 (0.070)	0.42 (0.026)	0.27 (0.017)	0.56 (0.035)
Option 3									
Metals Reduction Flocculation	1400.0 (87.0)	0.056 (0.0035)	27.0 (1.7)	3.4 (0.21)	0.42 (0.026)	0.014 (0.00087)	0.014 (0.00087)	0.014 (0.00087)	0.014 (0.00087)

Table VII-26. Annual Average Final Effluent Waste Loads Achievable by Candidate Technologies, Insulation Board Mechanical Pulping and Refining.

Candidate Technology	BOD		TSS		Total Phenols	
	kg/Kkg	lb/ton	kg/Kkg	lb/ton	kg/Kkg	lb/ton
Alternatives A and D, Biological Treatment Only	0.36	0.72	3.8	7.6	0.00010	0.00021
Alternative B, Polymer Addition Chemically-Assisted Clarification	0.36	0.72	3.4	6.8	0.00010	0.00021
Alternatiave C, Filtration	0.36	0.72	2.5	4.9	0.00010	0.00021

Table VII-27. Annual Average Final Effluent Waste Loads Achievable by Candidate Technologies, Insulation Board Thermo-Mechanical Pulping and Refining.

Candidate Technology	BOD		TSS		Total Phenols	
	kg/Kkg	lb/ton	kg/Kkg	lb/ton	kg/Kkg	lb/ton
Alternatives A and D, Biological Treatment Only	1.2	2.4	2.8	5.7	0.00042	0.00084
Alternative B, Polymer Addition Chemically-Assisted Clarification	1.2	2.4	2.5	5.0	0.00042	0.00084
Alternatiave C, Filtration	1.2	2.4	1.8	3.7	0.00042	0.00084

Table VII-28. Annual Average Final Effluent Waste Loads Achievable by Candidate Technologies.

S1S Hardboard

Candidate Technology	BOD		TSS		Total Phenols	
	kg/Kkg	lb/ton	kg/Kkg	lb/ton	kg/Kkg	lb/ton
Alternatives A and D Biological Treatment Only	1.3	2.6	3.1	6.2	0.00046	0.00092
Alternative B Polymer Addition Chemically Assisted Clarification	1.3	2.6	2.8	5.6	0.00046	0.00092
Alternative C Filtration	1.3	2.6	2.0	4.0	0.00046	0.00092

Table VII-29. Annual Average Final Effluent Waste Loads Achievable by Candidate Technologies.

S2S Hardboard

Candidate Technology	BOD		TSS		Total Phenols	
	kg/Kkg	lb/ton	kg/Kkg	lb/ton	kg/Kkg	lb/ton
Alternatives A and D Biological Treatment Only	2.2	4.3	5.9	11.8	0.0009	0.0018
Alternative B Polymer Addition Chemically Assisted Clarification	2.2	4.3	5.3	10.6	0.0009	0.0018
Alternative C Filtration	2.2	4.3	3.8	7.7	0.0009	0.0018

2. Control House--This facility contains office space for operators and for a small laboratory. The laboratory is complete with supplies and equipment for routine analysis. Furniture, electrical, sanitary facilities, heating, etc., are included. When the treatment system contains activated sludge, space is provided for sludge pumps.

3. Nutrient Addition to Biological Treatment--For anhydrous ammonia, a steel pressure tank is used with 30 days storage. Feed is through a commercial ammoniator. For phosphoric acid, a fiberglass-lined storage tank is used with 30 days storage capacity.

4. Complete Mix Activated Sludge--System includes: (a) a circular, reinforced concrete aeration basin with fixed surface aerators, a side water depth of 300 cm (10 ft), freeboard of 60 cm (2 ft); (b) a circular steel clarifier with scum removal facilities, a side water depth of 360 cm (12 ft), a surface overflow rate of 16,000 l/sq m (400 gal/sq ft) per day, and a freeboard of 60 cm (2 ft); (c) three sludge return pumps, each with capacity of pumping 100 percent of influent.

   System includes miscellaneous piping and all electrical requirements. A spray system for froth control is provided on the aeration basin.

   Unless otherwise stated, for a single storage unit, a MLSS of 2500 mg/l and an F/M ratio of 0.3 are assumed. For a two-stage unit, the MLSS in the first basin is assumed to be 3,000 mg/l, and in the second stage, 2,500 mg/l; F/M ratio in the first stage is assumed to be 0.5, and in the second stage, 0.3.

5. Aerobic Digestion--System includes a 360 cm (12 ft) deep circular steel tank with 20 days detention. Floating surface aerators are provided. Batch operation with decanting is assumed. Thickened sludge is assumed to enter the digester at 2 percent solids and leave at 3.5 percent. Ratio of sludge produced to BOD loading is assumed to be 0.3.

6. Dual Media Filtration--System consists of commercially available pressured filter with media of anthracite and sand. Loading assumed to be 4 gpm/sq ft. Backwash is automatically controlled. Backwash duration is 12 minutes at 160 l/min/sq m (15 gpm/sq ft).

7. Pump Station--The pump station contains at least three pumps with the capability of full capacity while one pump is out of service. Efficiency is assumed to be 85 percent. The station includes a wet well with protective covering and all piping and electrical.

8. Aerated Lagoon--The aerated lagoon consists of two cells in series. Solids are allowed to settle in both cells, and the cells are dredged each 10 years. A slope of 3 to 1 is assumed for the dikes, and a top width of 8 feet. While the biological rate constant can be expected to decrease about 20 percent from the first cell to the second, for simplicity of calculations a conservatively low value of 0.5 is assumed for both cells.

   Floating surface aerators are used to provide 0.015 kw (0.02 hp) per 3785 liters (1000 gal) of volume, or enough energy to provide 1.4 kg oxygen per kg BOD removed, whichever is larger.

   The cells are assumed to be lined.

9. Spray Irrigation--A loading rate of 33,000 liters per hectare (3,500 gal/acre) per day is assumed. The system consists of prepared (cleared, leveled, sodded) land with underground pipes, a pump station, and all necessary piping and electrical.

10. Sludge Thickening by Flotation--A surface loading of 4 l/min/sq m (0.4 gpm/sq ft) and a solids loading of 50 kg/sq m/day (10 lb/sq ft/day) are assumed. System includes the flotation unit, an effluent receiving tank, pressure relief valve, and all necessary piping and electrical. Sludge pumping is also included.

    It is assumed that the unit increases solids content from 1 percent to 3.5 percent.

11. Vacuum Filtration of Sludge--A solids loading rate of 20 kg/sq m/hr (4 lb/sq ft/hr) is assumed. Ferric chloride is added at the rate of 7 percent by weight of dry solids. Sludge pumping and all electrical and piping are included. It is assumed that the unit increases solids concentration from 3.5 to 15 percent.

12. Flow Equalization--A circular reinforced concrete tank with an epoxy coating is assumed. Aeration (0.015 kw per sq m) (75 hp per million gal) is provided to assist in mixing and to maintain aerobic conditions. Detention time is 24 hours.

13. Carbon Adsorption--System consists of pressurized, fixed downflow beds in parallel. A surface loading rate of 40 l/min/sq m (4 gal/min/sq ft) is assumed. Five percent of the flow is used for backwash. Empty bed contact time is assumed to be 50 minutes.

14. Polymer Addition--System consists of a 30-day storage tank and feed pumps.

SECTION VIII
COST, ENERGY, AND NON-WATER QUALITY ASPECTS

Cost Information

Cost information for the candidate treatment technologies developed in Section VII is presented in this section for the purpose of allowing an assessment of the economic impact of the technologies. A separate economic analysis of cost impact on the industry will be prepared, and the results will be published in a separate document.

The systems costed in this section are the hypothetical plants with no treatment in place. As shown in Section VII, many plants already have substantial treatment in operation. The assumptions used in developing the costs are listed in Table VIII-1.

It should be noted that a number of factors affect the cost of a particular facility, and that these highly variable factors may differ from those assumed herein. One of the most variable factors is the cost of land, which may range from a few hundred dollars per hectare in rural areas to millions of dollars (or total unavailability) in urban areas.

In some cases, individual installations may use cost accounting systems which cause reported costs to differ from those in this section. For example, it is not uncommon for a portion of a manufacturing plant's administrative costs to be allocated to the waste treatment system. Such factors are not included in this document.

ENERGY REQUIREMENTS OF CANDIDATE TECHNOLOGIES

Itemized energy costs are presented in Tables VIII-2 through VIII-53. Table VIII-54 presents a summary of energy costs.

NON-WATER QUALITY ASPECTS OF CANDIDATE TECHNOLOGIES

The primary non-water quality aspect of the candidate technologies involves the disposal of wastewater sludges on land or in landfills. Such disposal must be done with proper management. Table VIII-55 presents a summary of sludges generated by the various alternatives.

It has been shown in this document that priority pollutants are removed by biological treatment. Organic materials are biodegraded, stripped from the wastewater by aeration, or removed with the waste sludge. Metals are most certainly contained in the sludge.

It is not within the scope of this document to define whether waste materials from the timber products industry are to be considered hazardous. Therefore, the discussions that follow are general in nature and may or may not be applicable to the specific wastes from the industry.

Table VIII-1. Cost Assumptions.

1. All costs are reported in June, 1977, dollars.
2. Excavation costs $5.00 per cubic yard.
3. Reinforced concrete costs $210 per cubic yard.
4. Site preparation costs $2,000 per acre.
5. Contract hauling of sludge to landfill costs $25 per cubic yard.
6. Land costs $20,000 per acre except for those alternatives including aerated lagoons or spray irrigation, in which case land costs $2,000 per acre.
7. Surface dressing for lagoons costs $0.03 per square foot.
8. Fencing costs $2.00 per linear foot, installed.
9. Clay lining for lagoons costs $0.23 per square foot.
10. New carbon costs $0.96 per pound.
11. Epoxy coating costs $2.00 per square foot.
12. Electricity costs $0.05 per kilowatt-hour.
13. Phosphoric acid costs $0.25 per pound.
14. Anhydrous ammonia costs $0.18 per pound.
15. Polymer costs $0.60 per pound.
16. Engineering costs 15 percent of construction cost.
17. Contingency is 15 percent of capital cost.
18. Capital recovery is based on 20 years at 10 percent.
19. Annual insurance and taxes cost 3 percent of capital cost.
20. Average labor costs $20,000 per man per year.

If land disposal is to be used for materials considered to be hazardous, the disposal sites must not allow movement of pollutants to either ground or surface waters. Natural conditions which must exist include geological insurance that no hydraulic continuity can occur between liquids and gases from the waste and natural ground or surface waters. Disposal areas cannot be subject to washout, nor can they be located over active forest zones or where geological changes can impair natural barriers. Any rock fractures or fissures underlying the site must be sealed.

As a safeguard, lines may be needed at landfill sites. Liner materials should be pretested for compatibility with the wastes to be disposed.

Leachate from the landfill must be collected and treated. The nature of the treatment will vary with the nature of the waste, and may consist of neutralization, hydrolysis, biological treatment, or evaporation. Treatment in some cases may be achieved by recycling the leachate into the landfill.

In general, wastes considered to be hazardous should only be disposed of at a "specially designated" landfill, which is defined by the Federal Register (May 1, 1974) as a landfill at which complete long-term protection of subsurface waters is provided. Such sites should be designed to avoid direct hydraulic continuity with surface and subsurface waters, and any leachate or subsurface flow into the disposal area should be contained within the site unless treatment is provided. Monitoring wells should be established and a sampling and analysis program conducted.

If deep well injection is considered to be economically attractive, the system must be located on a porous, permeable formation of sufficient depth to insure continued, permanent storage. It must be below the lowest ground water aquifer, be confined above and below by impermeable zones, and contain no natural fractures or faults. The wastewater so disposed must be compatible with the formation, should be completely detoxified, and should have removal of any solids which could result in stratum plugging. Provisions for continued monitoring of well performance and subsurface movement of wastes must be provided.

Percolation of wastes considered to be hazardous from earthen impoundments (aerated lagoons, evaporation ponds, etc.) must be prevented. If the natural soild is pervious, artificial lining is necessary. Monitoring wells must be provided.

If incineration is used for materials considered to be hazardous, and thermal regeneration of carbon may fall into this category, provisions must be made to prevent the entry of hazardous pollutants into the atmosphere. In particular, incineration is not applicable to wastes containing heavy metals. Equipment requirements for air pollution control vary for different applications, but since the off gases of incineration can be controlled by scrubbing, with the resulting effluent being dis-

charged to the wastewater treatment facility, air quality impact need not be significant.

The costs presented here are considered to be conservatively, but not unreasonably, high. With careful management and good engineering, lower costs can be attained in many cases. For example, electricity is assumed to cost five cents per kilowatt-hour, but even in 1977 electricity can be obtained for three to four cents per kilowatt-hour in many locations.

In any event, the costs presented in this section should not be applied to a particular wastewater treatment facility. Cost estimates in specific cases must be based on designs, and specifications developed for those cases.

Tables VIII-2 through VIII-55 present cost summaries for each of the candidate technologies. In each case, energy cost is included in operating cost and is also presented separately.

As mentioned above, volatile organic compounds may be stripped from wastewater by aeration, such as in activated sludge units or aerated lagoons. However, the resulting air quality impact is not considered to be significant in the timber products industry.

Noise generated by the candidate treatment technologies should be equal to comparable municipal treatment plants, and odor should be less objectionable than municipal plants. Socioeconomic impacts are site-specific.

TABLE VIII-2. INSULATION BOARD MECHANICAL PULP
MODEL PLANT A
ALTERNATIVE A
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 16,740	$ 2,010
Screening	22,900	1,530	680
Equalization	380,380	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	55,120	3,540	1,210
Nutrient Addition	30,500	51,700	1,250
Activated Sludge	1,071,530	167,590	93,050
Aerobic Digester	960,000	210,000	158,000
Sludge Thickener	330,000	15,500	4,400
Vacuum Filtration	285,000	71,000	7,100
Sludge Disposal	--	288,900	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	544,490	--	--
Land	20,000	--	--
Contingency	629,160	--	--
Capital Recovery	--	561,880	--
Insurance and Taxes	--	144,100	--
Labor	--	120,000	--
Total	$4,803,570	$1,709,920	$ 298,830

TABLE VIII-3. INSULATION BOARD MECHANICAL PULP
MODEL PLANT A
ALTERNATIVE B
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 16,740	$ 2,010
Screening	22,900	1,530	680
Equalization	380,380	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	55,120	3,540	1,210
Nutrient Addition	30,500	51,700	1,250
Activated Sludge	1,071,530	167,590	93,050
Polymer Addition	7,290	37,590	750
Aerobic Digester	960,000	210,000	158,000
Sludge Thickener	330,000	15,500	4,400
Vacuum Filtration	285,000	71,000	7,100
Sludge Disposal	--	288,900	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	545,580	--	--
Land	20,000	--	--
Contingency	630,420	--	--
Capital Recovery	--	565,360	--
Insurance and Taxes	--	145,000	--
Labor	--	120,000	--
Total	$4,833,210	$1,751,890	$ 299,580

TABLE VIII-4. INSULATION BOARD MECHANICAL PULP
MODEL PLANT A
ALTERNATIVE C
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 16,740	$ 2,010
Screening	22,900	1,530	680
Equalization	380,380	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	55,120	3,540	1,210
Nutrient Addition	30,500	51,700	1,250
Activated Sludge	1,071,530	167,590	93,050
Filtration	285,000	71,000	7,100
Aerobic Digester	960,000	210,000	158,000
Sludge Thickener	330,000	15,500	4,400
Vacuum Filtration	285,000	71,000	7,100
Sludge Disposal	--	288,900	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	587,240	--	--
Land	20,000	--	--
Contingency	678,320	--	--
Capital Recovery	--	608,500	--
Insurance and Taxes	--	156,000	--
Labor	--	120,000	--
Total	$5,200,480	$1,839,440	$ 305,930

TABLE VIII-5. INSULATION BOARD
MECHANICAL PULPING
MODEL PLANT A
ALTERNATIVE D
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 107,100	$ 11,200	$ 1,340
Screening	22,900	1,530	680
Neutralization	55,120	3,540	1,250
Nutrient Addition	30,500	51,700	1,250
Aerated Lagoon	604,000	128,000	90,000
Monitoring Station	16,390	2,170	530
Laboratory	39,000	2,300	730
Engineering	40,650	---	---
Land	160,000	---	---
Contingency	46,750	---	---
Sludge Disposal	---	185,200	---
Capital Recovery	---	113,040	---
Insurance & Taxes	---	33,670	---
Labor	---	60,000	---
Total	$1,122,410	$592,350	$ 95,780

TABLE VIII-6. INSULATION BOARD MECHANICAL PULPING MODEL PLANT A ALTERNATIVE E COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 107,100	$ 11,200	$ 4,000
Screening	22,900	1,530	680
Neutralization	55,100	3,540	1,210
Nutrient Addition	30,500	51,700	1,250
Aerated Lagoon	277,700	103,800	65,000
Spray Irrigation	5,332,400	180,300	19,000
Laboratory	20,000	1,200	100
Engineering	835,200	---	---
Land	600,000	---	---
Contingency	960,480	---	---
Sludge Disposal	---	185,200	---
Capital Recovery	---	897,560	---
Insurance & Taxes	---	247,240	---
Labor	---	60,000	---
Total	$8,241,380	$1,743,270	$ 91,240

TABLE VIII-7. INSULATION BOARD MECHANICAL PULP
MODEL PLANT B
ALTERNATIVE A
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 10,770	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	43,650	3,290	1,180
Nutrient Addition	26,300	26,700	1,250
Activated Sludge	614,650	68,010	41,530
Aerobic Digester	600,000	117,000	79,500
Sludge Thickener	268,000	12,100	2,680
Vacuum Filtration	218,000	38,500	4,280
Sludge Disposal	--	144,450	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	366,180	--	--
Land	20,000	--	--
Contingency	424,100	--	--
Capital Recovery	--	379,570	--
Insurance and Taxes	--	97,540	--
Labor	--	120,000	--
Total	$3,251,480	$1,058,880	$ 153,130

TABLE VIII-8. INSULATION BOARD MECHANICAL PULP
MODEL PLANT B
ALTERNATIVE B
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 10,770	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	43,650	3,290	1,180
Nutrient Addition	26,300	26,700	1,250
Activated Sludge	614,650	68,010	41,530
Polymer Addition	6,030	19,310	750
Aerobic Digester	600,000	117,000	79,500
Sludge Thickener	268,000	12,100	2,680
Vacuum Filtration	218,000	38,500	4,280
Sludge Disposal	--	144,450	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	367,080	--	--
Land	20,000	--	--
Contingency	425,150	--	--
Capital Recovery	--	380,500	--
Insurance and Taxes	--	97,780	--
Labor	--	120,000	--
Total	$3,259,460	$1,079,360	$ 153,880

TABLE VIII-9. INSULATION BOARD MECHANICAL PULP
MODEL PLANT B
ALTERNATIVE C
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 10,770	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	43,650	3,290	1,180
Nutrient Addition	26,300	26,700	1,250
Activated Sludge	614,650	68,010	41,530
Filtration	167,540	14,690	4,360
Aerobic Digester	600,000	117,000	79,500
Sludge Thickener	268,000	12,100	2,680
Vacuum Filtration	218,000	38,500	4,280
Sludge Disposal	--	144,450	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	391,310	--	--
Land	20,000	--	--
Contingency	453,000	--	--
Capital Recovery	--	405,600	--
Insurance and Taxes	--	104,190	--
Labor	--	120,000	--
Total	$3,473,050	$1,106,250	$ 157,490

TABLE VIII-10. INSULATION BOARD
MECHANICAL PULPING
MODEL PLANT B
ALTERNATIVE D
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 68,800	$ 7,200	$ 2,820
Screening	19,500	1,380	680
Neutralization	43,650	3,290	1,180
Nutrient Addition	26,300	26,700	1,250
Aerated Lagoon	428,000	65,700	50,000
Monitoring Station	16,390	2,170	530
Laboratory	39,000	2,300	730
Engineering	32,050	---	---
Land	80,000	---	---
Contingency	36,850	---	---
Sludge Disposal	---	92,600	---
Capital Recovery	---	83,460	---
Insurance & Taxes	---	23,720	---
Labor	---	60,000	---
Total	$ 790,540	$ 368,520	$ 57,190

TABLE VIII-11. INSULATION BOARD
MECHANICAL PULPING
MODEL PLANT B
ALTERNATIVE E
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 68,800	$ 7,180	$ 2,800
Screening	19,500	1,380	680
Neutralization	43,600	3,290	1,180
Nutrient Addition	26,300	26,700	1,250
Aerated Lagoon	311,600	48,000	35,000
Spray Irrigation	2,681,200	93,600	11,500
Laboratory	20,000	1,200	100
Engineering	428,910	---	---
Land	300,000	---	---
Contingency	493,250	---	---
Sludge Disposal	---	92,600	---
Capital Recovery	---	480,780	---
Insurance & Taxes	---	131,790	---
Labor	---	60,000	---
Total	$4,393,160	$ 946,520	$ 52,510

TABLE VIII-12.

INSULATION BOARD
THERMO-MECHANICAL PULPING AND/OR HARDBOARD PRODUCTION
MODEL PLANT C
ALTERNATIVE A
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 16,740	$ 6,030
Screening	22,900	1,530	680
Equalization	380,380	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	59,620	3,580	1,210
Nutrient Addition	31,600	53,500	1,250
Activated Sludge	1,590,060	208,450	138,600
Aerobic Digester	670,000	137,000	94,000
Sludge Thickener	280,000	13,000	3,000
Vacuum Filtration	230,000	44,000	4,800
Sludge Disposal	---	168,900	---
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	563,860	---	---
Land	20,000	---	---
Contingency	648,440	---	---
Capital Recovery	---	583,930	---
Insurance & Taxes	---	149,740	---
Labor	---	120,000	---
Total	$4,991,350	$1,557,810	$280,700

TABLE VIII-13.

INSULATION BOARD
THERMO-MECHANICAL PULPING AND/OR HARDBOARD PRODUCTION
MODEL PLANT C
ALTERNATIVE B
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 16,740	$ 6,030
Screening	22,900	1,530	680
Equalization	380,380	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	59,620	3,580	1,210
Nutrient Addition	31,600	53,500	1,250
Activated Sludge	1,590,060	208,450	138,600
Polymer Addition	7,290	37,590	750
Aerobic Digester	670,000	137,000	94,000
Sludge Thickener	280,000	13,000	3,000
Vacuum Filtration	230,000	44,000	4,800
Sludge Disposal	---	168,900	---
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	564,950	---	---
Land	20,000	---	---
Contingency	649,690	---	---
Capital Recovery	---	585,070	---
Insurance & Taxes	---	150,030	---
Labor	---	120,000	---
Total	$5,000,980	$1,596,830	$281,450

TABLE VIII-14.

INSULATION BOARD
THERMO-MECHANICAL PULPING AND/OR HARDBOARD PRODUCTION
MODEL PLANT C
ALTERNATIVE C
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 16,740	$ 6,030
Screening	22,900	1,530	680
Equalization	380,380	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	59,620	3,580	1,210
Nutrient Addition	31,600	53,500	1,250
Activated Sludge	1,590,060	208,450	138,600
Filtration	267,060	25,340	8,550
Aerobic Digester	670,000	137,000	94,000
Sludge Thickener	280,000	13,000	3,000
Vacuum Filtration	230,000	44,000	4,800
Sludge Disposal	---	168,900	---
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	603,920	---	---
Land	20,000	---	---
Contingency	694,500	---	---
Capital Recovery	---	625,420	---
Insurance & Taxes	---	160,340	---
Labor	---	120,000	---
Total	$5,344,530	$1,635,240	$289,250

TABLE VIII-15.

INSULATION BOARD
THERMO-MECHANICAL PULPING AND/OR HARDBOARD PRODUCTION
MODEL PLANT C
ALTERNATIVE D
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 107,100	$ 11,200	$ 4,000
Screening	22,900	1,530	680
Neutralization	59,600	3,580	1,210
Nutrient Addition	31,600	53,500	1,250
Aerated Lagoon	723,000	199,000	160,000
Monitoring Station	16,400	2,170	530
Laboratory	39,000	2,300	730
Engineering	41,490	---	---
Land	220,000	---	---
Contingency	47,710	---	---
Sludge Disposal	---	185,200	---
Capital Recovery	---	127,890	---
Insurance & Taxes	---	39,260	---
Labor	---	60,000	---
Total	$1,308,800	$ 685,630	$168,400

TABLE VIII-16

INSULATION BOARD
THERMO-MECHANICAL PULPING AND/OR HARDBOARD PRODUCTION
MODEL PLANT C
ALTERNATIVE E
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 107,100	$ 11,160	$ 4,000
Screening	22,900	1,530	680
Neutralization	59,600	3,580	1,210
Nutrient Addition	31,600	53,500	1,250
Aerated Lagoon	343,800	113,500	90,000
Spray Irrigation	5,327,100	180,100	20,000
Laboratory	20,000	1,200	100
Engineering	835,250	---	---
Land	600,000	---	---
Contingency	960,530	---	---
Sludge Disposal	---	185,200	---
Capital Recovery	---	905,370	---
Insurance & Taxes	---	249,340	---
Labor	---	60,000	---
Total	$8,307,880	$1,764,480	$117,240

TABLE VIII-17.

INSULATION BOARD
THERMO-MECHANICAL PULPING AND/OR HARDBOARD PRODUCTION
MODEL PLANT D
ALTERNATIVE A
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 11,700	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	45,950	3,320	1,180
Nutrient Addition	26,800	31,900	1,250
Activated Sludge	1,086,800	120,360	71,560
Aerobic Digester	420,000	76,000	47,300
Sludge Thickener	228,000	12,800	1,850
Vacuum Filtration	180,000	24,000	2,900
Sludge Disposal	---	84,500	---
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	398,720	---	---
Land	20,000	---	---
Contingency	458,530	---	---
Capital Recovery	---	412,920	---
Insurance & Taxes	---	106,062	---
Labor	---	120,000	---
Total	$3,535,400	$1,044,512	$148,750

TABLE VIII-18.

INSULATION BOARD
THERMO-MECHANICAL PULPING AND/OR HARDBOARD PRODUCTION
MODEL PLANT D
ALTERNATIVE B
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 11,700	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	45,950	3,320	1,180
Nutrient Addition	26,800	31,900	1,250
Activated Sludge	1,086,800	120,360	71,560
Polymer Addition	6,030	19,310	750
Aerobic Digester	420,000	76,000	47,300
Sludge Thickener	228,000	12,800	1,850
Vacuum Filtration	180,000	24,000	2,900
Sludge Disposal	---	84,500	---
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	399,630	---	---
Land	20,000	---	---
Contingency	459,570	---	---
Capital Recovery	---	413,860	---
Insurance & Taxes	---	106,300	---
Labor	---	120,000	---
Total	$3,543,380	$1,065,000	$149,500

TABLE VIII-19.

INSULATION BOARD
THERMO-MECHANICAL PULPING AND/OR HARDBOARD PRODUCTION
MODEL PLANT D
ALTERNATIVE C
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 11,700	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	45,950	3,320	1,180
Nutrient Addition	26,800	31,900	1,250
Activated Sludge	1,086,800	120,360	71,560
Filtration	167,540	14,690	4,360
Aerobic Digester	420,000	76,000	47,300
Sludge Thickener	228,000	12,800	1,850
Vacuum Filtration	180,000	24,000	2,900
Sludge Disposal	---	84,500	---
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	423,850	---	---
Land	20,000	---	---
Contingency	487,430	---	---
Capital Recovery	---	438,940	---
Insurance & Taxes	---	112,710	---
Labor	---	120,000	---
Total	$3,756,970	$1,091,870	$153,110

TABLE VIII-20.

INSULATION BOARD
THERMO-MECHANICAL PULPING AND/OR HARDBOARD PRODUCTION
MODEL PLANT D
ALTERNATIVE D
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 68,800	$ 7,800	$ 2,820
Screening	19,500	1,380	680
Neutralization	45,950	3,320	1,180
Nutrient Addition	26,800	31,900	1,250
Aerated Lagoon	550,600	106,600	80,000
Monitoring Station	16,400	2,170	530
Laboratory	39,000	2,300	730
Engineering	32,470	--	--
Land	110,000	--	--
Contingency	37,340	--	--
Sludge Disposal	--	92,600	--
Capital Recovery	--	98,300	--
Insurance & Taxes	--	28,410	--
Labor	--	60,000	--
Total	$ 946,860	$ 434,780	$ 87,190

TABLE VIII-21.

INSULATION BOARD
THERMO-MECHANICAL PULPING AND/OR HARDBOARD PRODUCTION
MODEL PLANT D
ALTERNATIVE E
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 68,800	$ 7,800	$ 2,800
Screening	19,500	1,380	680
Neutralization	45,950	3,320	1,180
Nutrient Addition	26,800	31,900	1,250
Aerated Lagoon	328,000	64,700	50,000
Spray Irrigation	2,678,600	93,600	11,000
Laboratory	20,000	1,200	100
Engineering	428,950	--	--
Land	300,000	--	--
Contingency	493,290	--	--
Sludge Disposal	--	92,600	--
Capital Recovery	--	482,750	--
Insurance & Taxes	--	132,300	--
Labor	--	60,000	--
Total	$4,409,890	$ 971,550	$ 67,010

TABLE VIII-22. WET PROCESS HARDBOARD S1S
MODEL PLANT E
ALTERNATIVE A
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 17,850	$ 6,030
Screening	22,900	1,530	680
Equalization	380,380	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	65,120	3,640	1,210
Nutrient Addition	31,600	53,500	1,250
Activated Sludge	1,590,060	208,450	138,600
Aerobic Digester	1,200,000	255,000	197,000
Sludge Thickener	350,000	17,400	5,100
Vacuum Filtration	305,000	85,000	8,250
Sludge Disposal	--	356,900	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	665,930	--	--
Land	20,000	--	--
Contingency	765,820	--	--
Capital Recovery	--	689,640	--
Insurance & Taxes	--	176,740	--
Labor	--	120,000	--
Total	$5,891,300	$2,043,090	$ 389,250

TABLE VIII-23. WET PROCESS HARDBOARD S1S
MODEL PLANT E
ALTERNATIVE B
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 17,850	$ 6,030
Screening	22,900	1,530	680
Equalization	380,380	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	65,120	3,640	1,210
Nutrient Addition	31,600	53,500	1,250
Activated Sludge	1,590,060	208,450	138,600
Polymer Addition	7,290	37,590	750
Aerobic Digester	1,200,000	255,000	197,000
Sludge Thickener	350,000	17,400	5,100
Vacuum Filtration	305,000	85,000	8,250
Sludge Disposal	--	356,900	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	667,030	--	--
Land	20,000	--	--
Contingency	767,080	--	--
Capital Recovery	--	690,780	--
Insurance & Taxes	--	177,030	--
Labor	--	120,000	--
Total	$5,900,950	$2,082,110	$ 390,000

TABLE VIII-24. WET PROCESS HARDBOARD S1S
MODEL PLANT E
ALTERNATIVE C
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 17,850	$ 6,030
Screening	22,900	1,530	680
Equalization	380,380	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	65,120	3,640	1,210
Nutrient Addition	31,600	53,500	1,250
Activated Sludge	1,590,060	208,450	138,600
Filtration	267,060	25,340	8,550
Aerobic Digester	1,200,000	255,000	197,000
Sludge Thickener	350,000	17,400	5,100
Vacuum Filtration	305,000	85,000	8,250
Sludge Disposal	--	356,900	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	705,990	--	--
Land	20,000	--	--
Contingency	811,890	--	--
Capital Recovery	--	731,130	--
Insurance & Taxes	--	187,330	--
Labor	--	120,000	--
Total	$6,244,490	$2,120,510	$ 397,800

TABLE VIII-25. WET PROCESS HARDBOARD S1S
MODEL PLANT E
ALTERNATIVE D
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 107,100	$ 11,900	$ 4,000
Screening	22,900	1,530	680
Neutralization	65,100	3,640	1,210
Nutrient Addition	31,600	53,500	1,250
Aerated Lagoon	729,600	158,400	130,000
Monitoring Station	16,400	2,170	530
Laboratory	39,000	2,300	730
Engineering	42,320	--	--
Land	184,000	--	--
Contingency	48,660	--	--
Sludge Disposal	--	185,200	--
Capital Recovery	--	129,520	--
Insurance and Taxes	--	38,600	--
Labor	--	60,000	--
Total	$1,286,680	$ 646,760	$ 138,400

TABLE VIII-26. WET PROCESS HARDBOARD S1S
MODEL PLANT E
ALTERNATIVE E
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 107,100	$ 11,160	$ 4,000
Screening	22,900	1,530	680
Neutralization	59,600	3,580	1,210
Nutrient Addition	31,600	53,500	1,250
Aerated Lagoon	343,800	113,500	90,000
Spray Irrigation	5,327,100	180,100	20,000
Laboratory	20,000	1,200	100
Engineering	835,250	--	--
Land	600,000	--	--
Contingency	960,530	--	--
Sludge Disposal	--	185,200	--
Capital Recovery	--	905,370	--
Insurance and Taxes	--	249,340	--
Labor	--	60,000	--
Total	$8,307,880	$1,764,480	$ 117,240

TABLE VIII-27. WET PROCESS HARDBOARD S1S
MODEL PLANT F
ALTERNATIVE A
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 11,700	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	48,250	3,360	1,180
Nutrient Addition	26,800	31,900	1,250
Activated Sludge	1,086,800	120,360	71,560
Aerobic Digester	690,000	145,000	100,000
Sludge Thickener	285,000	13,200	3,100
Vacuum Filtration	235,000	46,500	4,950
Sludge Disposal	--	178,400	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	456,370	--	--
Land	20,000	--	--
Contingency	524,820	--	--
Capital Recovery	--	472,620	--
Insurance and Taxes	--	121,310	--
Labor	--	120,000	--
Total	$4,043,640	$1,305,300	$ 204,750

TABLE VIII-28. WET PROCESS HARDBOARD S1S
MODEL PLANT F
ALTERNATIVE B
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 11,700	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	48,250	3,360	1,180
Nutrient Addition	26,800	31,900	1,250
Activated Sludge	1,086,800	120,360	71,560
Polymer Addition	6,030	19,310	750
Aerobic Digester	690,000	145,000	100,000
Sludge Thickener	285,000	13,200	3,100
Vacuum Filtration	235,000	46,500	4,950
Sludge Disposal	--	178,400	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	457,270	--	--
Land	20,000	--	--
Contingency	525,860	--	--
Capital Recovery	--	473,550	--
Insurance and Taxes	--	121,550	--
Labor	--	120,000	--
Total	$4,051,610	$1,325,780	$ 205,500

TABLE VIII-29. WET PROCESS HARDBOARD S1S
MODEL PLANT F
ALTERNATIVE C
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 11,700	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	48,250	3,360	1,180
Nutrient Addition	26,800	31,900	1,250
Activated Sludge	1,086,800	120,360	71,560
Filtration	167,540	14,690	4,360
Aerobic Digester	690,000	145,000	100,000
Sludge Thickener	285,000	13,200	3,100
Vacuum Filtration	235,000	46,500	4,950
Sludge Disposal	--	178,400	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	481,500	--	--
Land	20,000	--	--
Contingency	553,720	--	--
Capital Recovery	--	498,640	--
Insurance and Taxes	--	127,960	--
Labor	--	120,000	--
Total	$4,265,210	$1,352,660	$ 209,110

TABLE VIII-30. WET PROCESS HARDBOARD S1S
MODEL PLANT F
ALTERNATIVE D
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 68,800	$ 7,800	$ 2,800
Screening	19,500	1,380	680
Neutralization	48,200	3,360	1,180
Nutrient Addition	26,800	31,900	1,250
Aerated Lagoon	517,400	106,000	80,000
Monitoring Station	16,400	2,170	530
Laboratory	39,000	2,300	730
Engineering	32,810	--	--
Land	90,000	--	--
Contingency	37,730	--	--
Sludge Disposal	--	92,600	--
Capital Recovery	--	94,750	--
Insurance and Taxes	--	26,900	--
Labor	--	60,000	--
Total	$ 896,640	$ 429,160	$ 87,170

TABLE VIII-31. WET PROCESS HARDBOARD S1S
MODEL PLANT F
ALTERNATIVE E
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 68,800	$ 7,800	$ 2,800
Screening	19,500	1,380	680
Neutralization	45,950	3,320	1,180
Nutrient Addition	26,800	31,900	1,250
Aerated Lagoon	328,000	64,700	50,000
Spray Irrigation	2,678,600	93,600	11,000
Laboratory	20,000	1,200	100
Engineering	428,950	--	--
Land	300,000	--	--
Contingency	493,290	--	--
Sludge Disposal	--	92,600	--
Capital Recovery	--	482,750	--
Insurance and Taxes	--	132,300	--
Labor	--	60,000	--
Total	$4,409,890	$ 971,550	$ 67,010

TABLE VIII-32. WET PROCESS HARDBOARD S2S
MODEL PLANT G
ALTERNATIVE A
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 17,850	$ 6,030
Screening	22,900	1,530	680
Equalization	380,000	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	70,120	3,710	1,210
Nutrient Addition	36,200	69,000	1,250
Activated Sludge	1,698,060	238,730	161,600
Aerobic Digester	1,300,000	270,000	210,000
Sludge Thickener	355,000	17,800	5,350
Vacuum Filtration	315,000	90,000	8,600
Sludge Disposal	--	378,500	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	700,770	--	--
Land	20,000	--	--
Contingency	805,880	--	--
Capital Recovery	--	725,720	--
Insurance and Taxes	--	185,950	--
Labor	--	120,000	--
Total	$6,198,420	$2,176,230	$ 425,850

TABLE VIII-33. WET PROCESS HARDBOARD S2S
MODEL PLANT G
ALTERNATIVE B
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 17,850	$ 6,030
Screening	22,900	1,530	680
Equalization	380,000	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	70,120	3,710	1,210
Nutrient Addition	36,200	69,000	1,250
Activated Sludge	1,698,060	238,730	161,600
Polymer Addition	7,290	37,590	750
Aerobic Digester	1,300,000	270,000	210,000
Sludge Thickener	355,000	17,800	5,350
Vacuum Filtration	315,000	90,000	8,600
Sludge Disposal	--	378,500	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	701,860	--	--
Land	20,000	--	--
Contingency	807,140	--	--
Capital Recovery	--	726,850	--
Insurance and Taxes	--	186,240	--
Labor	--	120,000	--
Total	$6,208,060	$2,215,240	$ 426,600

TABLE VIII-34. WET PROCESS HARDBOARD S2S
MODEL PLANT G
ALTERNATIVE C
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 160,650	$ 17,850	$ 6,030
Screening	22,900	1,530	680
Equalization	380,000	37,210	26,710
Primary Clarifier	241,770	12,080	940
Neutralization	70,120	3,710	1,210
Nutrient Addition	36,200	69,000	1,250
Activated Sludge	1,698,060	238,730	161,600
Filtration	267,060	25,340	8,550
Aerobic Digester	1,300,000	270,000	210,000
Sludge Thickener	355,000	17,800	5,350
Vacuum Filtration	315,000	90,000	8,600
Sludge Disposal	--	378,500	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	740,820	--	--
Land	20,000	--	--
Contingency	851,950	--	--
Capital Recovery	--	767,200	--
Insurance and Taxes	--	196,550	--
Labor	--	120,000	--
Total	$6,551,600	$2,253,650	$ 434,400

TABLE VIII-35. WET PROCESS HARDBOARD S2S
MODEL PLANT G
ALTERNATIVE D
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 107,100	$ 11,900	$ 4,000
Screening	22,900	1,530	680
Neutralization	70,100	3,710	1,210
Nutrient Addition	36,200	69,000	1,250
Aerated Lagoon	881,900	239,000	210,000
Monitoring Station	16,400	2,170	530
Laboratory	39,000	2,300	730
Engineering	43,760	--	--
Land	210,000	--	--
Contingency	50,320	--	--
Sludge Disposal	--	185,200	--
Capital Recovery	--	148,900	--
Insurance and Taxes	--	44,330	--
Labor	--	60,000	--
Total	$1,477,680	$ 768,040	$ 218,400

TABLE VIII-36. WET PROCESS HARDBOARD S2S
MODEL PLANT G
ALTERNATIVE E
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 107,100	$ 11,900	$ 4,000
Screening	22,900	1,530	680
Neutralization	70,100	3,710	1,210
Nutrient Addition	36,200	69,000	1,250
Aerated Lagoon	543,600	153,800	130,000
Spray Irrigation	5,327,100	180,000	20,000
Laboratory	20,000	1,200	100
Engineering	837,510	--	--
Land	600,000	--	--
Contingency	963,140	--	--
Sludge Disposal	--	185,200	--
Capital Recovery	--	931,180	--
Insurance and Taxes	--	255,830	--
Labor	--	60,000	--
Total	$8,527,650	$1,853,450	$ 157,240

TABLE VIII-37. WET PROCESS HARDBOARD S2S
MODEL PLANT H
ALTERNATIVE A
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 11,700	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	50,450	3,390	1,180
Nutrient Addition	27,800	36,200	1,250
Activated Sludge	1,164,300	136,330	84,060
Aerobic Digester	725,000	153,000	104,000
Sludge Thickener	290,000	13,600	3,300
Vacuum Filtration	240,000	48,500	5,170
Sludge Disposal	--	189,300	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	475,220	--	--
Land	20,000	--	--
Contingency	546,510	--	--
Capital Recovery	--	492,140	--
Insurance and Taxes	--	126,300	--
Labor	--	120,000	--
Total	$4,209,880	$1,371,410	$ 221,670

TABLE VIII-38. WET PROCESS HARDBOARD S2S
MODEL PLANT H
ALTERNATIVE B
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 11,700	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	50,450	3,390	1,180
Nutrient Addition	27,800	36,200	1,250
Activated Sludge	1,164,300	136,330	84,060
Polymer Addition	6,030	19,310	750
Aerobic Digester	725,000	153,000	104,000
Sludge Thickener	290,000	13,600	3,300
Vacuum Filtration	240,000	48,500	5,170
Sludge Disposal	--	189,300	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	476,130	--	--
Land	20,000	--	--
Contingency	547,550	--	--
Capital Recovery	--	493,080	--
Insurance and Taxes	--	126,540	--
Labor	--	120,000	--
Total	$4,217,860	$1,391,900	$ 222,420

TABLE VIII-39. WET PROCESS HARDBOARD S2S
MODEL PLANT H
ALTERNATIVE C
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (3)	$ 103,140	$ 11,700	$ 4,230
Screening	19,500	1,380	680
Equalization	248,890	20,670	13,490
Primary Clarifier	207,000	10,750	830
Neutralization	50,450	3,390	1,180
Nutrient Addition	27,800	36,200	1,250
Activated Sludge	1,164,300	136,330	84,060
Filtration	167,540	14,690	4,360
Aerobic Digester	725,000	153,000	104,000
Sludge Thickener	290,000	13,600	3,300
Vacuum Filtration	240,000	48,500	5,170
Sludge Disposal	--	189,300	--
Control House	75,680	5,980	2,950
Monitoring Station	16,390	2,170	530
Engineering	500,350	--	--
Land	20,000	--	--
Contingency	575,410	--	--
Capital Recovery	--	518,170	--
Insurance and Taxes	--	132,943	--
Labor	--	120,000	--
Total	$4,431,450	$1,418,770	$ 226,030

TABLE VIII-40. WET PROCESS HARDBOARD S2S
MODEL PLANT H
ALTERNATIVE D
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 68,800	$ 7,800	$ 2,800
Screening	19,500	1,380	680
Neutralization	50,400	3,390	1,180
Nutrient Addition	27,800	36,200	1,250
Aerated Lagoon	567,000	116,300	90,000
Monitoring Station	16,400	2,170	530
Laboratory	39,000	2,300	730
Engineering	33,290	--	--
Land	104,000	--	--
Contingency	38,280	--	--
Sludge Disposal	--	92,600	--
Capital Recovery	--	101,070	--
Insurance and Taxes	--	28,930	--
Labor	--	60,000	--
Total	$ 964,470	$ 452,140	$ 97,170

TABLE VIII-41. WET PROCESS HARDBOARD S2S
MODEL PLANT H
ALTERNATIVE E
COST SUMMARY

	Capital Cost	Operating Cost	Energy Cost
Pump Stations (2)	$ 68,800	$ 7,800	$ 2,800
Screening	19,500	1,380	680
Neutralization	50,450	3,390	1,180
Nutrient Addition	27,800	36,200	1,250
Aerated Lagoon	377,700	83,000	67,000
Spray Irrigation	2,678,600	93,600	11,000
Laboratory	20,000	1,200	100
Engineering	429,770	--	--
Land	300,000	--	--
Contingency	494,240	--	--
Sludge Disposal	--	92,600	--
Capital Recovery	--	489,440	--
Insurance and Taxes	--	134,010	--
Labor	--	60,000	--
Total	$4,466,860	$1,002,620	$ 84,010

TABLE VIII-42. WOOD PRESERVING DIRECT DISCHARGE--OPTION I WITH ACTIVATED SLUDGE ALTERNATIVE.

Cost Summary

		Capital Cost	Cost of Operation*	Cost of Energy	Total Annual Cost
Step 1	Oil-Water Separation	$154,100	$ 19,900	$ 3,500	$ 35,400
Steps 2, 3	Flocculation, Filtration	26,000	13,600	400	16,600
Step 4	Activated Sludge	186,000	20,300	3,400	42,300
Step 5	Rapid Sand Filter	92,900	6,800	500	17,700
Step 6	Activated Carbon	53,000	7,000	100	13,200
	Monitoring Station	21,700	2,900	500	5,400
	Pump Station	26,500	2,600	300	5,600
	Control House	80,700	8,400	3,000	17,300
	Total	$640,900	$ 81,500	$ 11,700	$153,500

Includes cost of energy, but not capital recovery.

TABLE VIII-43. WOOD PRESERVING DIRECT DISCHARGE--OPTION 1 WITH AERATED LAGOON ALTERNATIVE.

		Cost Summary			
		Capital Cost	Cost of Operation*	Cost of Energy	Total Annual Cost
Step 1	Oil-Water Separation	$154,100	$ 19,900	$ 3,500	$ 35,400
Steps 2, 3	Flocculation, Filtration	26,000	13,600	400	16,600
Step 4	Activated Sludge	125,000	9,100	600	23,200
Step 5	Rapid Sand Filter	92,900	6,800	500	17,700
Step 6	Activated Carbon	53,000	7,000	100	13,200
	Monitoring Station	21,700	2,900	500	5,400
	Pump Station	26,500	2,600	300	5,600
	Control House	64,000	5,100	700	12,400
	Total	$563,200	$ 67,000	$ 6,600	$129,500

* Includes cost of energy, but not capital recovery.

TABLE VIII-44. WOOD PRESERVING DIRECT DISCHARGE--OPTION 2 WITH ACTIVATED SLUDGE ALTERNATIVE.

Cost Summary

		Capital Cost	Cost of Operation*	Cost of Energy	Total Annual Cost
Step 1	Oil-Water Separation	$154,100	$ 19,900	$ 3,500	$ 35,400
Steps 2, 3	Flocculation, Filtration	26,000	13,600	400	16,600
Step 4	Multi-Stage Activated Sludge	288,500	32,800	5,600	66,700
	Monitoring Station	21,700	2,900	500	5,400
	Pump Station	26,500	2,600	300	5,600
	Laboratory	80,700	8,400	3,000	17,300
	Total	$597,500	$ 80,200	$ 13,300	$142,000

* Includes cost of energy but not capital recovery.

TABLE VIII-45. WOOD PRESERVING DIRECT DISCHARGE--OPTION 2 WITH AERATED LAGOON ALTERNATIVE.

		Capital Cost	Cost of Operation*	Cost of Energy	Total Annual Cost
Step 1	Oil-Water Separation	$154,100	$ 19,900	$ 3,500	$ 35,400
Steps 2, 3	Flocculation, Filtration	26,000	13,600	400	16,600
Step 4	Multi-Stage Aerated Lagoon	250,000	18,200	1,200	46,400
	Monitoring Station	21,700	2,900	500	5,400
	Pump Station	26,500	2,600	300	5,600
	Control House	64,000	5,100	700	12,400
	Total	$542,300	$ 62,300	$ 6,600	$121,800

* Includes cost of energy but not capital recovery.

TABLE VIII-46. WOOD PRESERVING DIRECT DISCHARGE--OPTION 3.

Cost Summary

		Capital Cost	Cost of Operation	Cost of Energy	Total Annual Cost
Step 1	Oil-Water Separation	$154,100	$ 19,900	$ 3,500	$ 35,400
Steps 2, 3	Flocculation, Filtration	26,000	13,600	400	16,600
Step 4, 5, 6	Chromium Reduction	154,000	18,500	3,500	36,300
Step 7	Multi-Stage Activated Sludge Station	188,500	32,800	5,600	66,700
	Monitoring Station	21,700	2,900	500	5,400
	Control House	80,700	8,400	3,000	17,300
	Pump Station	26,500	2,600	300	5,600
	Total	$751,500	$ 98,700	$ 16,800	$181,900
Aerated Lagoon Alternative		$696,300	$ 80,800	$ 10,100	$156,700

TABLE VIII-47. WOOD PRESERVING INDIRECT DISCHARGE--OPTION 1.

Cost Summary

		Capital Cost	Cost of Operation	Cost of Energy	Total Annual Cost
Step 1	Oil-Water Separation	$154,100	$ 19,900	$ 3,500	$ 35,400
Steps 2, 3	Flocculation, Filtration	26,000	13,600	400	16,600
	Monitoring Station	21,700	2,900	500	5,400
	Pump Station	26,500	2,600	300	5,600
	Laboratory	18,000	4,000	700	6,100
	Total	$246,300	$ 43,000	$ 5,400	$ 69,100

TABLE VIII-48. WOOD PRESERVING INDIRECT DISCHARGE--OPTION 2.

Cost Summary

		Capital Cost	Cost of Operation	Cost of Energy	Total Annual Cost
Step 1	Oil-Water Separation	$154,100	$ 19,900	$ 3,500	$ 35,400
Steps 2, 3	Flocculation/Filtration	26,000	13,600	400	16,600
Step 4	Activated Sludge	186,000	20,300	3,400	42,300
	Monitoring Station	21,700	2,900	500	5,400
	Pump Station	26,500	2,600	300	5,600
	Laboratory	80,700	8,400	3,000	17,300
	Total	$495,000	$ 67,700	$ 11,100	$122,600
Aerated Lagoon Alternative		$417,300	$ 53,200	$ 6,000	$ 98,600

TABLE VIII-49. WOOD PRESERVING INDIRECT DISCHARGE--OPTION 3.

Cost Summary

		Capital Cost	Cost of Operation	Cost of Energy	Total Annual Cost
Step 1	Oil-Water Separation	$154,100	$ 19,900	$ 3,500	$ 34,000
Steps 2, 3	Flocculation, Filtration	26,000	13,600	400	16,600
Steps 4, 5, 6	Chromium Reduction	154,000	18,500	3,500	36,300
	Monitoring Station	21,700	2,900	500	5,400
	Control House	18,000	4,000	700	6,100
	Pump Station	26,500	2,600	300	5,600
	Total	$400,300	$ 61,500	$ 8,900	$104,000

TABLE VIII-50. WOOD PRESERVING SELF-CONTAINED DISCHARGE--OPTION 1.

Cost Summary

		Capital Cost	Cost of Operation	Cost of Energy	Total Annual Cost
Step 1	Oil-Water Separation	$154,100	$ 19,900	$ 3,500	$ 35,400
Steps 2, 3	Flocculation, Filtration	26,000	13,600	400	16,600
Steps 4	Spray Irrigation	197,300	17,000	3,600	35,500
	Laboratory	18,000	4,000	700	6,100
	Pump Station	26,500	2,600	300	5,600
	Total	$421,900	$ 57,100	$ 8,500	$ 99,200

TABLE VIII-51. WOOD PRESERVING SELF-CONTAINED DISCHARGE--OPTION 2.

Cost Summary

		Capital Cost	Cost of Operation	Cost of Energy	Total Annual Cost
Step 1	Oil-Water Separation	$154,100	$ 19,900	$ 3,500	$ 35,400
Steps 2, 3	Flocculation, Filtration	26,000	13,600	400	16,600
Steps 4	Spray Evaporation*	685,000	32,500	3,600	40,500
	Laboratory	18,000	4,000	700	6,100
	Pump Station	26,500	2,600	300	5,600
	Total	$909,600	$ 72,600	$ 8,500	$104,200

* Costs adopted from Treatment of Wood Preserving Wastewater by T.D. Reynolds and P.A. Shack, Texas Water Resources Institute, Texas A&M University, October, 1976.

TABLE VIII-52. WOOD PRESERVING SELF-CONTAINED DISCHARGE--OPTION 3.

Cost Summary

		Capital Cost	Cost of Operation	Cost of Energy	Total Annual Cost
Step 1	Oil-Water Separation	$154,100	$ 19,900	$ 3,500	$ 35,400
Steps 2, 3	Flocculation, Filtration	26,000	13,600	400	16,600
Step 4	Activated Sludge	186,000	20,300	3,400	42,300
Step 5	Spray Irrigation	197,300	17,000	3,600	35,500
	Laboratory	80,700	8,400	3,000	17,300
	Monitoring Station	21,700	2,900	500	5,400
	Pump Station	26,500	2,600	300	5,600
	Total	$692,300	$ 84,700	$ 14,700	$158,100
Aerated Lagoon Alternative		$614,600	$ 70,200	$ 9,600	$134,100

TABLE VIII-53
WOOD PRESERVING

SUMMARY

	Investment Costs			Annual Costs			
	Capital Cost	Construction Cost	Cost of Land	Cost of Operation	Cost of Labor	Cost of Energy	Total Annual Cost
Direct Discharge							
Option 1 (Activated Sludge)	$640,900	$624,800	$ 16,100	$ 81,500	$ 24,600	$ 11,700	$153,500
Option 1 (Aerated Lagoon)	563,200	547,600	15,500	67,000	21,000	6,600	129,500
Option 2 (Activated Sludge)	597,500	579,100	18,400	80,200	26,100	13,300	147,000
Option 2 (Aerated Lagoon)	542,300	521,900	20,400	62,300	22,500	6,600	121,800
Option 3 (Activated Sludge)	751,000	730,000	20,400	98,700	29,600	16,800	181,900
Option 3 (Aerated Lagoon)	696,300	673,900	22,400	80,800	26,000	10,100	156,700
Indirect Discharge							
Option 1	$246,300	$236,000	$ 10,300	$ 43,000	$ 15,500	$ 5,400	$ 69,100
Option 2 (Activated Sludge)	495,000	479,200	15,800	67,700	22,600	11,100	122,600
Option 2 (Aerated Lagoon)	417,300	402,000	15,300	53,200	19,000	6,000	98,600
Option 3	400,300	388,000	12,300	61,500	19,000	8,900	104,000
Self-Contained Discharge							
Option 1	$421,900	$371,600	$ 50,300	$ 57,100	$ 19,000	$ 8,500	$ 99,200
Option 2	909,600	798,500	111,100	72,600	19,000	8,500	104,200
Option 3 (Activated Sludge)	692,300	639,500	52,800	84,700	26,100	14,700	158,100
Option 3 (Aerated Lagoon)	614,600	559,300	55,300	70,200	22,500	9,600	134,100

TABLE VIII-54. ENERGY COST SUMMARY.

Model Plant	Alternative	Annual Energy Cost
A	A	298,830
	B	299,580
	C	305,930
	D	95,780
	E	91,240
B	A	153,130
	B	153,880
	C	157,490
	D	57,190
	E	52,510
C	A	280,700
	B	281,450
	C	289,250
	D	168,400
	E	117,240
D	A	148,750
	B	149,500
	C	153,110
	D	87,190
	E	67,010
E	A	389,250
	B	390,000
	C	397,800
	D	138,400
	E	117,240
F	A	204,750
	B	205,500
	C	209,110
	D	87,170
	E	67,010
G	A	425,850
	B	426,600
	C	434,400
	D	218,400
	E	157,240

TABLE VIII-54. ENERGY COST SUMMARY (Cont'd.).

Model Plant	Alternative	Annual Energy Cost
H	A	221,670
	B	222,420
	C	226,030
	D	97,170
	E	84,010
Wood Preserving Direct Discharge	Option 1 with Activated Sludge	11,700
Wood Preserving Direct Discharge	Option 1 with Aerated Lagoon	6,600
Wood Preserving Direct Discharge	Option 2 with Activated Sludge	13,300
Wood Preserving Direct Discharge	Option 2 with Aerated Lagoon	6,600
Wood Preserving Direct Discharge	Option 3 with Activated Sludge	16,800
Wood Preserving Direct Discharge	Option 3 with Aerated Lagoon	10,100
Wood Preserving Indirect Discharge	Option 1	5,400
Wood Preserving Indirect Discharge	Option 2	11,100
Wood Preserving Indirect Discharge	Option 3	8,900
Wood Preserving Self-Contained Discharge	Option 1	8,500
Wood Preserving Self-Contained Discharge	Option 2	8,500
Wood Preserving Self-Contained Discharge	Option 3 with Activated Sludge	14,700
Wood Preserving Self-Contained Discharge	Option 3 with Aerated Lagoon	9,600

TABLE VIII-55. SLUDGE GENERATION BY CANDIDATE TECHNOLOGIES.

Plant	Alternative	Dry Solids kg/day
A	A, B, C	4400
	D, E	2800
B	A, B, C	2200
	D, E	1400
C	A, B, C	2600
	D, E	2800
D	A, B, C	1300
	D, E	1400
E	A, B, C	5400
	D, E	2800
F	A, B, C	6700
	D, E	1400
G	A, B, C	5800
	D, E	2800
H	A, B, C	2900
	D, E	1400

SECTION IX

BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

The U.S. Environmental Protection Agency will propose effluent limitations for BAT, NSPS, and pretreatment standards for new and existing sources of the wood preserving, insulation board, and wet process hardboard industries upon review and evaluation of technical information contained in this document, comments from reviewers of this document, and other information as appropriate.

Information pertaining to the potential toxicity of discharged wastes to aquatic organisms, animals, and the human population, as well as information concerning the economic impact on the industry if it is required to install additional pollution control technology, will be considered prior to determination of proposed effluent limitations and guidelines.

SECTION X

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

The U.S. Environmental Protection Agency will propose effluent limitations for BAT, NSPS, and pretreatment standards for new and existing sources of the wood preserving, insulation board, and wet process hardboard industries upon review and evaluation of technical information contained in this document, comments from reviewers of this document, and other information as appropriate.

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SECTION XI

NEW SOURCE PERFORMANCE STANDARDS

The U.S. Environmental Protection Agency will propose effluent limitations for BAT, NSPS, and pretreatment standards for new and existing sources of the wood preserving, insulation board, and wet process hardboard industries upon review and evaluation of technical information contained in this document, comments from reviewers of this document, and other information as appropriate.

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SECTION XII

PRETREATMENT GUIDELINES

The U.S. Environmental Protection Agency will propose effluent limitations for BAT, NSPS, and pretreatment standards for new and existing sources of the wood preserving, insulation board, and wet process hardboard industries upon review and evaluation of technical information contained in this document, comments from reviewers of this document, and other information as appropriate.

Information pertaining to the potential toxicity of discharged wastes to aquatic organisms, animals, and the human population, as well as information concerning the economic impact on the industry if it is required to install additional pollution control technology, will be considered prior to determination of proposed effluent limitations and guidelines.

SECTION XIII
PERFORMANCE FACTORS FOR TREATMENT PLANT OPERATIONS

Factors Which Influence Variations in Performance of Wastewater Treatment Facilities

The factors influencing the variation in performance of wastewater treatment facilities are common to all sub-categories. The most important factors are summarized in this section.

Temperature

Temperature affects the rate of biological reaction with lower temperatures resulting in decreased biological activity which, for a given detention time, causes higher effluent BOD levels. Effluent solids levels also increase as a result of incomplete bio-oxidation and decreased settling rates under reduced temperatures. Settling basins and aerated lagoons are susceptible to thermal inversions. Significant variations in the levels of effluent solids may result as settled solids rise to the surface and are discharged.

Proper design and operation considerations can reduce the adverse effects of temperature on treatment efficiencies. Such considerations include the installation of insulation and the addition of heat. Techniques for temperature control are both well known and commonly used in the sanitary engineering field. Cost-effectiveness is usually the critical criterion for the extent and effectiveness of temperature control.

Shock Loading

Once a system is acclimated to a given set of steady state conditions, rapid quantitative or qualitative changes in loading rates can cause a decrease in treatment efficiencies. Several days or weeks are often required for a system to adjust to a new set of operating conditions. Systems with short retention times, such as activated sludge, are particularly sensitive to shock loading.

While it is unlikely that total and permanent prevention of shock loadings for a particular system can be accomplished, proper design and operation can greatly reduce adverse effects. Sufficient flow equalization prior to biological treatment can mitigate slug loads. Complete mix activated sludge is less likely to upset conditions than other activated sludge modifications.

System Stabilization

A new biological system, or one that has been out of operation, requires a period of stabilization up to several weeks before optimum, consistent efficiency can be expected. During this start-up period, large variations in pollutant parameters can be expected in the discharge.

System Operation

A primary disadvantage of any activated sludge system is operational difficulty. Operators must be well-trained specialists who are thoroughly familiar with the system they are operating.

Nutrient Requirements

Adequate amounts of nutrients, particularly nitrogen and phosphorus, are required to maintain a viable microbial population in a biological system. Proper design and operation of a system will provide sufficient nutrients for optimum performance.

System Controllability

In addition to the design considerations mentioned above, an activated sludge system should include appropriate meters and accurate, controllable gates, valves, and pumps for optimum performance. A qualified instrument technician should be available.

An adequate laboratory should be provided, along with monitoring facilities. Essential control tests should be conducted at least once every 8-hour shift, and more frequently when necessary.

Variability Analysis

In order to quantify demonstrated variations for the plants providing sufficient data, a statistical data analysis was conducted as explained below.

The data collection portfolio requested the plants to provide historical data for the most recent 12-month period for which the data were available. Data requested included daily production figures and the plant's monitoring results for both the raw process wastewater and the treated process effluent discharged from the plant. Intermediate treatment streams were requested if the plants had data on these streams. Parameters of interest were flow, BOD, COD, TOC, TSS, phenols, heavy metals, and any of the substances on the Priority Pollutant List.

The purpose of the data analysis was: 1) to characterize the raw waste levels in each subcategory; 2) to determine the reduction of pollutants demonstrated by the plant treatment systems from actual long-term operating data; and 3) to quantify the variables exhibited by the treated effluent from the treatment systems.

Data were analyzed for twelve wet process hardboard plants and six insulation board plants. In the hardboard segment, nine of the plants primarily produce S1S hardboard, while three are primarily S2S producers. Two of the S2S producers also produce insulation board at the

same facility. The six insulation board plants include five mechanical pulping and refining plants and one thermo-mechanical pulping and refining plant.

The historical data provided by each plant reported over a 12-month time period formed the most descriptive data base for meaningful analysis. Therefore, all available data from the 18 plants were used in analysis exactly as received from each plant. Not all of the eighteen plants submitted both influent and effluent data. Available data were used where applicable. Plants 262, 64, and 824 made process and/or treatment system changes during the year that dramatically changed the resulting raw waste or effluent characteristics. Two sets of analyses were made for these plants. The first set was an annual average value using all 12 months of data. The second analyses were made on the data obtained after the process and/or treatment changes were made and consisted of 4 to 6 months operating data.

Data from the remaining plants in each industry segment were not used for the following reasons:

Hardboard Segment

1. Plant 288--This plant produces both hardboard and insulation board. The influent raw waste is monitored for flow; however, the raw waste is combined with raw wastes from other industrial processes. Consequently, no meaningful waste characterization could be obtained from the data.
2. Plant 22--This plant is a self-contained discharger and has no monitoring practices. Therefore, no data existed.
3. Plant 666--This plant produces mineral wool fiber. The process water from the hardboard and insulation board processes receives no treatment and is completely mixed with the mineral wool effluent before sampling and discharge to the city sewer. No meaningful raw waste characteristics could be obtained.
4. Plant 428--This plant did not submit sufficient information in time for accurate data analysis. 1975 data has been reported for this plant.

Insulation Board Segment

1. Plants 137 and 447--These plants have no monitoring practices and no data were submitted.
2. Plant 989--This plant is a self-contained discharger. Insufficient data was sent to provide any meaningful analysis.
3. Plant 1111--This plant did not respond to the collection data portfolio with any information other than to state it had no process water discharge.
4. Plant 127--This plant produces both insulation board and mineral wool fiber in approximately equal amounts. The wastewaters are comingled such that no meaningful data could be obtained.
5. Plants 373, 663, 1035, 1071, and 123--These plants produce both hardboard and insulation board and are included in the explanation of the hardboard segment.

Unlike the wood preserving industry, many of the wet process insulation and hardboard plants maintain extensive monitoring records. In most cases, one year's operating data was obtained for analysis with data reported on either a daily or weekly basis. Because of the large volume of data, analyses were assisted by use of the computer.

Data from each plant were coded for keypunching directly from the data sheets provided by the plant according to waste stream. The code for the waste streams used appear in Table XIII-1. The data were then keypunched. Special emphasis was placed on accuracy. The data were checked after coding and then again after keypunching to insure the highest possible accuracy.

All pollutant waste loadings were converted to a pounds/ton basis. This was accomplished by first computing the annual average production in tons per day for each plant. This average was calculated by dividing the total year's production by the number of actual operating days. This value was then used with applicable conversion factors to determine waste loadings on a pounds/ton basis. Final results are reported in both metric and English units.

The computer output for each plant consisted of the following information:

1. Annual daily averages for pollutant loadings for all parameters desired;
2. Values of daily maximum and daily minimum pollutant loadings;
3. Thirty-day moving averages for pollutant loadings;
4. Maximum 30-day and 7-day moving averages for pollutant loadings; and
5. Statistical variability analysis on daily and 30-day data.

This study concentrated on the analysis of two pollutant parameters--BOD and TSS. These parameters were chosen for two reasons. First, almost every plant analyzed in each subcategory monitored them on a regular basis (usually daily or weekly). Therefore, a large data base existed for analysis within and between plants. Second, they are parameters of special interest of both the insulation and hardboard subcategories. Since most of the plants utilize biological treatment systems, BOD is the logical oxygen demand parameter to analyze. The importance of TSS analysis comes from the nature of the process--both insulation and hardboard plants produce fibrous suspended solids in their raw waters and generate biological suspended solids during biological treatment.

Thirty-day moving averages were computed by summing 30 consecutive days of data and then dividing by the number of data points in that 30-day period. For this study a minimum of four data points per 30-day period were required to compute a meaningful 30-day average. By using 30-day moving averages rather than monthly averages, seasonality effects such as climate and flow rate of the process waste water are more realistically analyzed.

Table XIII-1. Environmental Protection Agency Wet Process Hardboard Wastewater Stream Standard Designation.

Designation	Description
20 Series	Raw Wastewater Receiving Treatment
30 Series	Preliminary Treatment
40 Series	Primary Treatment Effluent
50 Series	Biological Treatment Effluent
60 Series	Post Storage and/or Treatment
70 Series	Final Discharge
80 Series	Raw Wastewater not Receiving Treatment

A statistical analysis was performed on the daily and 30-day average of the effluents from the model plants to determine the effluent variabilities associated with the biological treatment systems of the model plants. This analysis can be used to predict maximum effluent loadings which will not be exceeded 99 percent of the time.

The statistical analysis program provided by the Environmental Protection Agency calculates variability using: 1) normal probability; 2)logarithmic normal probability; and 3) three-parameter logarithmic normal probability. The EPA has found in past studies for these industries that normal probability yields positive coefficients of symmetry; i.e., the data is skewed to the right. In this case the actual variability of the data is underestimated. Log normal probability, on the other hand, tends to give a negative coefficient of symmetry (data is skewed to the left) and thus overestimates the actual variability. The three-parameter log normal distribution most accurately describes the actual variabilities in the data. The three-parameter log normal analysis adds a constant to the data points prior to log normal analysis. The objective is to obtain a zero coefficient of symmetry (i.e., the data is symmetrical about the mean). This distribution curve gives the most accurate predictions of excursions using normal or log normal probability. A constant is added and the coefficient of symmetry is calculated. If this coefficient approximates zero, the analysis stops. If the symmetry coefficient does not approximate zero, a new constant is added and the procedure continues until the coefficient of symmetry approximates zero. The actual variability ratios were calculated as follows: the value predicted by the three-parameter log normal analysis as the maximum value at the 99 percent confidence level was divided by the mean of the normal sample.

Lack of long-term data from the wood preserving segment prevented any quantification of variability. However, the variability ratios for the wet process hardboard and insulation board plants that provided sufficient treated effluent data for variability analysis are presented in Table XIII-2 and Table XIII-3. The monthly variations in wastewater characteristics for the eighteen plants for which data were analyzed are shown graphically in Figures XIII-1 through XIII-18.

Table XIII-2. Short-Term Variability Ratios, Wet Process Hardboard.

Plant No.	BOD		TSS	
	Maximum Day	30-Day Maximum	Maximum Day	30-Day Maximum
S1S Hardboard				
24	5.7	4.0	5.8	3.7
262	4.3	5.0	4.2	3.9
444	2.3	3.2	1.9	1.8
606	3.5	11.7	3.2	5.0
888	2.4	3.0	2.5	2.3
824	11.1	4.5	5.7	4.8
42	11.4	20.5	9.3	12.8
64	2.3	2.3	3.4	2.1
S2S Hardboard				
248	3.6	2.5	3.0	1.8
373	1.8	1.6	2.4	1.5
1071	5.6	4.3	3.7	1.9

Table XIII-3. Short-Term Variability Ratios, Insulation Board.

Plant No.	BOD		TSS	
	Maximum Day	30-Day Maximum	Maximum Day	30-Day Maximum
Mechanical Pulping and Refining				
555	8.8	2.6	12.7	2.1
125	6.0	3.5	5.5	3.5
Thermo-Mechanical Pulping and Refining and/or Hardboard Production at Same Facility				
373	1.8	1.6	2.4	1.5
1071	5.6	4.3	3.7	1.9

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

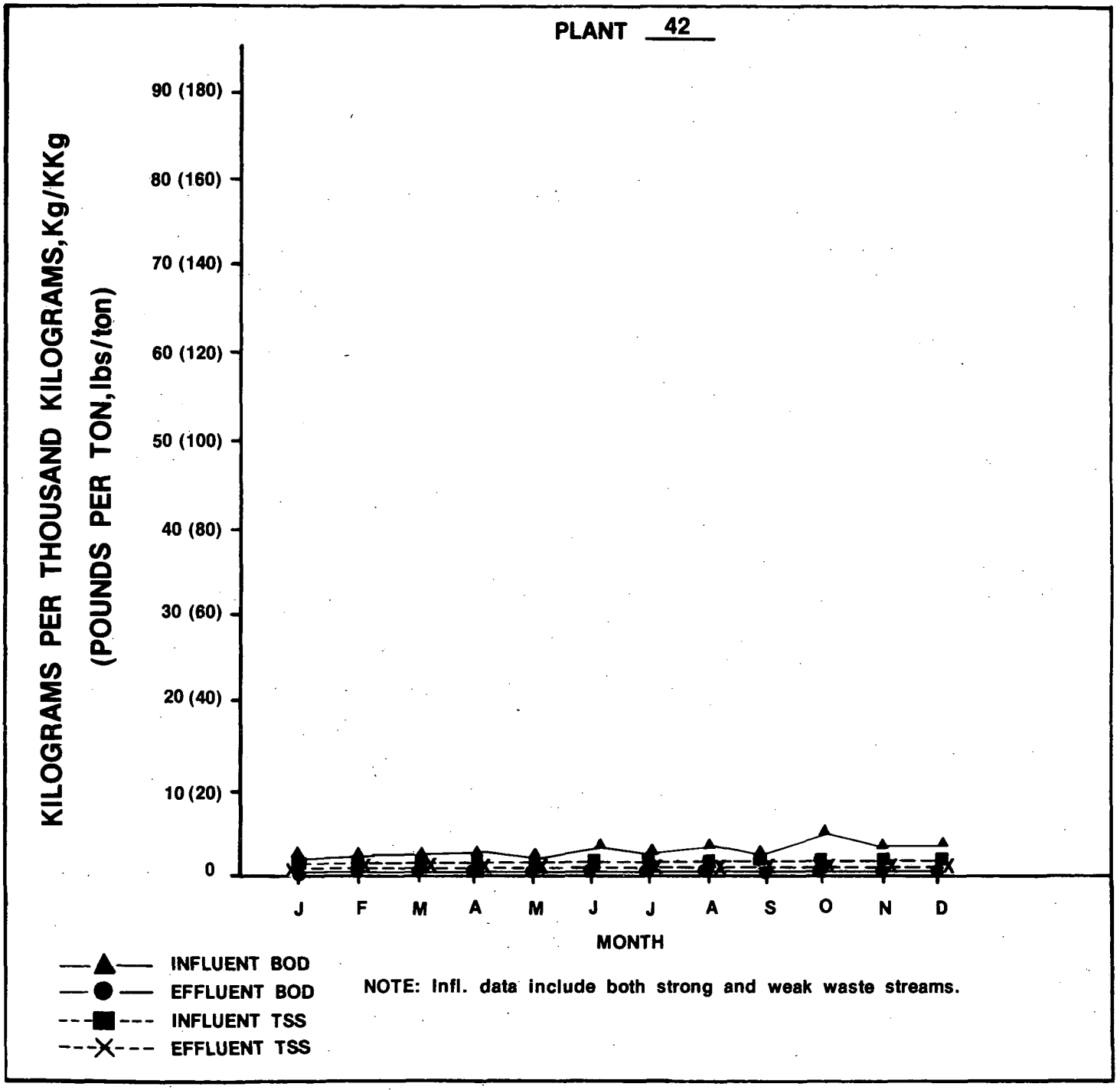

Figure XIII - 1

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

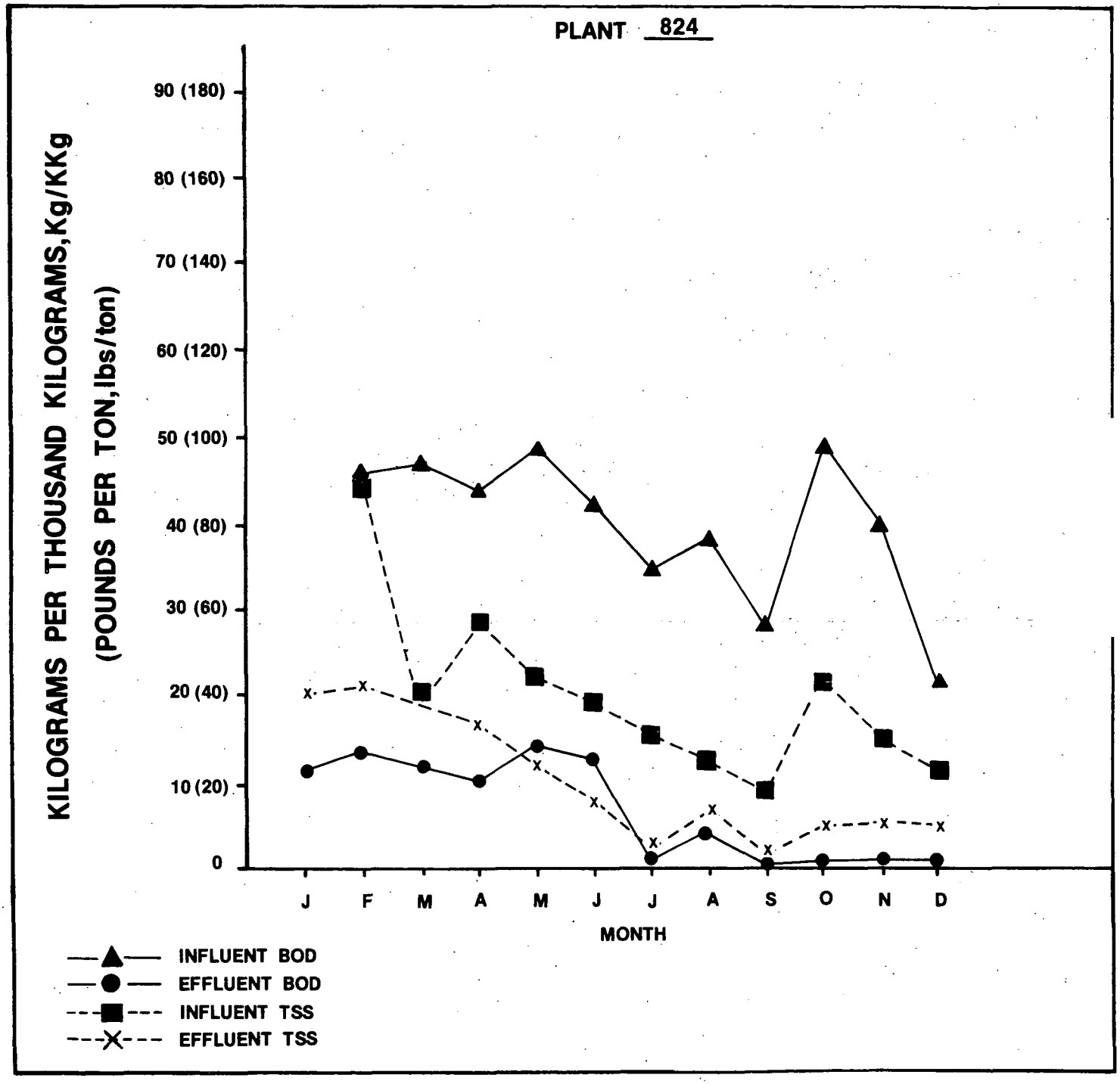

Figure XIII - 2

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

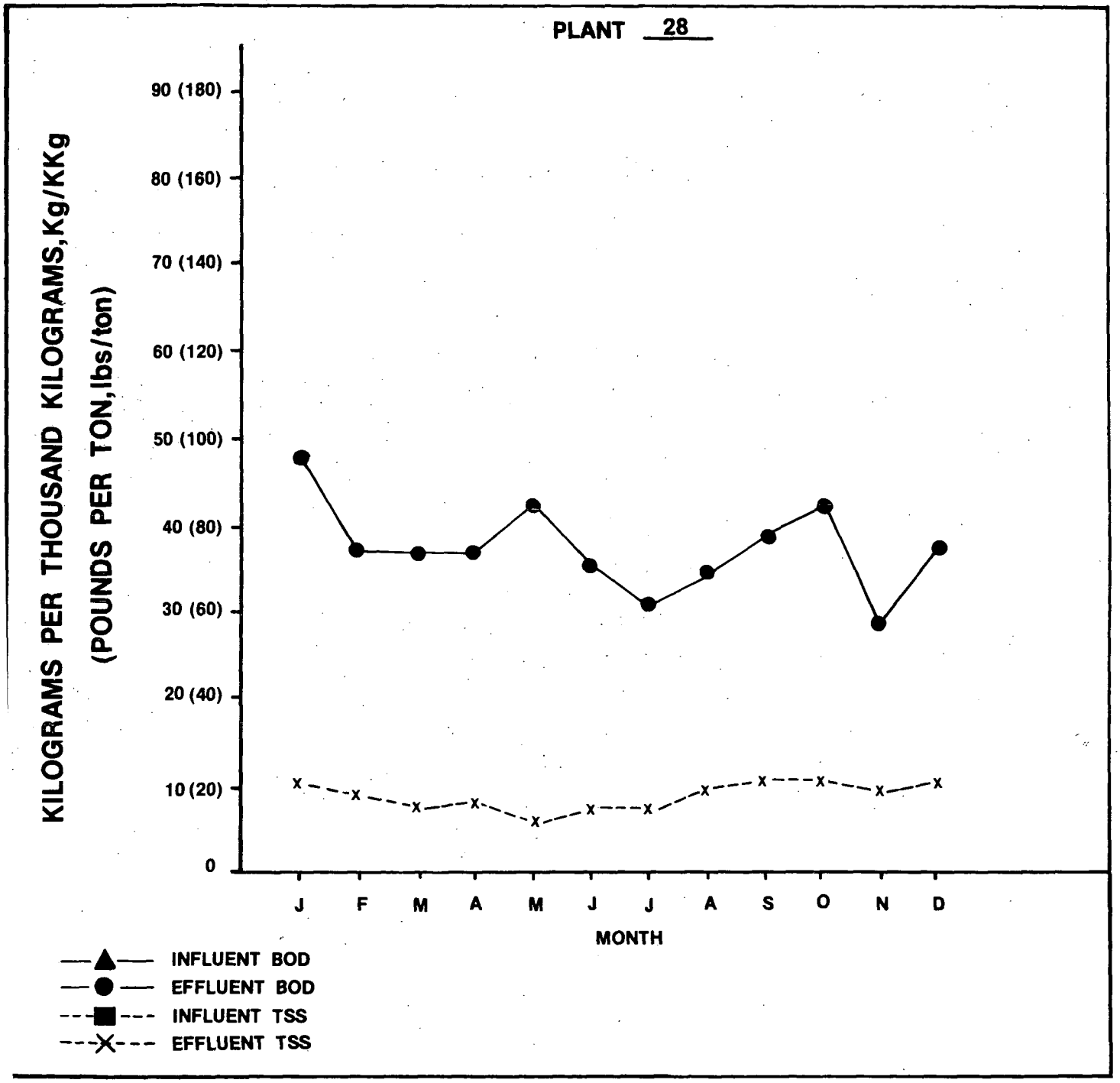

Figure XIII - 3

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

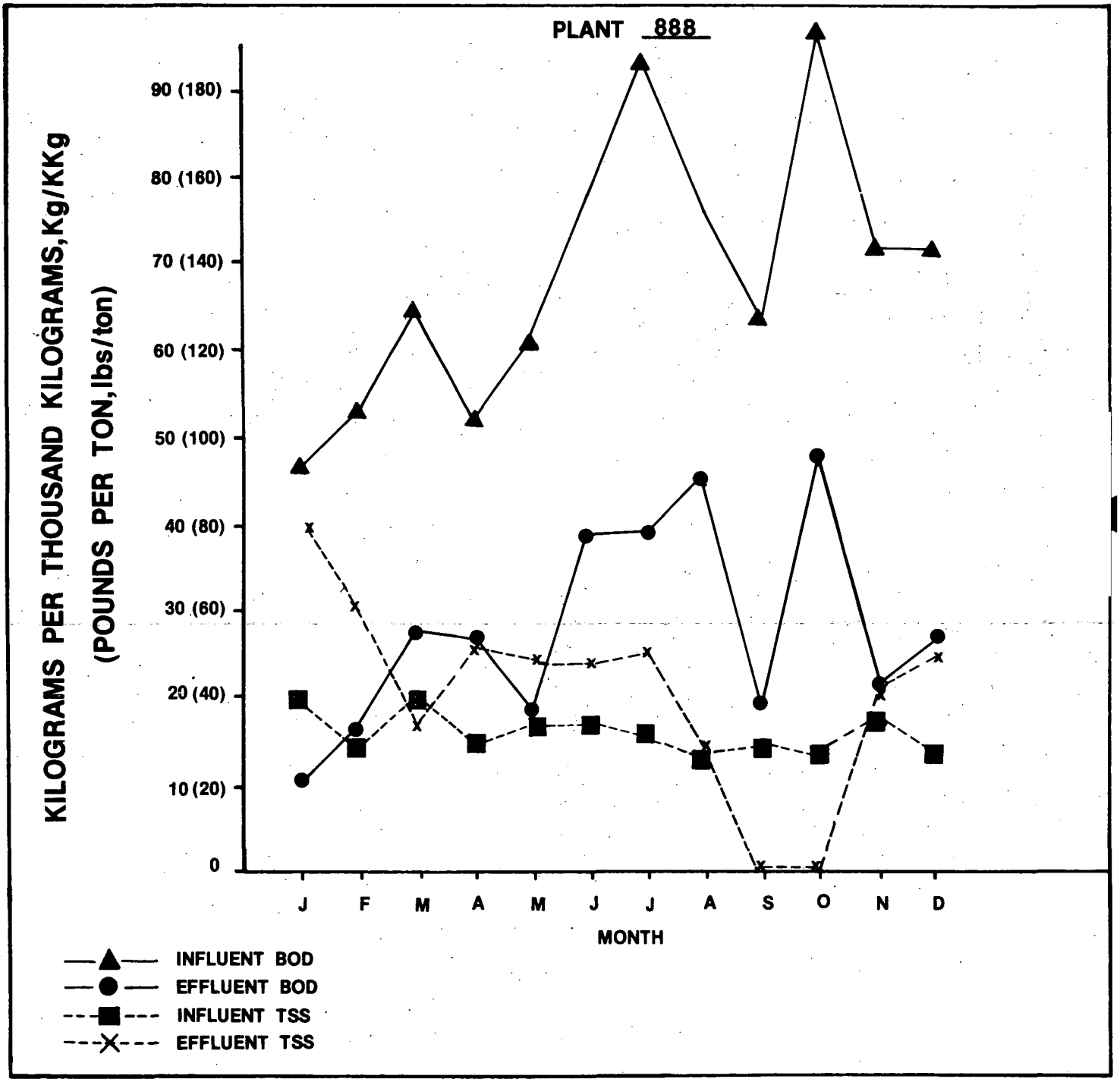

Figure XIII - 4

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

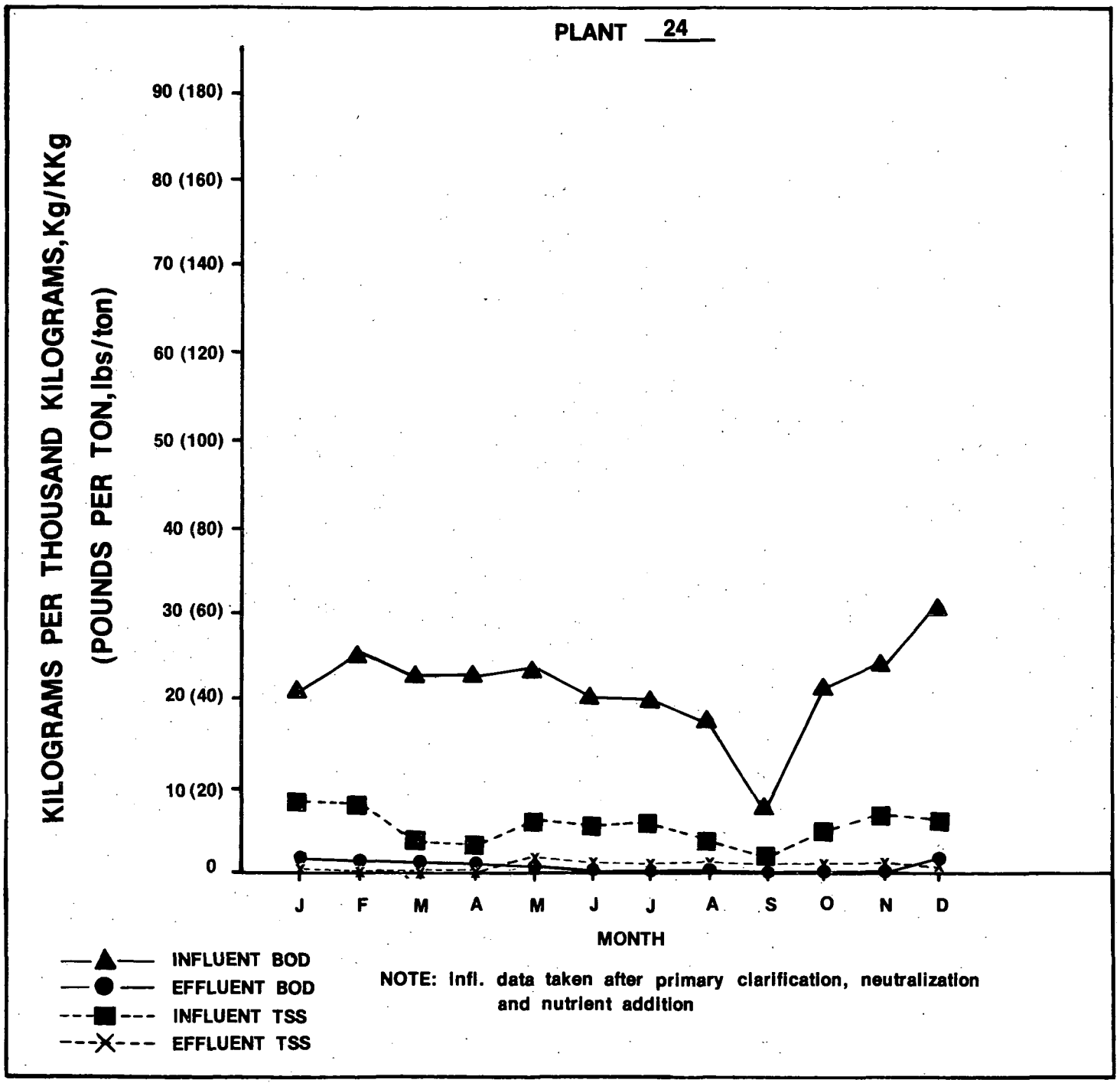

Figure XIII - 5

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

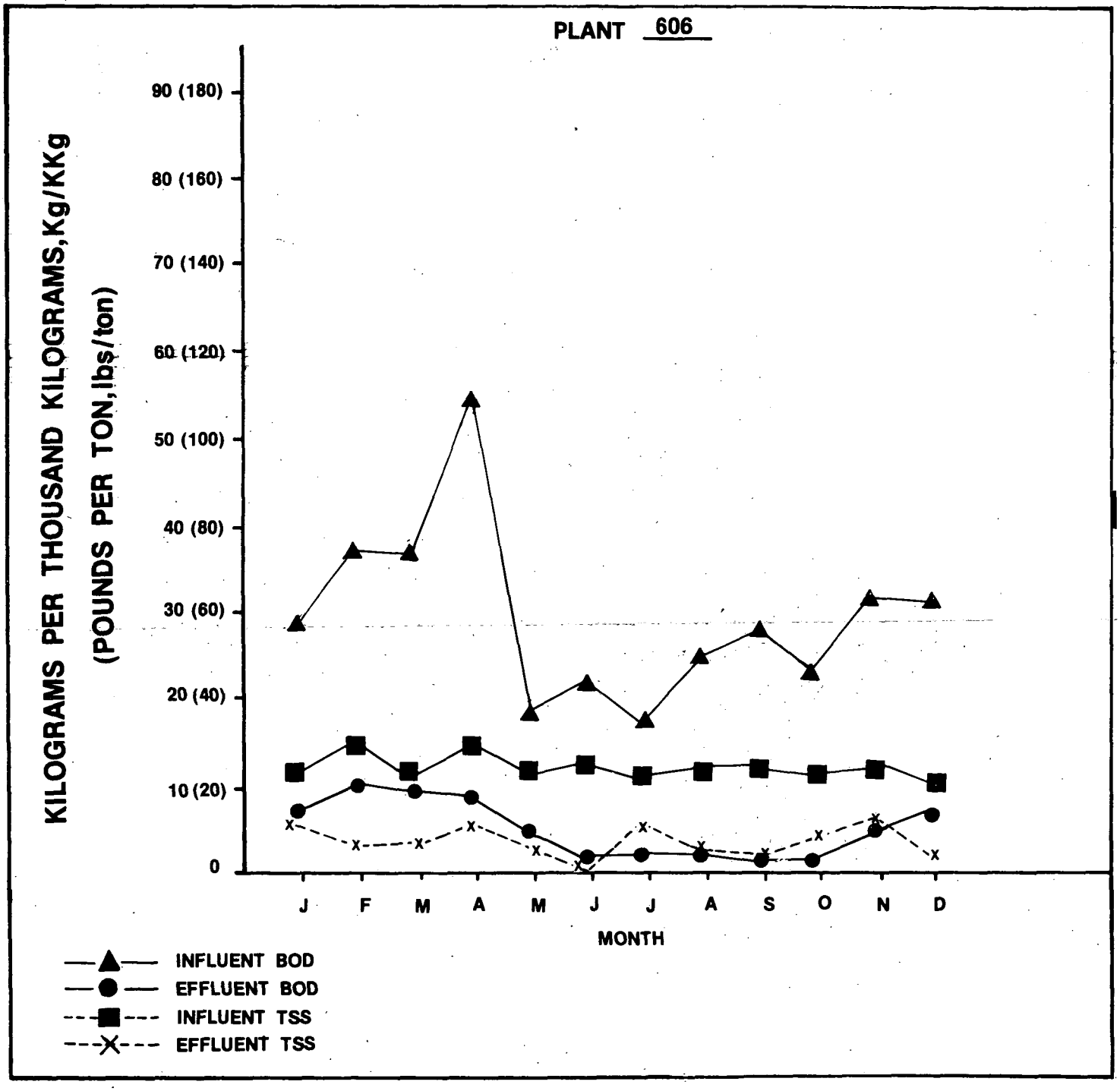

Figure XIII - 6

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

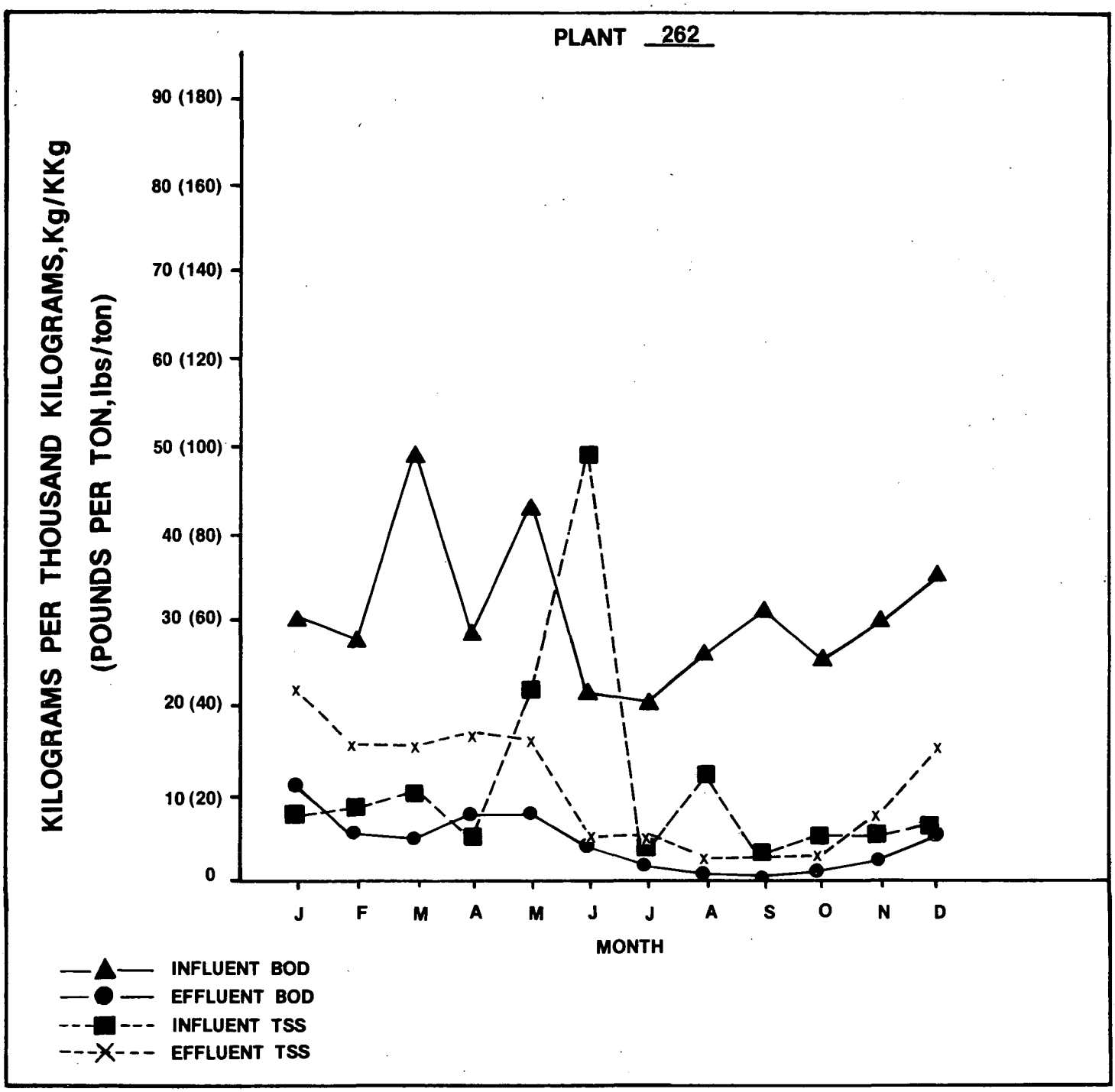

Figure XIII - 7

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

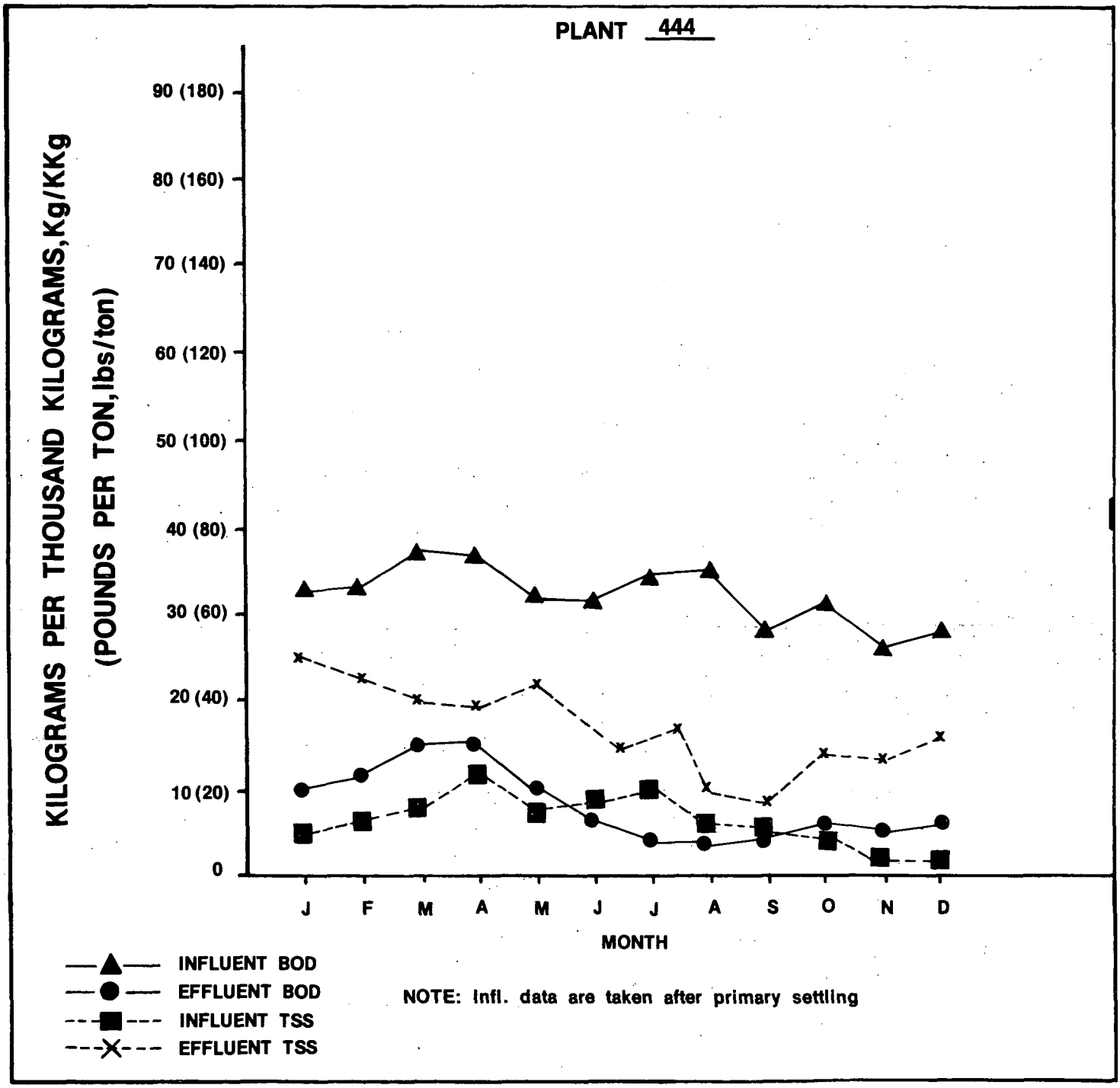

Figure XIII - 8

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

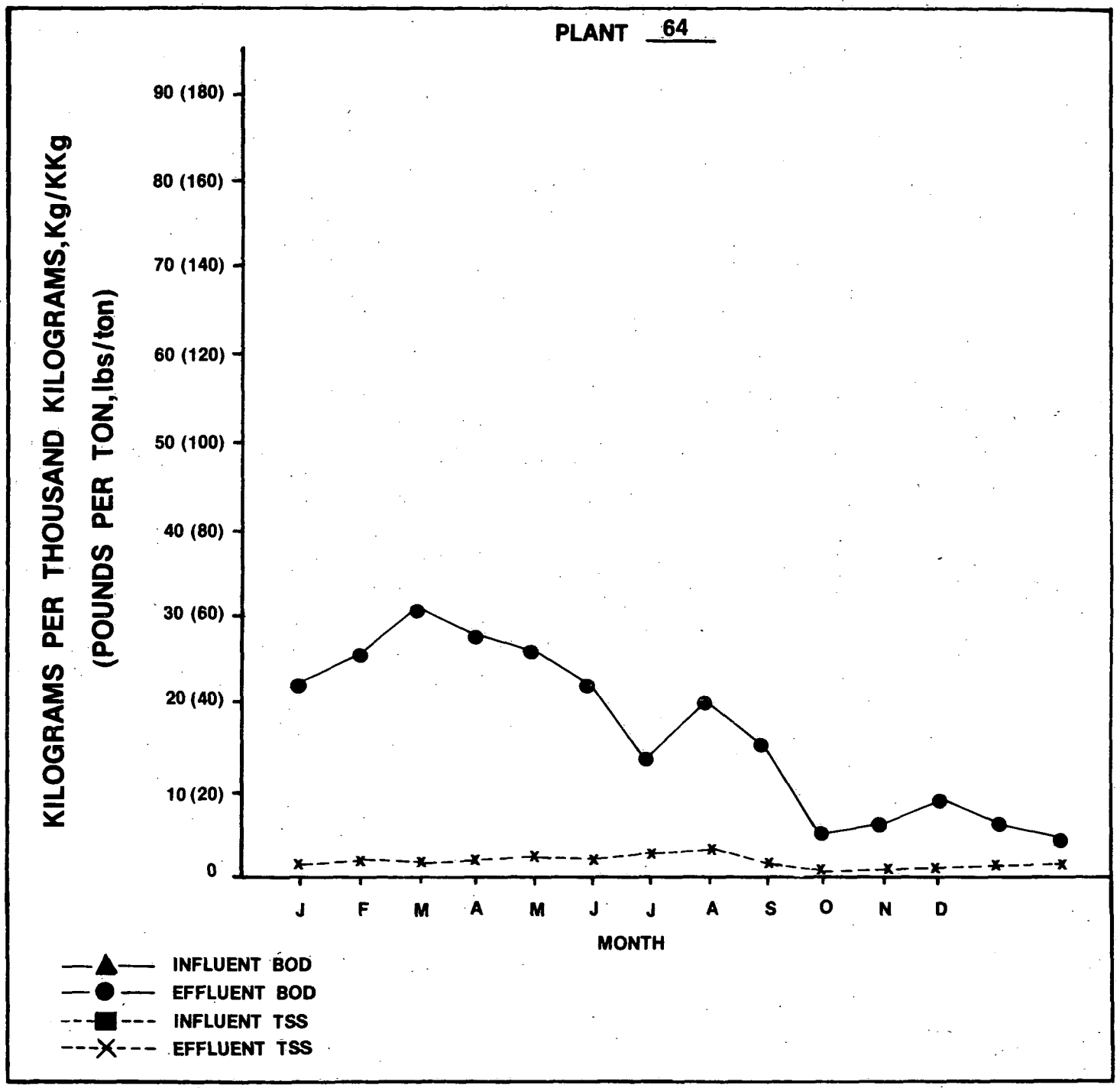

Figure XIII - 9

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

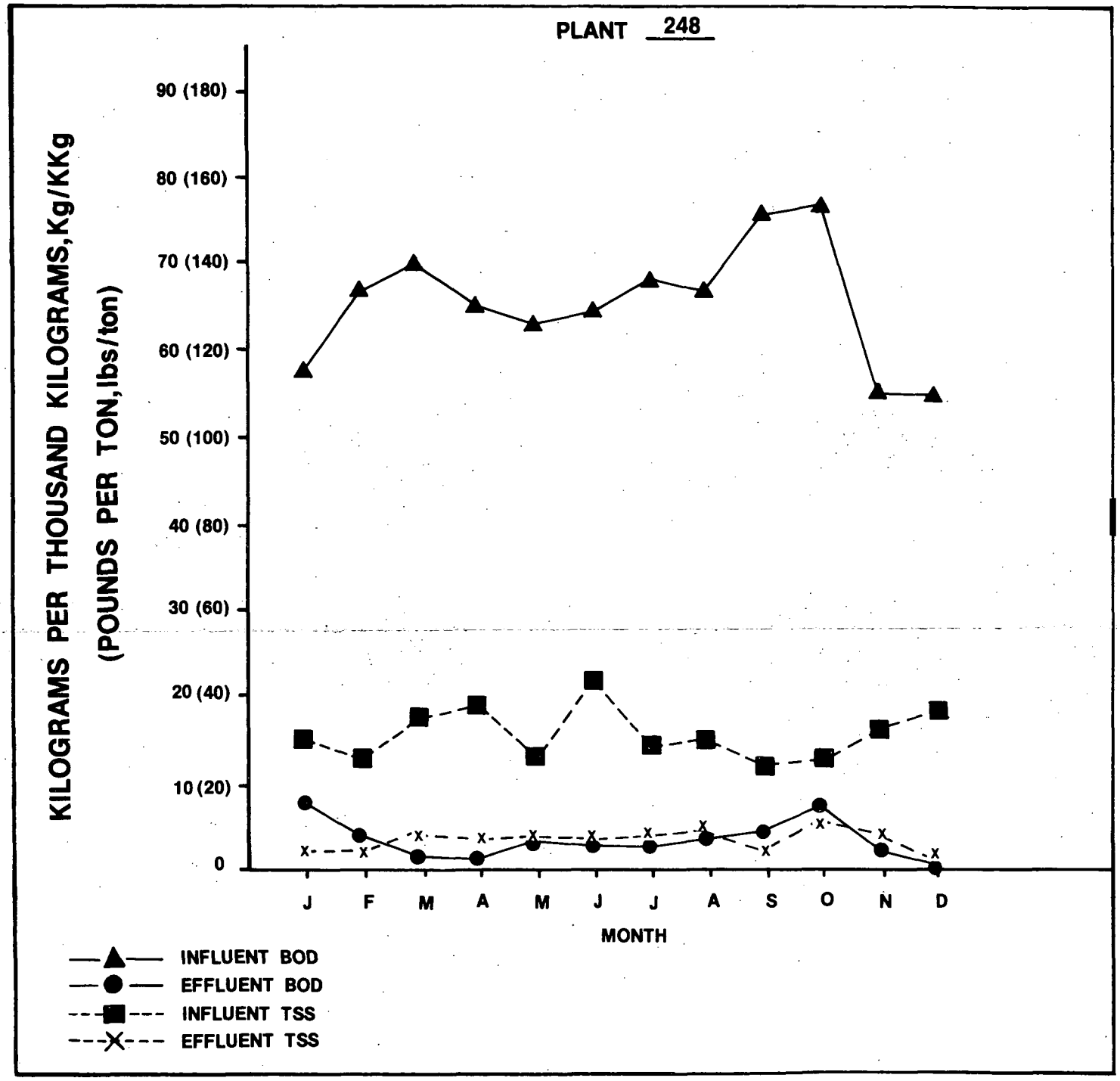

Figure XIII - 10

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

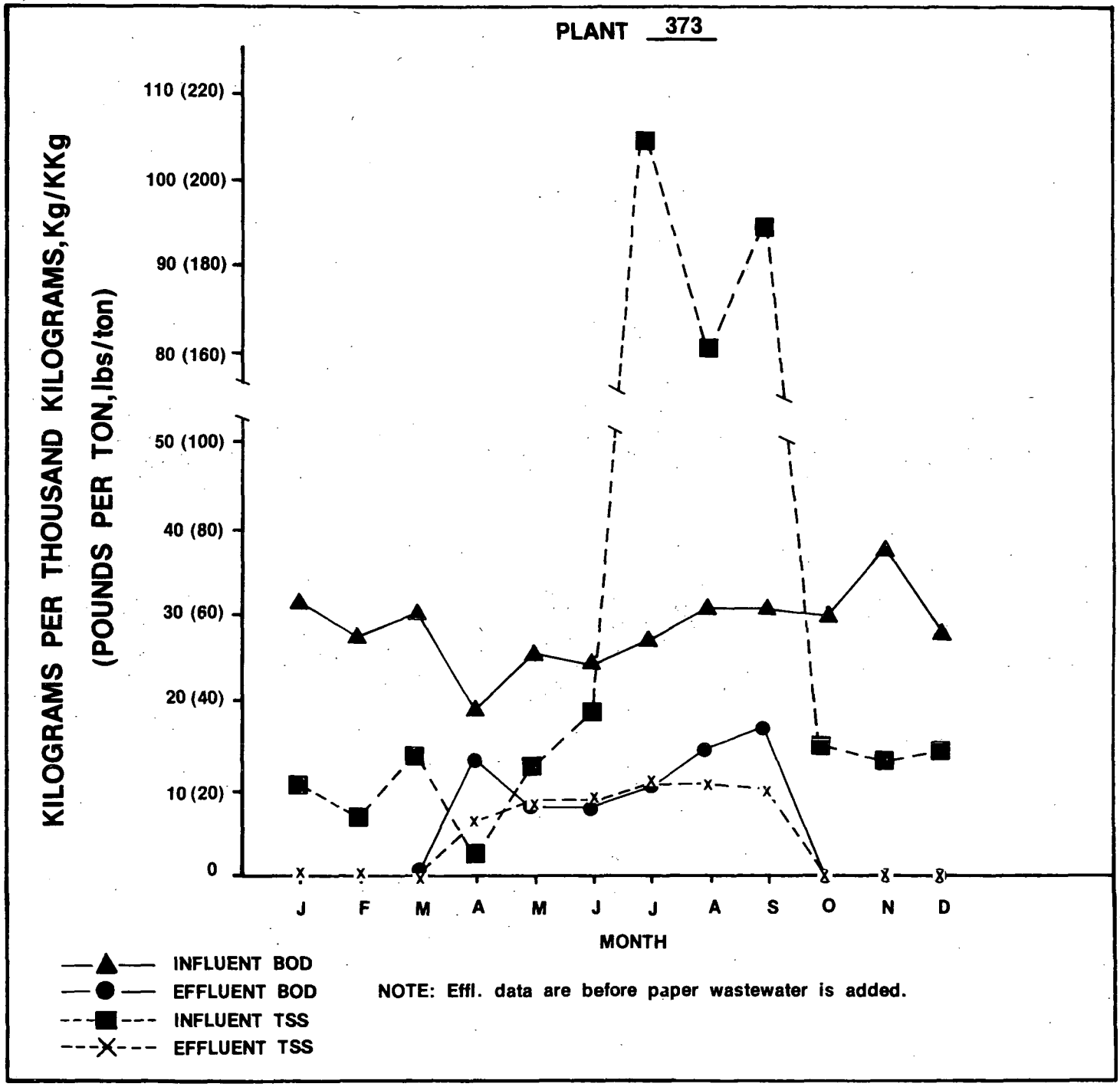

Figure XIII - 11

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

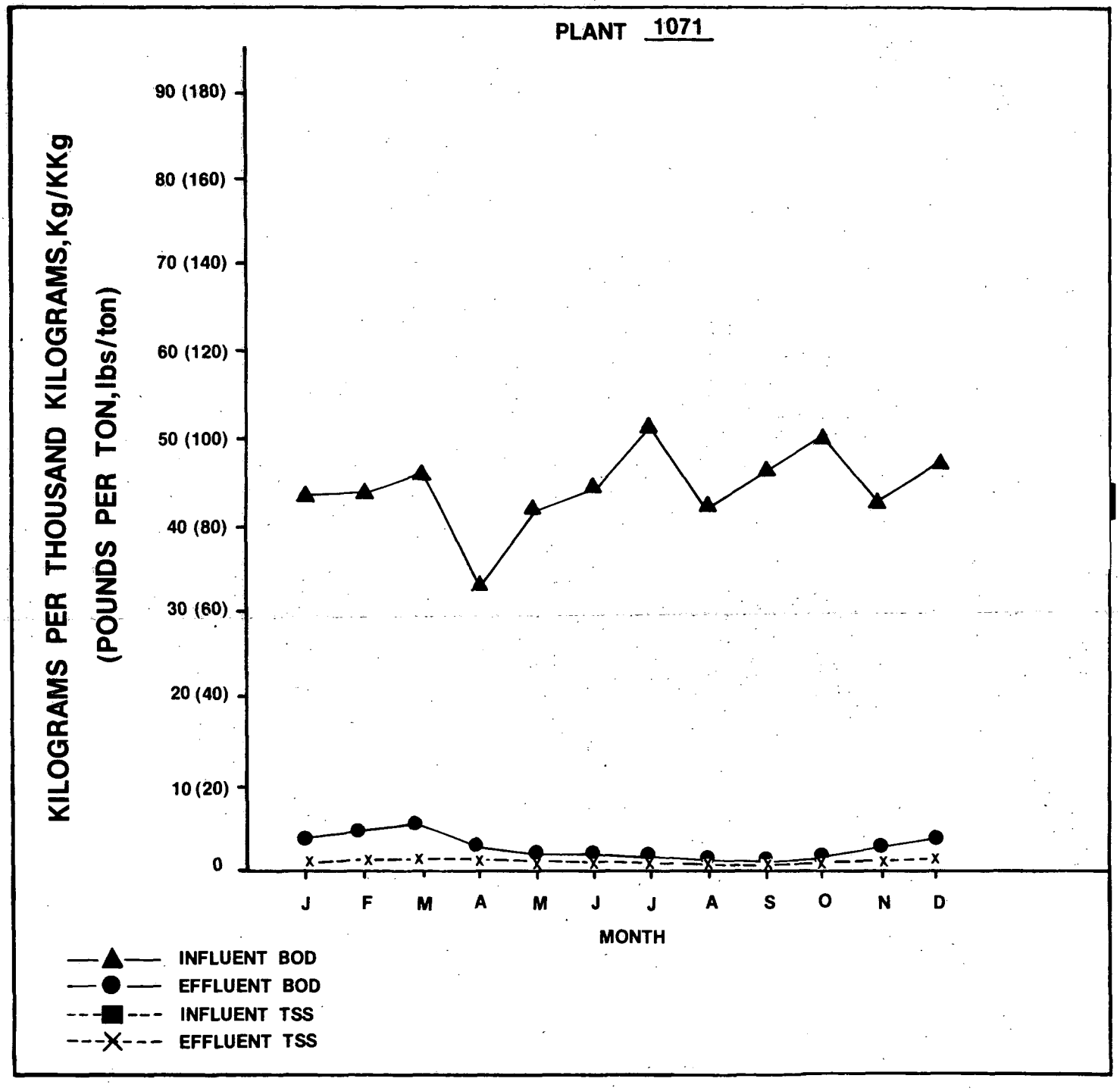

Figure XIII - 12

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

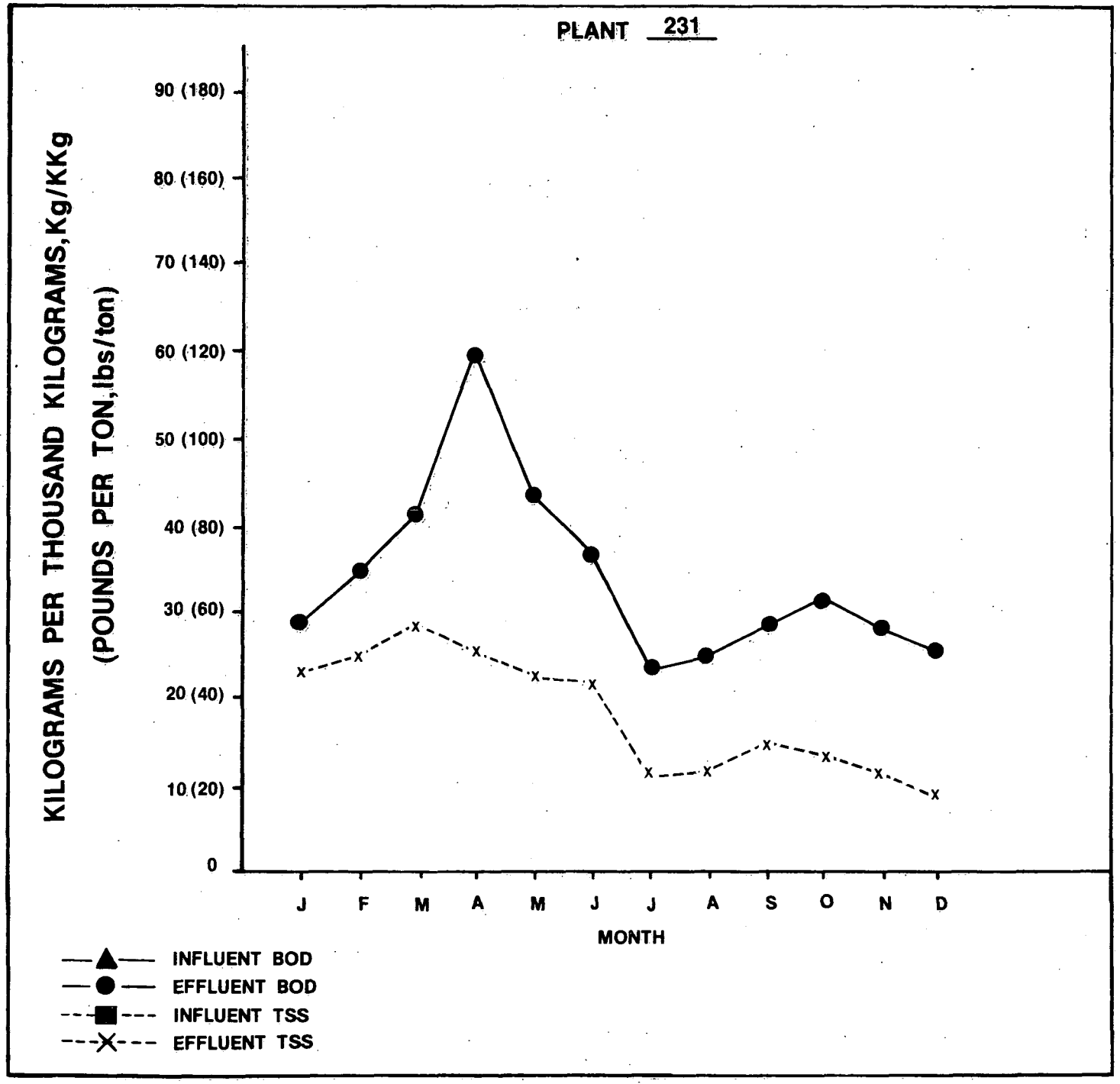

Figure XIII - 13

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

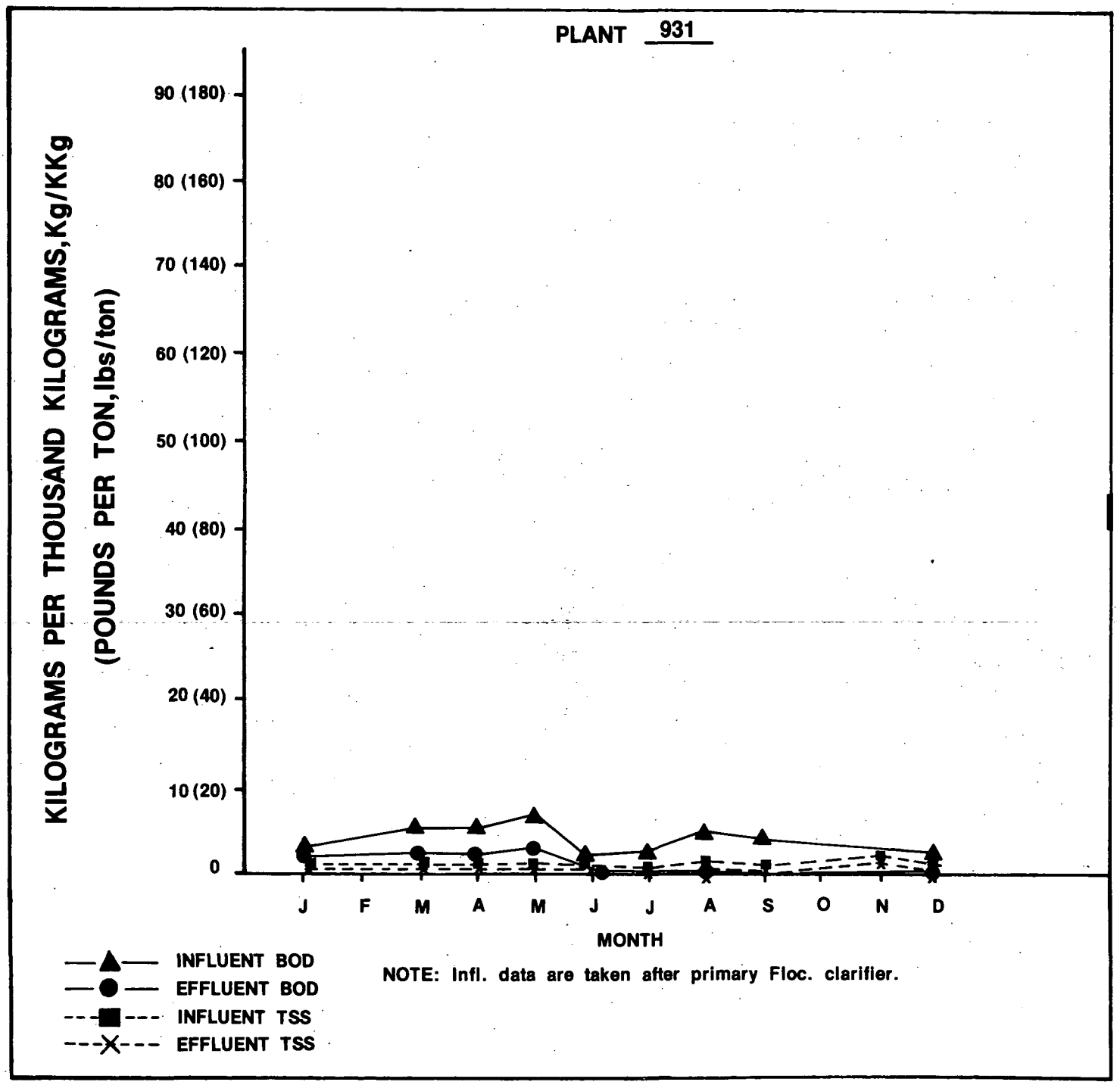

Figure XIII - 14

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

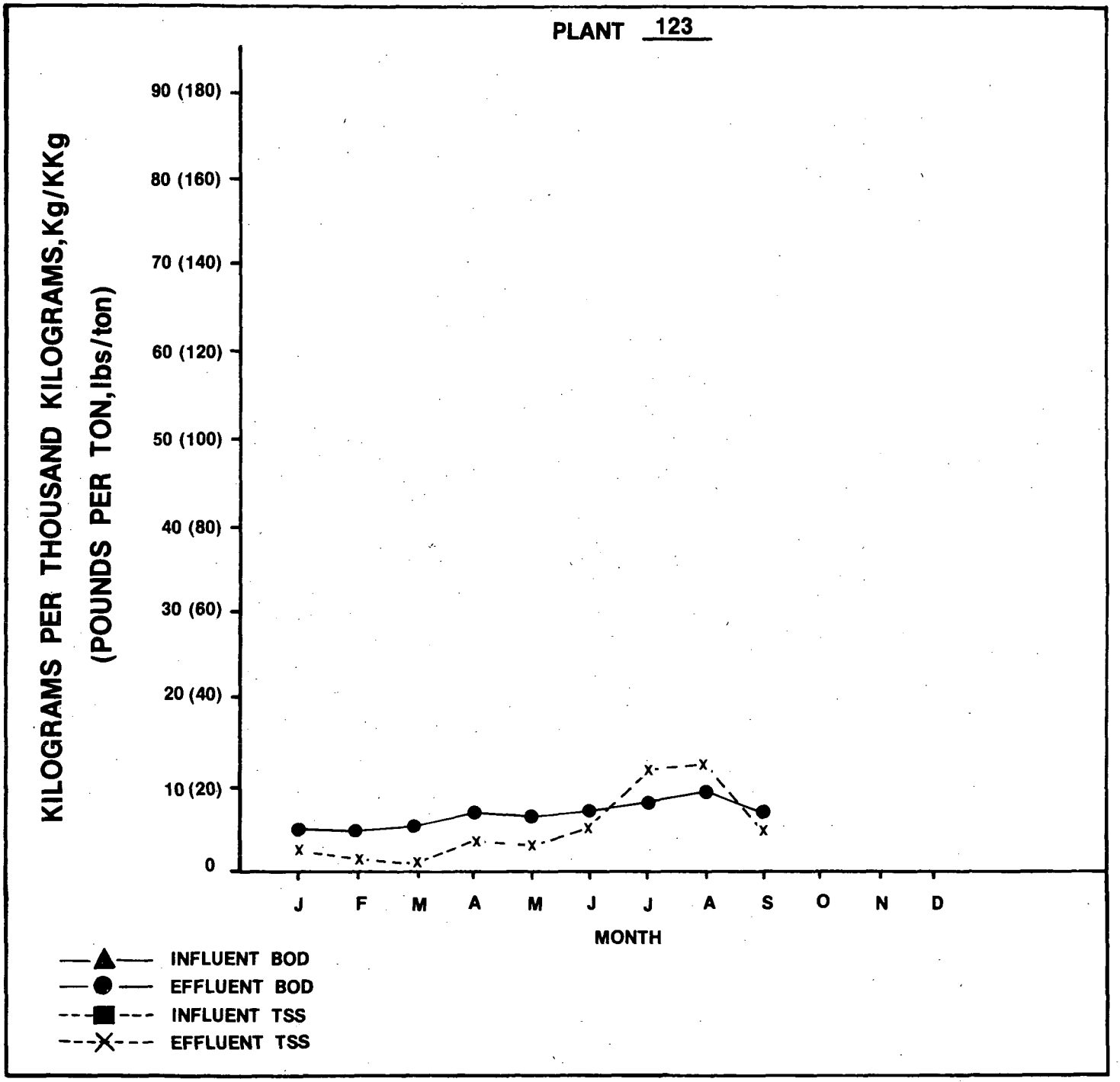

Figure XIII - 15

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

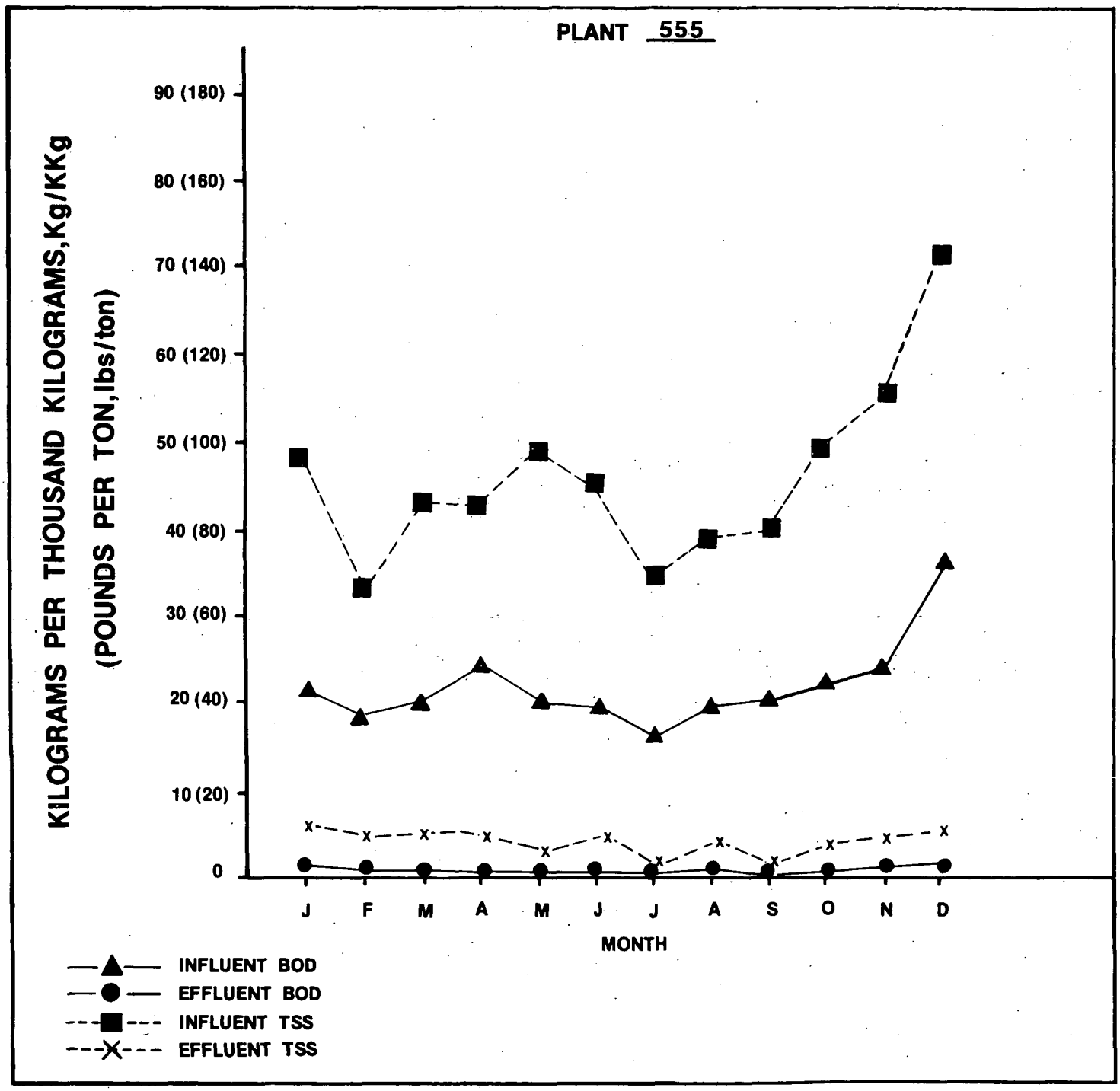

Figure XIII - 16

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

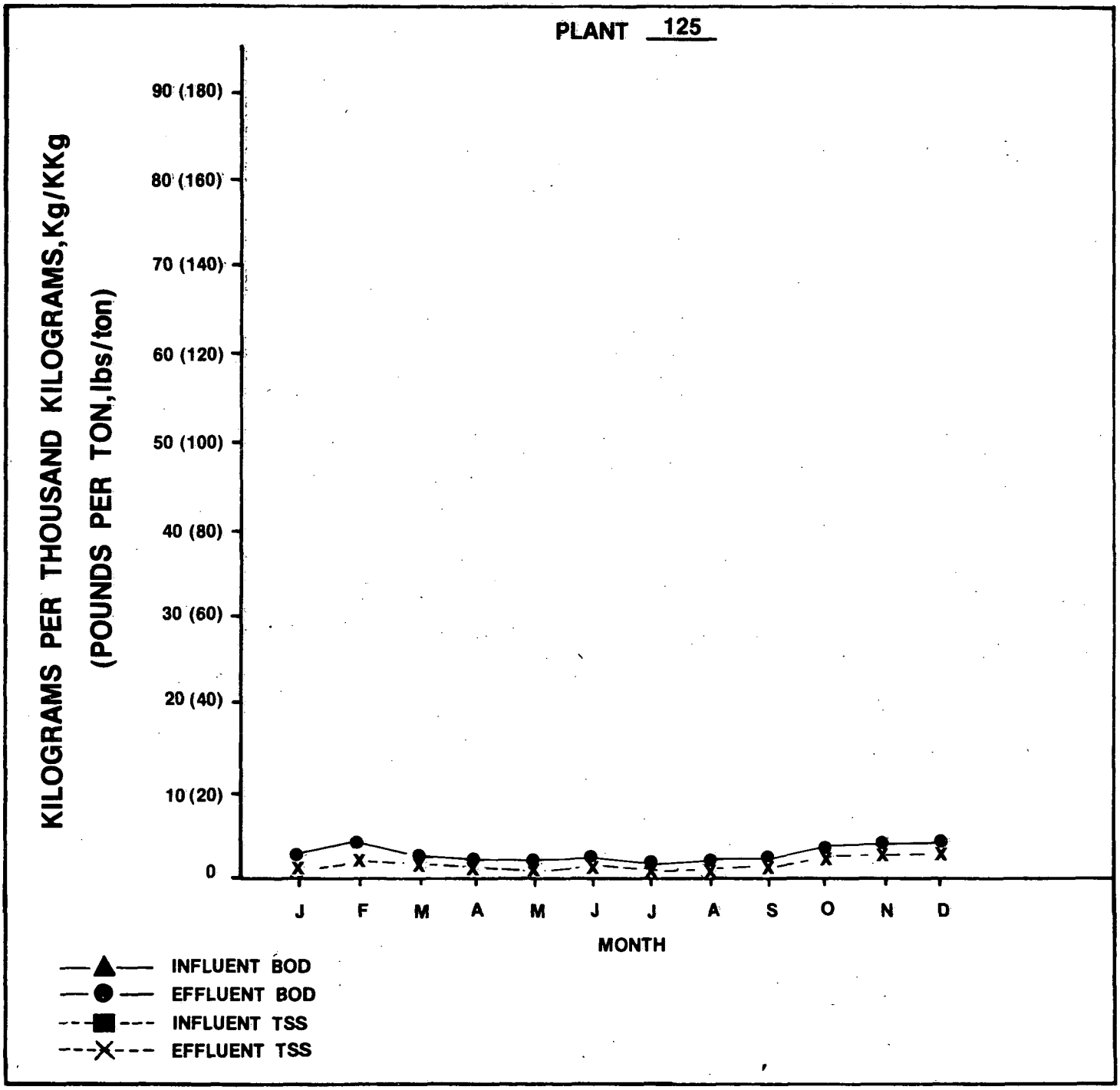

Figure XIII - 17

MONTHLY VARIATION IN WASTE WATER CHARACTERISTIC

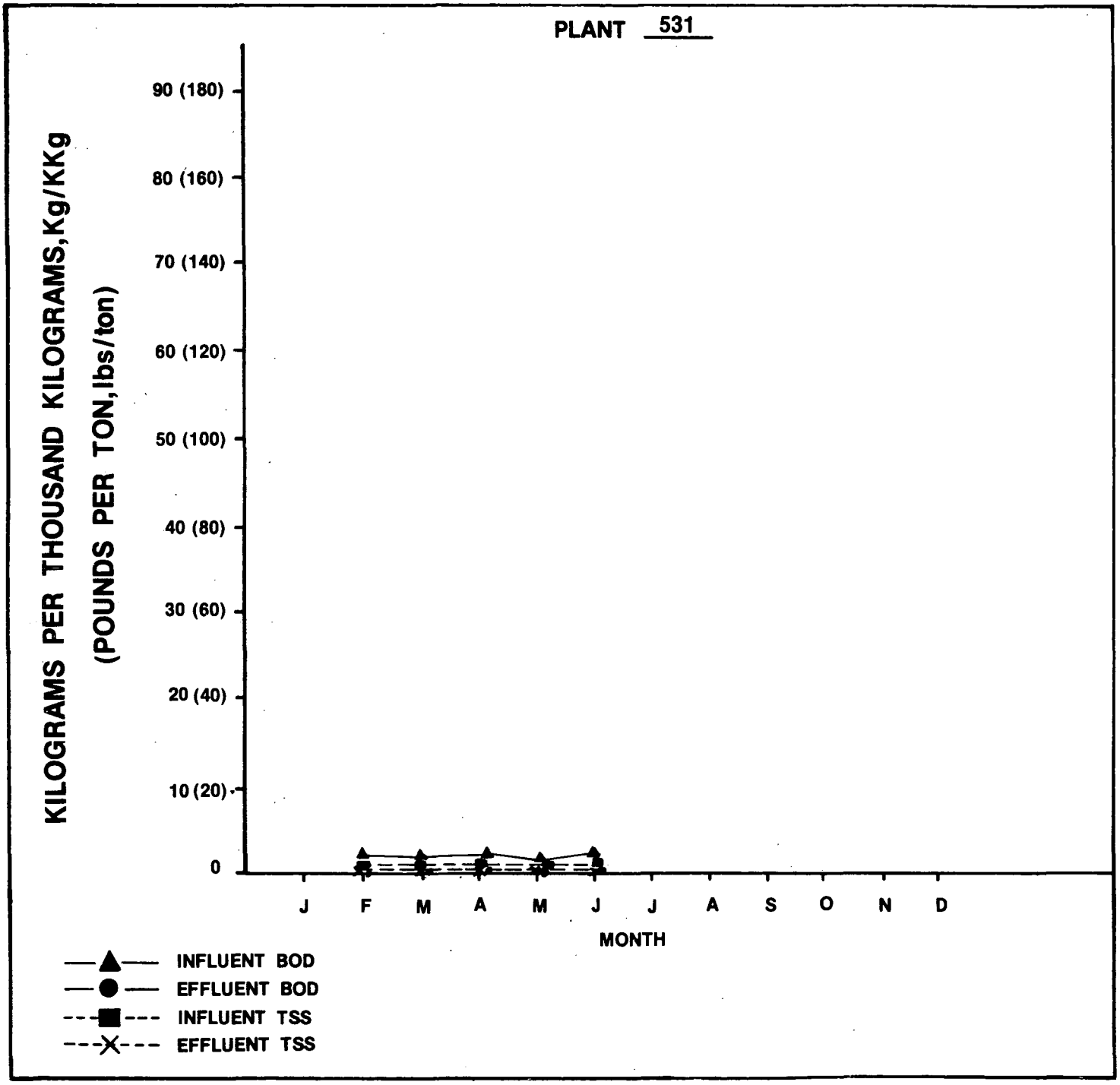

Figure XIII - 18

SECTION XIV

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SECTION XVI

GLOSSARY OF TERMS AND ABBREVIATIONS

ACA--Ammonical Copper Sulfate.

"Act"--The Federal Water Pollution Control Act Amendments of 1972.

Activated Sludge--Sludge floc produced in raw or settled wastewater by the growth of zoogleal bacteria and other organisms in the presence of dissolved oxygen and accumulated in sufficient concentration by returning floc previously formed.

Activated Sludge Process--A biological wastewater treatment process in which a mixture of wastewater and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated wastewater (mixed liquor) by sedimentation and wasted or returned to the process as needed.

Additive--Any material introduced prior to the final consolidation of a board to improve some property of the final board or to achieve a desired effect in combination with another additive. Additives include binders and other materials. Sometimes a specific additive may perform more than one function. Fillers and preservatives are included under this term.

Aerated Lagoon--A natural or artificial wastewater treatment pond in which mechanical or diffused-air aeration is used to supplement the oxygen supply.

Aerobic--Condition in which free elemental oxygen is present.

Air-drying--Drying veneer by placing the veneer in stacks open to the atmosphere, in such a way as to allow good circulation of air. It is used only in the production of low quality veneer.

Air-felting--Term applied to the forming of a fiberboard from an air suspension of wood or other cellulose fiber and to the arrangement of such fibers into a mat for board.

Anaerobic--Condition in which free elemental oxygen is absent.

Asplund Method--An attrition mill which combines the steaming and defibering in one unit in a continuous operation.

Attrition Mill--Machine which produces particles by forcing coarse material, shavings, or pieces of wood between a stationary and a rotating disk, fitted with slotted or grooved segments.

Back--The side reverse to the face of a panel, or the poorer side of a panel in any grade of plywood that has a face and back.

Bagasse--The solid matter remaining after extraction of liquids from sugar cane.

Biological Wastewater Treatment--Forms of wastewater treatment in which bacterial or biochemical action is intensified to stabilize, oxidize, and nitrify the unstable organic matter present. Intermittent sand filters, contact beds, trickling filters, and activated sludge processes are examples.

Blowdown--The removal of a portion of any process flow to maintain the constituents of the flow at desired levels.

BOD--Biochemical Oxygen Demand is a measure of biological decomposition of orgnaic matter in a water sample. It is determined by measuring the oxygen required by microorganisms to oxidize the organic contaminants of a water sample under standard laboratory conditions. The standard conditions include incubation for five days at 20°C.

BOD7--A modification of the BOD test in which incubation is maintained for seven days. The standard test in Sweden.

Boultonizing--A conditioning process in which unseasoned wood is heated in an oily preservative under a partial vacuum to reduce its moisture content prior to injection of the preservative.

Casein--A derivative of skimmed milk used in making glue.

Caul--A steel plate or screen on which the formed mat is placed for transfer to the press, and on which the mat rests during the pressing process.

CCA-type Preservative--Any one of several inorganic salt formulations based on salts of copper, chromium, and arsenic.

Chipper--A machine which reduces logs or wood scraps to chips.

Clarifier--A unit of which the primary purpose is to reduce the amount of suspended matter in a liquid.

Closed Steaming--A method of steaming in which the steam required is generated in the retort by passing boiler steam through heating coils that are covered with water. The water used for this purpose is recycled.

cm--Centimeters.

COD--Chemical Oxygen Demand. Its determination provides a measure of the oxygen demand equivalent to that portion of matter in a sample which is susceptible to oxidation by a strong chemical oxidant.

Coil Condensate--The condensate formed in steam lines and heating coils.

Cold Pressing--See Pressing.

Composite Board--Any combination of different types of board, either with another type board or with another sheet material. The composite board may be laminated in a separate operation or at the same time as the board is pressed. Examples of composite boards include veneer-faced particle board, hardboard-faced insulation board and particle board, and metal-faced hardboard.

Conditioning--The practice of heating logs prior to cutting in order to improve the cutting properties of the wood and in some cases to facilitate debarking.

Cooling Pond--A water reservoir equipped with spray aeration equipment from which cooling water is drawn and to which it is returned.

Creosote--A complex mixture of organic materials obtained as a by-product from coking and petroleum refining operations that is used as a wood preservative.

cu m--Cubic meters.

cu ft--Cubic feet.

Curing--The physical-chemical change that takes place either to thermosetting synthetic resins (polymerization) in the hot presses or to drying oils (oxidation) used for oil-treating board. The treatment to produce that change.

Cutterhead Barker--See Debarker.

Cylinder Condensate--Steam condensate that forms on the walls of the retort during steaming operations.

CZC--Chromated Zinc Chloride.

Data Collection Portfolio--Information solicited from industry under Section 308 of the Act.

Debarker--Machines which remove bark from logs. Debarkers may be wet or dry, depending on whether or not water is used in the operation. There are several types of debarkers including drum barkers, ring barkers, bag barkers, hydraulic barkers, and cutterhead barkers. With the exception

of the hydraulic barker, all use abrasion or scraping actions to remove bark. Hydraulic barkers utilize high pressure streams of water.

Decker, Deckering--A method of controlling pulp consistency in hardboard production.

Defiberization--The reduction of wood materials to fibers.

Digester--1) Device for conditioning chips using high pressure steam, 2) A tank in which biological decomposition (digestion) of the organic matter in sludge takes place.

Disc Pulpers--Machines which produce pulp or fiber through the shredding action of rotating and stationary discs.

DO--Dissolved Oxygen is a measure of the amount of free oxygen in a water sample. It is dependent on the physical, chemical, and biochemical activities of the water sample.

Dry-felting--See Air-felting.

Dry Process--See Air-felting.

Durability--As applied to wood, its lasting qualities or permanence in service with particular reference to decay. May be related directly to an exposure condition.

FCAP--Fluor-chrom-arsenate-phenol. An inorganic water-borne wood preservative.

Fiber (Fibre)--The slender thread-like elements of wood or similar cellulosic material, which, when separated by chemical and/or mechanical means, as in pulping, can be formed into fiberboard.

Fiberboard--A sheet material manufactured from fibers of wood or other ligno-cellulosic materials with the primary bond deriving from the arrangement of the fibers and their inherent adhesive properties. Bonding agents or other materials may be added during manufacture to increase strength, resistance to moisture, fire, insects or decay, or to improve some other property of the product. Alternative spelling: fibreboard. Synonym: fibre building board.

Fiber Preparation--The reduction of wood to fiber or pulp, utilizing mechanical, thermal, or explosive methods.

Finishing--The final preparation of the product. Finishing may include redrying, trimming, sanding, sorting, molding, and storing, depending on the operation and product desired.

Fire Retardant--A formulation of inorganic salts that imparts fire resistance when injected into wood in high concentrations.

Flocculation--The agglomeration of colloidal and finely divided suspended matter.

Flotation--The raising of suspended matter to the surface of the liquid in a tank as scum--by aeration, the evolution of gas, chemicals, electrolysis, heat, or bacterial decomposition--and the subsequent removal of the scum by skimming.

F:M ratio--The ratio of organic material (food) to mixed liquor (microorganisms) in an aerated sludge aeration basin.

Formation (Forming)--The felting of wood or other cellulose fibers into a mat for fiberboard. Methods employed: air-felting and wet-felting.

Gal--Gallons.

GPD--Gallons per day.

GPM--Gallons per minute.

Grading--The selection and categorization of different woods as to their suitability for various uses. Criteria for selection include such features of the wood as color, defects, and grain direction.

Hardboard--A compressed fiberboard with a density greater than 0.5 g/cu m (31 lb/cu ft).

Hardboard Press--Machine which completes the reassembly of wood particles and welds them into a tough, durable, grainless board.

Hardwood--Wood from deciduous or broad-leaf trees. Hardwoods include oak, walnut, lavan, elm, cherry, hickory, pecan, maple, birch, gum, cativo, teak, rosewood, and mahogany.

Heat-treated Hardboard--Hardboard that has been subjected to special heat treatment after hot-pressing to increase strength and water resistance.

Holding Ponds--See Impoundment.

Hot Pressing--See Pressing.

Humidification--The seasoning operation to which newly pressed hardboard is subjected to prevent warpage due to excessive dryness.

Impoundment--A pond, lake, tank, basin, or other space, either natural or created in whole or in part by the building of engineering structures, which is used for storage, regulation, and control of water, including wastewater.

Insulation Board--A form of fiberboard having a density less than 0.5 g/cu m (31 lb/cu ft).

Kjld-N--Kjeldahl Nitrogen: Total organic nitrogen plus ammonia of a sample.

Kl/day--Thousands of liters per day.

Lagoon--A pond containing raw or partially treated wastewater in which aerobic or anaerobic stabilization occurs.

Land Spreading--see Soil Irrigation.

Leaching--Mass transfer of chemicals to water from wood which is in contact with it.

l/day--Liters per day.

Metric ton--One thousand kilograms.

MGD--Million gallons per day.

mg/l--Milligrams per liter (equals parts per million, ppm, when the specific gravity is one).

Mixed Liquor--A mixture of activated sludge and organic matter undergoing activated sludge treatment in an aeration tank.

ml/l--Milliliters per liter.

mm--Millimeters.

Modified-closed Steaming--A method of steam conditioning in which the condensate formed during open steaming is retained in the retort until sufficient condensate accumulates to cover the coils. The remaining steam required is generated as in closed steaming.

No Discharge--The complete prevention of polluted process wastewater from entering navigable waters.

Non-pressure Process--A method of treating wood at atmospheric pressure in which the wood is simply soaked in hot or cold preservative.

NPDES--National Pollutant Discharge Elimination System.

Nutrients--The nutrients in contaminated water are routinely analyzed to characterize the food available for microorganisms to promote organic decomposition. They are:

Ammonia Nitrogen (NH_3), mg/l as N

Kjeldahl Nitrogen (ON), mg/l as N

Nitrate Nitrogen (NO_3), mg/l as N

Total Phosphate (TP), mg/l as P

Ortho Phosphate (OP), mg/l as P

Oil-recovery System--Equipment used to reclaim oil from wastewater.

Oily Preservative--Pentachlorophenol-petroleum solutions and creosote in the various forms in which it is used.

Open Steaming--A method of steam conditioning in which the steam required is generated in a boiler.

PCB--Polychlorinated Biphenyls.

PCP--Pentachlorophenol.

Pearl Benson Index--A measure of color producing substances.

Pentachlorophenol--A chlorinated phenol with the formula $C1_5C_6OH$ and formula weight of 266.35 that is used as a wood preservative. Commercial grades of this chemical are usually adulterated with tetrachlorophenol to improve its solubility.

pH--pH is a measure of the acidity or alkalinity of a water sample. It is equal to the negative log of the hydrogen ion concentration.

Phenol--The simplest aromatic alcohol.

Phenols, Phenolic Compounds--A wide range of organic compounds with one or more hydroxyl groups attached to the aromatic ring.

Point Source--A discrete source of pollution. Channeled wastewater.

POTW--Publicly owned treatment works.

Pressure Process--A process in which wood preservatives and fire retardants are forced into wood using air or hydrostatic pressure.

Pretreatment--Any wastewater treatment processes used to partially reduce pollution load before the wastewater is delivered into a treatment facility. Usually consists of removal of coarse solids by screening or other means.

Primary Treatment--The first major treatment in a wastewater treatment works. In the classical sense, it normally consists of clarification.

As used in this document, it generally refers to treatment steps preceding biological treatment.

Priority Pollutants--Those compounds listed in the 1976 Consent Decree.

Process Wastewater--Water, which during manufacturing or processing, comes into contact with or results in the production or use of any raw material, intermediate product, finished product, by-product, or waste product.

psi--Pounds per square inch.

Radio Frequency Heat--Heat generated by the application of an alternating electric current, oscillating in the radio frequency range, to a dielectric material. In recent years the method has been used to cure synthetic resin glues.

Resin--Secretions of saps of certain plants or trees. It is an oxidation or polymerization product of the terpenes, and generally contains "resin" acids and ethers.

Retort--A steel vessel in which wood products are pressure impregnated with chemicals that protect the wood from biological deterioration or that impart fire resistance. Also called treating cylinder.

Roundwood--Wood that is still in the form of a log, i.e., round.

RWL--Raw Waste Load. Pollutants contained in untreated wastewater.

S1S Hardboard--Hardboard finished so as to be smooth on one side.

S2S Hardboard--Hardboard finished so as to be smooth on both sides.

Secondary Treatment--The second major step in a waste treatment system. As used in this document, the term refers to biological treatment.

Sedimentation Tank--A basin or tank in which water or wastewater containing settleable solids is retained to remove by gravity a part of the suspended matter.

Settling Ponds--An impoundment for the settling out of settleable solids.

Sludge--The accumulated solids separated from liquids, such as water or wastewater, during processing.

Softwood--Wood from evergreen or needle-bearing trees.

Soil Irrigation--A method of land disposal in which wastewater is applied to a prepared field. Also referred to as soil percolation.

Solids--Various types of solids are commonly determined on water samples. These types of solids are:

Total Solids (TS)--The material left after evaporation and drying a sample at 103°-105° C.

Suspended Solids (SS)--The material removed from a sample filtered through a standard glass fiber filter. Then it is dried at 103°-105°C.

Total Suspended Solids (TSS)--Same as Suspended Solids.

Dissolved Solids (DS)--The difference between the total and suspended solids.

Volatile Solids (VS)--The material which is lost when the sample is heated to 550°C.

Settleable Solids (STS)--The material which settles in an Immhoff cone in one hour.

Spray Evaporation--A method of wastewater disposal in which the water in a holding lagoon equipped with spray nozzles is sprayed into the air to expedite evaporation.

Spray Irrigation--A method of disposing of some organic wastewaters by spraying them on land, usually from pipes equipped with spray nozzles. See Soil Irrigation.

sq m--Square meter.

Steam Conditioning--A conditioning method in which unseasoned wood is subjected to an atmosphere of steam at 120°C (249° F) to reduce its moisture content and improve its permeability preparatory to preservative treatment.

Steaming--Treating wood material with steam to soften it.

Sump--(1) A tank or pit that receives drainage and stores it temporarily, and from which the drainage is pumped or ejected. (2) A tank or pit that receives liquids.

Synthetic Resin (Thermosetting)--Artificial resin (as opposed to natural) used in board manufacture as a binder. A combination of chemicals which can be polymerized, e.g., by the application of heat, into a compound which is used to produce the bond or improve the bond in a fiberboard or particle board. Types usually used in board manufacture are phenol formaldehyde, urea formaldehyde, or melamine formaldehyde.

Tempered Hardboard--Hardboard that has been specially treated in manufacture to improve its physical properties considerably. Includes, for example, oil-tempered hardboard. Synonym: superhardboard.

Tertiary Treatment--The third major step in a waste treatment facility. As used in this document, the term refers to treatment processes following biological treatment.

Thermal Conductivity--The quantity of heat which flows per unit time across unit area of the subsurface of unit thickness when the temperature of the faces differs by one degree.

Thermosetting--Adhesives which, when cured under heat or pressure, "set" or harden to form films of great tenacity and strength. Subsequent heating in no way softens the bending matrix.

TOC--Total Organic Carbon is a measure of the organic contamination of a water sample. It has an empirical relationship with the biochemical and chemical oxygen demands.

T-PO_4-P--Total phosphate as phosphorus. See Nutrients.

Total Phenols--See Phenols.

Traditional Parameters--Those parameters historically of interest, e.g., BOD, COD, SS, as compared to Priority Pollutants.

Turbidity--(1) A condition in water or wastewater caused by the presence of suspended matter, resulting in the scattering and absorption of light rays. (2) A measure of the fine suspended matter in liquids. (3) An analytical quantity usually reported in arbitrary turbidity units determined by measurements of light diffraction.

Vacuum Water--Water extracted from wood during the vacuum period following steam conditioning.

Vapor Drying--A process in which unseasoned wood is heated in the hot vapors of an organic solvent, usually xylene, to season it prior to preservative treatment.

Vat--Large metal containers in which logs are "conditioned" or heated prior to cutting. The two basic methods for heating are by direct steam contact in "steam vats" or by steam-heated water in "hot water vats."

Veneer--A thin sheet of wood of uniform thickness produced by peeling, slicing, or sawing logs, bolts, or flitches. Veneers may be categorized as either hardwood or softwood, depending on the type of woods used and the intended purpose.

Water Balance--The water gain (incoming water) of a system versus water loss (water discharged or lost).

Water-borne Preservative--Any one of several formulations of inorganic salts, the most common of which are based on copper, chromium, and arsenic.

Wet-felting--Term applied to the forming of a fiberboard from a suspension of pulp in water usually on a cylinder, deckle box, or Fourdrinier machine; the interfelting of wood fibers from a water suspension into a mat for board.

Wet Process--See Wet-felting.

Wet Scrubber--An air pollution control device which involves the wetting of particles in an air stream and the impingement of wet or dry particles on collecting surfaces, followed by flushing.

Wood Extractives--A mixture of chemical compounds, primarily carbohydrates, removed from wood during steam conditioning.

Wood Preservatives--A chemical or mixture of chemicals with fungistatic and insecticidal properties that is injected into wood to protect it from biological deterioration.

Zero Discharge--See No Discharge.

APPENDIX A-1

TOXIC OR POTENTIALLY TOXIC SUBSTANCES NAMED IN CONSENT DEGREE

Acenapthene
Acrolein
Acrylonitrile
Aldrin/Dieldrin
Antimony
Arsenic
Asbestos
Banzidine
Benzene
Beryllium
Cadmium
Carbon Tetrachloride
Chlordane
Chlorinated Benzene
Chlorinated Ethanes
Chlorinated Ethers
Chlorinated Phenol
Chloroform
2-Chlorophenol
Chromium
Copper
Cyanide
DDT
Dichlorobenzene
Dichlorobenzidine
Dichloroethylene
2,4-Dichlorophenol
Dichloropropane
2,4-Dimethylphenol
Dinitrotoluene
Diphenylhydrazine
Endosulfan
Endrin
Ethylbenzene
Flouranthene
Haloethers
Halomethanes
Heptachlor
Hexachlorobutadiene
Hexachlorocyclohexane
Hexachlorocyclopentadiene
Isophorone
Lead
Mercury
Nickel
Nitrobenzene
Nitrophenol
Nitrosamines

APPENDIX A-2

LIST OF SPECIFIC UNAMBIGUOUS RECOMMENDED PRIORITY POLLUTANTS

1. benzidine
2. 1,2,4-trichlorobenzene
3. hexachlorobenzene
4. chlorobenezene
5. bis(chloromethyl) ether
6. bis(2-chloroethyl) ether
7. 2-chloroethyl vinyl ether (mixed)
8. 1,2-dichlorobenzene
9. 1,3-dichlorobenzene
10. 1,4-dichlorobenzene
11. 3,3-dichlorobenzidine
12. 2,4-dinitrotoluene
13. 2,6-dinitrotoluene
14. 1,2-diphenylhydrazine
15. ethylbenzene
16. 4-chlorophenyl phenyl ether
17. 4-bromophenyl phenyl ether
18. bis(2-chloroisopropyl) ether
19. bis(2-chloroethoxy) methane
20. isophorone
21. nitrobenzene
22. N-nitrosodimethylamine
23. N-nitrosodiphenylamine
24. N-nitrosodi-n-propylamine
25. bis(2-ethylhexyl) phthalate
26. butyl benzyl phthalate
27. di-n-butyl phthalate
28. diethyl phthalate
29. dimethyl phthalate
30. toluene
31. vinyl chloride (chloroethylene)
32. acrolein
33. acrylonitrile
34. acenaphthene
35. 2-chloronaphthalene
36. fluroanthene
37. naphthalene
38. 1,2-benzanthracene
39. benzo (a)pyrene (3,4-benzopyrene)
40. 3,4-benzofluoranthene
41. 11,12-benzofluoranthene
42. chrysene
43. acenaphthylene
44. anthracene
45. 1,12-benzoperylene
46. fluroene
47. phenanthrene
48. 1,2:5,6-dibenzanthracene

2. List of Specific Unambiguous Recommended Priority Pollutants

1. benzidine
2. 1,2,4-trichlorobenzene
3. hexachlorobenzene
4. chlorobenezene
5. bis(chloromethyl) ether
6. bis(2-chloroethyl) ether
7. 2-chloroethyl vinyl ether (mixed)
8. 1,2-dichlorobenzene
9. 1,3-dichlorobenzene
10. 1,4-dichlorobenzene
11. 3,3-dichlorobenzidine
12. 2,4-dinitrotoluene
13. 2,6-dinitrotoluene
14. 1,2-diphenylhydrazine
15. ethylbenzene
16. 4-chlorophenyl phenyl ether
17. 4-bromophenyl phenyl ether
18. bis(2-chloroisopropyl) ether
19. bis(2-chloroethoxy) methane
20. isophorone
21. nitrobenzene
22. N-nitrosodimethylamine
23. N-nitrosodiphenylamine
24. N-nitrosodi-n-propylamine
25. bis(2-ethylhexyl) phthalate
26. butyl benzyl phthalate
27. di-n-butyl phthalate
28. diethyl phthalate
29. dimethyl phthalate
30. toluene
31. vinyl chloride (chloroethylene)
32. acrolein
33. acrylonitrile
34. acenaphthene
35. 2-chloronaphthalene
36. fluroanthene
37. naphthalene
38. 1,2-benzanthracene
39. benzo (a)pyrene (3,4-benzopyrene)
40. 3,4-benzofluoranthene
41. 11,12-benzofluoranthene
42. chrysene
43. acenaphthylene
44. anthracene
45. 1,12-benzoperylene
46. fluroene
47. phenanthrene
48. 1,2:5,6-dibenzanthracene

49. indeno (1,2,3-,C,D)pyrene
50. pyrene
51. benzene
52. carbon tetrachloride (tetrachloromethane)
53. 1,2-dichloroethane
54. 1,1,1-trichloroethane
55. hexachloroethane
56. 1,1-dichloroethane
57. 1,1,2-trichloroethane
58. 1,1,2,2-tetrachloroethane
59. chloroethane
60. 1,1-dichloroethylene
61. 1,2-trans-dichloroethylene
62. 1,2-dichloropropane
63. 1,3-dichloropropylene (1,3-dichloropropene)
64. methylene chloride (dichloromethane)
65. methyl chloride (chloromethane)
66. methyl bromide (bromomethane)
67. bromoform (tribromomethane)
68. dichlorobromomethane
69. trichlorofluoromethane
70. dichlorodifluoromethane
71. chlorodibromomethane
72. hexachlorobutadiene
73. hexachlorocyclopentadiene
74. tetrachloroethylene
75. chloroform (trichloromethane)
76. trichloroethylene
77. aldrine
78. dieldrin
79. chlordane (technical mixture and metabolites)
80. 4,4-DDT
81. 4,4-DDE (p,p-DDX)
82. 4,4-DDD (p,p-TDE)
83. endosulfan
84. endosulfan
85. endosulfan sulfate
86. endrin
87. endrin aldehyde
88. endrin ketone
89. heptachlor
90. heptachlor epoxide
91. a-BHC
92. b-BHC
93. c-BHC (lindane)
94. d-BHC
95. PCB-1242(Arochlor 1242)
96. PCB-1254 (Arochlor 1254)
97. toxaphene
98. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

99. 2,4,6-trichlorophenol
100. parachlorometa cresol
101. 2-chlorophenol
102. 2,4-dichlorophenol
103. 2,4-dimethylphenol
104. 2-nitrophenol
105. 4-nitrophenol
106. 2,4-dinitrophenol
107. 4,6-dinitro-o-cresol
108. pentachlorophenol
109. phenol
110. cyanide (Total)
111. asbestos (Fibrous)
112. arsenic (Total)
113. antimony (Total)
114. beryllium (Total)
115. cadmium (Total)
116. chromium (Total)
117. copper (Total)
118. lead (Total)
119. mercury (Total)
120. nickel (Total)
121. selenium (Total)
122. silver (Total)
123. thallium (Total)
124. zinc (Total)

Table A-1. Itemization of Volatile Priority Pollutants

chloromethane	dichlorodifluoromethane
bromomethane	vinyl chloride
chloroethane	methylene chloride
trichlorofluoromethane	1,1-dichloroethylene
bromochloromethane (IS)	1,1-dichloroethane
trans-1,2-dichloroethylene	chloroform
1,2-dichloroethane	1,1,1-trichloroethane
carbon tetrachloride	bromodichloromethane
bis-chloromethyl ether (d)	1,2-dichloropropane
trans-1,3-dichloropropene	trichloroethylene
dibromochloromethane	cis-1,3-dichloropropene
1,1,2-trichloroethane	benzene
2-chloroethylvinyl ether	2-bromo-1-chloropropane (IS)
bromoform	1,1,2,2-tetrachloroethene
1,1,2,2-tetrachloroethane	1,4-dichlorobutane (IS)
toluene	chlorobenzene
ethylbenzene	acrolein
acrylonitrile	

Table A-2. Base Neutral Extractables.

1,3-dichlorobenzene	1,4-dichlorobenzene
hexachloroethane	1,2-dichlorobenzene
bis(2-chloroisopropyl) ether	hexachlorobutadiene
1,2,4-trichlorobenzene	naphthalene
bis(2-chloroethyl) ether	hexachlorocyclopentadiene
nitrobenzene	bis(2-chloroethoxy) methane
2-chloronaphthalene	acenaphthylene
acenaphthene	isophorone
fluorene	2,6-dinitrotoluene
1,2-diphenylhydrazine	2,4-dinitrotoluene
N-nitrosodiphenylamine	hexachlorobenzene
4-bromophenyl phenyl ether	phenanthrene
anthracene	dimethylphthalate
diethylphthalate	fluoranthene
pyrene	di-n-butylphthalate
benzidine	butyl benzylphthalate
chrysene	bis(2-ethylhexyl)phthalate
benzo(a)anthracene	benzo(b)fluoranthene
benzo(k)fluoranthene	benzo(a)pyrene
indeno(1,2,3-cd)pyrene	dibenzo(a,h)anthracene
benzo(g h i)perylene	N-nitrosodimethylamine
N-nitrosodi-n-propylamine	4-chloro-phenyl phenyl ether
endrin aldehyde	3,3'-dichlorobenzidine
2,3,7,8-tetrachlorodibenzo-p-dioxin	bis(chloromethyl) ether

Table A-3. Acidic Extractables.

2-chlorophenol
phenol
2,4-dichlorophenol
2-nitrophenol
p-chloro-m-cresol
2,4,6-trichlorophenol
2,4-dimethylphenol
2,4-dinitrophenol
4,6-dinitro-o-cresol
4-nitrophenol
pentachlorophenol

Table A-4. Pesticides and PCB's.

-endosulfan
-BHC
-BHC
-BHC
aldrin
heptachlor
heptachlor epoxide
-endosulfan
dieldrin
4,4'-DDE
4,4'-DDD
4,4'-DDT
endrin
endosulfan sulfate
-BHC
chlordane
toxaphene
PCB-1242
PCB-1254

APPENDIX B

ANALYTICAL METHODS AND EXPERIMENTAL PROCEDURE

Introduction

This appendix describes the analytical methods employed in the screening and verification analyses of priority pollutants in the waste streams of the timber products processing industry.

Since the timber industry was the first industry selected for BAT review, extensive method development was necessary during the screening phase of the project. A concerted effort was made to follow the first draft protocol issued by EPA's Environmental Monitoring and Support Laboratory (EMSL) in Cincinnati. This first draft protocol outlines a method of experimental procedure used to analyze priority pollutants in industrial wastewater at part per billion (ppb) levels. Analysis at these levels is complicated by the existence of gross interference of all types many times more concentrated than the parameter of interest. This dictates that the method must be very selective for the pollutant of interest.

Priority pollutant parameters may be divided into the following classes: organic priority pollutants; cyanide; and metals. The organic class includes volatiles (purgeable), semivolatiles (extractable), pesticides and PCB's, and phenols. Traditional parameters (BOD, COD, TOC, TSS, oil and grease, and total phenols) were analyzed during the verification phase only.

Organic Priority Pollutants

Organic priority pollutants were divided into three groups as follows:

- Volatile Organic Analysis (VOA)
- Semivolatile Organic including
  - a) Base-neutral extractable (BN)
  - b) Acidic extractable (ACID)
- Pesticides and PCB's

The volatile division was based on whether a compound could be purged from water at room temperature with a dry stream of nitrogen. The semivolatiles were those compounds which could be extracted from basic solution (pH 12) referred to as base-neutral, and those which were extracted from acidic solution (pH 1) referred to as acidic. The primary method of analysis of volatile and semivolatile parameters was gas chromatography--mass spectroscopy (GCMS).

Pesticides were treated as a separate class of compounds and analyzed by gas chromatography equipped with an electron capture detector (GCEC).

Phenols were also treated as a special case in the screening analysis. They were not analyzed in the acidic portion of the semivolatile but as a separate analysis using gas chromatography--flame ionization detector (GC-FID). The rationale and procedure will be discussed later.

Volatile Organic Priority Pollutants

The analysis technique employed for VOA's was based on the Bellar-Lichtenberg method in which water is purged with an inert gas to vaporize the volatile components. The components are then trapped on an appropriate medium and flashed onto the GCMS column for analysis. A detailed literature reference is included in the protocol.

The reference uses only GC for analysis since the method is for drinking water. However, the wastewater samples from the timber industry have sufficient interferences that GCMS is required. The screening samples were analyzed using full scan spectra for identification and total ion current peak area for quantitation.

The verification analyses were performed by the use of selected ion monitoring which produced both qualitative and quantitative results. A list of the compounds analyzed as VOA are presented in Table A-1.

Standards were prepared by injecting ul quantities of neat liquids into a known amount of distilled water. The concentration was calculated by the weight difference before and after the injection. Dilutions of this solution were made for working standards. Five-milliliter aliquots of these standards were transferred to the purging device and purged with nitrogen at 40 ul/min for 12 minutes onto a Tenax-4C trap of 18 cm in length and 0.3 cm outside diameter. The trap was immediately flashed into the GCMS.

The samples were prepared by placing one five-millimeter aliquot per sample hyprovial into the purge device and following the same procedure as for the standard. If there was a foaming problem, glass wool was employed to protect the tenax trap.

The following criteria were used for confirmation of parameters in the screening analysis. The peak must elute at the same time as the standard and the full spectra must match that of the standard for the compound to be identified as present. The criteria varied somewhat for the verification analysis in that the coelution of selected mass ions on extracted ion plot was required. If these ions and the total ion current peak eluted at the same time as the standard, with the same relative intensity, the compound was identified as being present. The EPA protocol was followed explicitly for the identification and quantitation of the parameter. Also, all instrumental parameters were exactly as listed in the EPA protocol.

Table A-1. Itemization of Volatile Priority Pollutants

chloromethane	dichlorodifluoromethane
bromomethane	vinyl chloride
chloroethane	methylene chloride
trichlorofluoromethane	1,1-dichloroethylene
bromochloromethane (IS)	1,1-dichloroethane
trans-1,2-dichloroethylene	chloroform
1,2-dichloroethane	1,1,1-trichloroethane
carbon tetrachloride	bromodichloromethane
bis-chloromethyl ether (d)	1,2-dichloropropane
trans-1,3-dichloropropene	trichloroethylene
dibromochloromethane	cis-1,3-dichloropropene
1,1,2-trichloroethane	benzene
2-chloroethylvinyl ether	2-bromo-1-chloropropane (IS)
bromoform	1,1,2,2-tetrachloroethene
1,1,2,2-tetrachloroethane	1,4-dichlorobutane (IS)
toluene	chlorobenzene
ethylbenzene	acrolein
acrylonitrile	

Semivolatile Priority Pollutants

As previously discussed, the semivolatiles were divided into two subclasses by the acidic or basic properties of each parameter. The base-neutral fraction was extracted from water after the pH was adjusted to 12. The solvent used was methylene chloride and there was no clean-up procedure employed. It was presumed that any clean-up procedure would not be universal for all parameters of interest and, therefore, the sample was analyzed with all interferences present.

The method for analysis for all semivolatiles was GCMS. In the screening phase, as for VOA's, the total ion chromatogram and full mass spectra were used for both quantitative and qualitative analysis.

For the verification phase, extracted ion plots were used for both qualitative and quantitative results.

Standards were prepared by dissolving a pure solute into a solvent. Dilutions and composites of these stock solutions were made for working solutions. These solutions were injected on the GCMS column in the same manner as the samples.

A 900 ml aliquot of the sample was adjusted to pH 12 and extracted by methylene chloride using a separatory funnel. Three successive extractions were performed and the organic layers were combined and concentrated in a Kuderna-Darrish concentrater apparatus. The sample was then ready for injection on the GCMS. Table A-2 is a listing of all compounds that are extracted in the base-neutral fraction.

All GCMS parameters are noted in the EPA protocol for the verification analysis. The only change used in the screening procedure was the use of an SP1000 column instead of the SP2250. This is not a significant change since both columns will achieve the separation. A typical total ion current chromatogram is shown in Figure A-1. This figure does not show all of the BN's. The method for identification and quantitation is identical to that used for VOA's.

Variations in procedure between the screening and verification phases for BN's are the same as for VOA's. The acidic fraction of the samples was extracted from the same 900 ml sample as the base-neutral. After the BN was extracted, the sample was adjusted to pH 1 and extracted three successive times with methylene chloride. These extracts were concentrated and injected on the GCMS. Standards were prepared in the same way as for the base-neutral fraction. Table A-3 is a list of the parameters in the acid fraction.

Table A-2. Base Neutral Extractables.

1,3-dichlorobenzene	1,4-dichlorobenzene
hexachloroethane	1,2-dichlorobenzene
bis(2-chloroisopropyl) ether	hexachlorobutadiene
1,2,4-trichlorobenzene	naphthalene
bis(2-chloroethyl) ether	hexachlorocyclopentadiene
nitrobenzene	bis(2-chloroethoxy) methane
2-chloronaphthalene	acenaphthylene
acenaphthene	isophorone
fluorene	2,6-dinitrotoluene
1,2-diphenylhydrazine	2,4-dinitrotoluene
N-nitrosodiphenylamine	hexachlorobenzene
4-bromophenyl phenyl ether	phenanthrene
anthracene	dimethylphthalate
diethylphthalate	fluoranthene
pyrene	di-n-butylphthalate
benzidine	butyl benzylphthalate
chrysene	bis(2-ethylhexyl)phthalate
benzo(a)anthracene	benzo(b)fluoranthene
benzo(k)fluoranthene	benzo(a)pyrene
indeno(1,2,3-cd)pyrene	dibenzo(a,h)anthracene
benzo(g h i)perylene	N-nitrosodimethylamine
N-nitrosodi-n-propylamine	4-chloro-phenyl phenyl ether
endrin aldehyde	3,3'-dichlorobenzidine
2,3,7,8-tetrachlorodibenzo-p-dioxin	bis(chloromethyl) ether

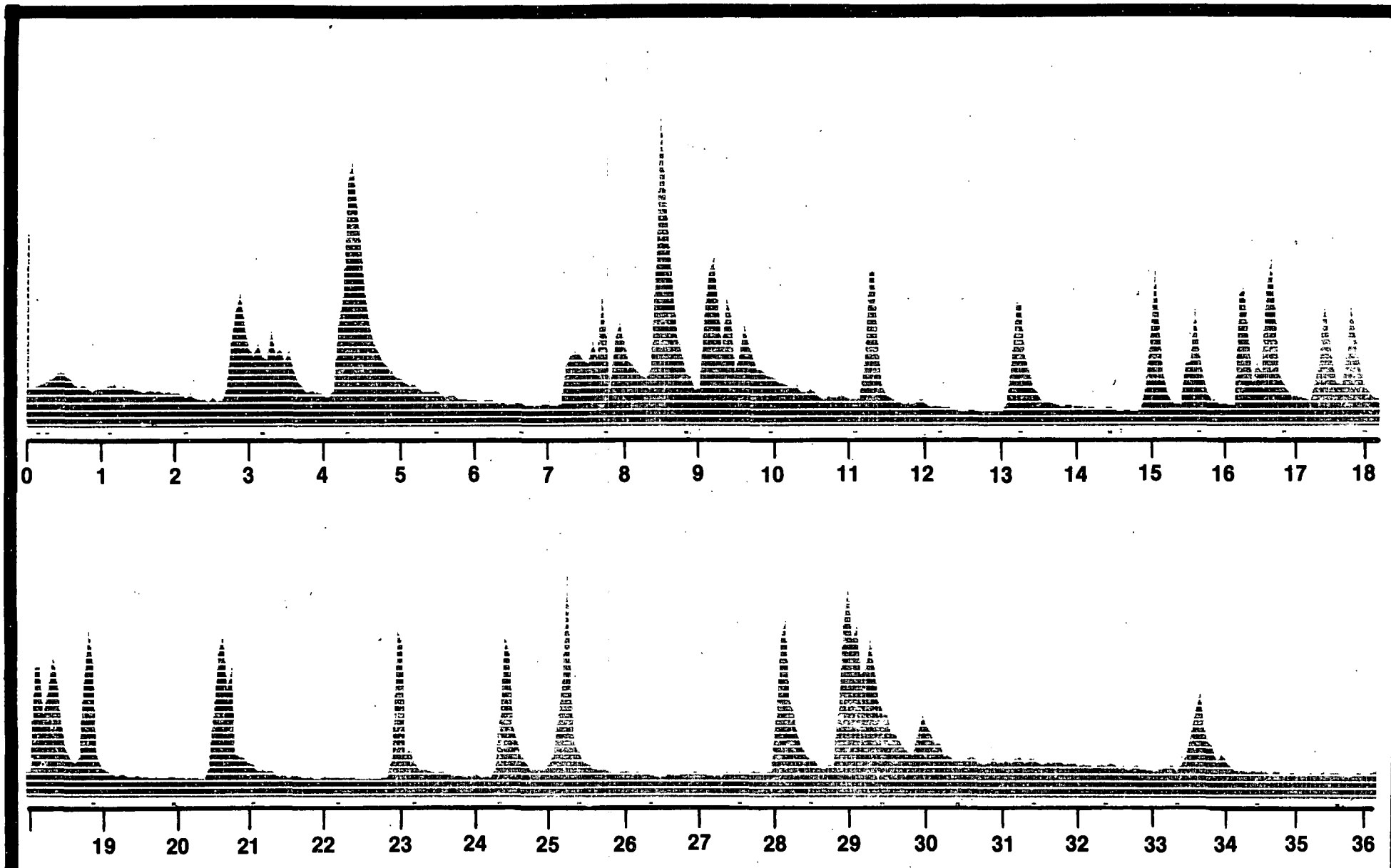

FIGURE B - 1. Base -Neutral Total Ion Current Chromatogram

For the verification analysis the EPA protocol was followed explicitly. It should be noted that there are very few data that would support the extraction influences of the phenols under these stringent conditions. Although the protocol was followed, the data may be deficient due to potential deficiencies in the protocol. These problems were first encountered during screening analysis and an alternative method was chosen from the literature (Ref. Anal. Chem., Vol.47, No. 8, July 1975 , p. 1325). This method involved the collection of a separate sample using copper sulfate and phosphoric acid as preservatives. A standard phenol steam distillation was used followed by an ion exhange separation. The resin used was Amherlst A-26. Acid and acetone was used to elute the phenols from the column. The eluate was then extracted with hexane, concentrated and injected into a GC equipped with a hydrogen flame ionization detector (GC-FIB). The chromatographic conditions were:

Instrument:	Perkin-Elmer 3920
Column:	6' x 1/8", SS, packed with Tenax GC 30/80 meh
Gas:	He 40 ml/min
	H_2 25 psi
	Air 50 psi
Injection:	5 y l

Identification and quantitation was made by traditional GC methods which are able to chromatograph the phenols and do not require such harsh conditions. The recoveries are 75-100 percent for various phenols. This procedure was discussed with EPA before it was adopted. All phenols on Table A-3 are amenable to this procedure. The verification analysis followed the EPA protocol and identification and quantitation were done as previously discussed. Figure A-2 is a typical total ion current chromatogram of the acidic mixed standard by GCMS.

Pesticides and PCB's

Pesticides and PCB's were separated from GCMS analysis since the GCMS detection limit for pesticides is relatively high compared to electron capture. Any concentrations that were sufficiently high, however, were confirmed on GCMS. Polychlorinated biphenyls also are extracted with the pesticides and may be analyzed in conjunction with pesticides. PCB's, however, were analyzed by GCMS for the verification phase. The procedure is well known and is outlined in the EPA protocol. Table A-4 is a list of the pesticides of interest as priority pollutants. In the screening phase some of these were not analyzed specifically since standards were difficult to obtain from the literature and a search was conducted for those pesticides. Figure 3 is a typical GCED chromatogram of a pesticide standard.

Table A-3. Acidic Extractables.

2-chlorophenol
phenol
2,4-dichlorophenol
2-nitrophenol
p-chloro-m-cresol
2,4,6-trichlorophenol
2,4-dimethylphenol
2,4-dinitrophenol
4,6-dinitro-o-cresol
4-nitrophenol
pentachlorophenol

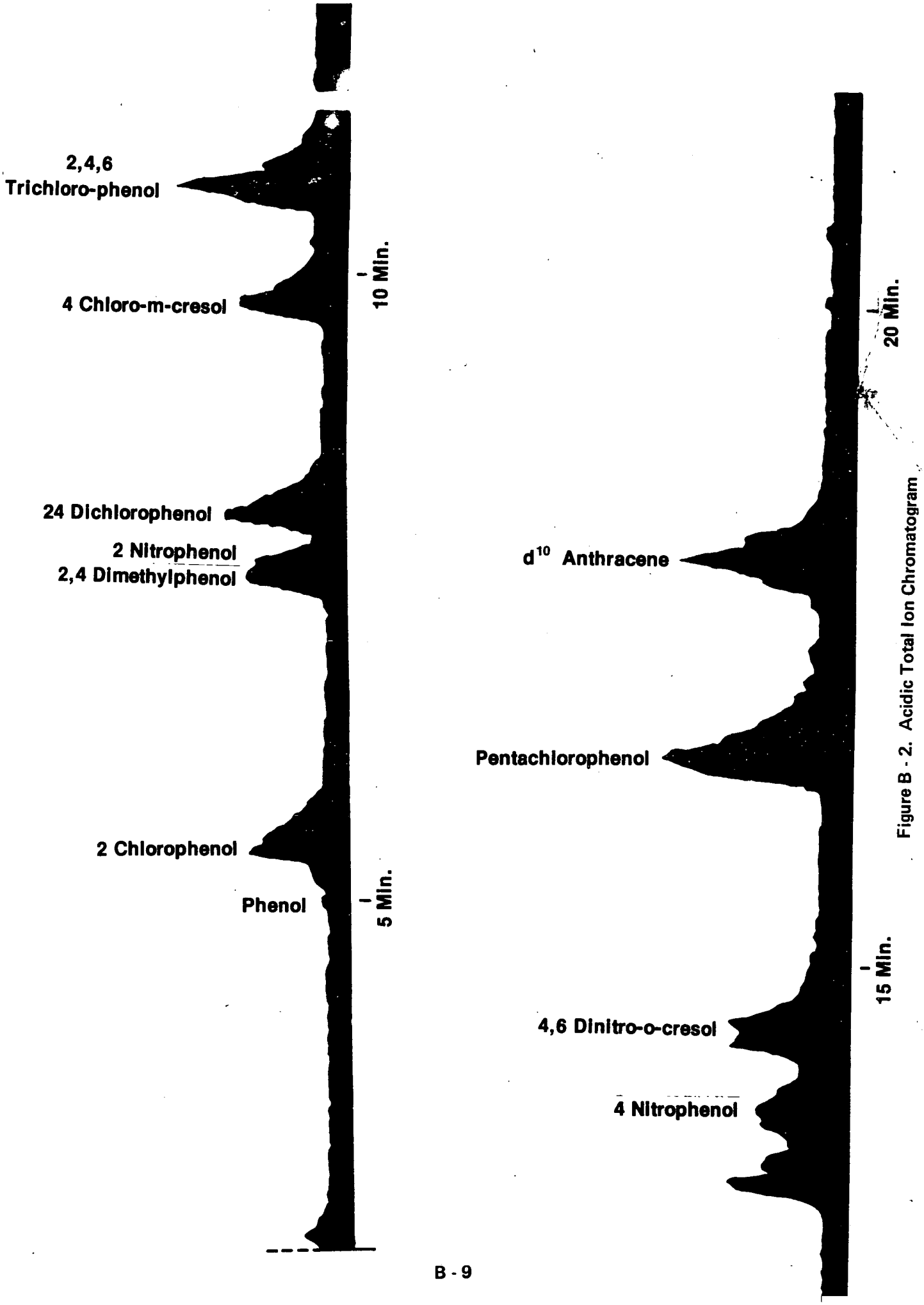

Figure B - 2. Acidic Total Ion Chromatogram

Table A-4. Pesticides and PCB's.

-endosulfan
-BHC
-BHC
-BHC
aldrin
heptachlor
heptachlor epoxide
-endosulfan
dieldrin
4,4'-DDE
4,4'-DDD
4,4'-DDT
endrin
endosulfan sulfate
-BHC
chlordane
toxaphene
PCB-1242
PCB-1254

Cyanide

The protocol method for cyanide was taken from "Methods of Chemical Analysis of Water and Waste" (1974). This method entailed a steam distillation of hydrogen cyanide from a strongly acidic solution. The gas was then absorbed in a solution of sodium hydroxide. The color was developed by addition of pyridine-pyrazolone solution. Quantitation was accomplished by use of a standard curve calculation.

Metals Analysis

Metals analyzed consisted of the following:

- Beryllium
- Cadmium
- Chromium
- Copper
- Nickel
- Lead
- Zinc
- Silver
- Arsenic
- Antimony
- Selenium
- Thallium
- Mercury

Metal analyses for screening, with the exception of mercury, was done by the Chicago EPA laboratory using Inductively Coupled Argon Plasma analysis. Mercury was collected as a separate sample in a 500 ml glass container with nitric acid as a preservative. The analysis was done by standard cold vapor techniques using a calibration curve calculation for quantitation. Verification analysis for metals was done by another EPA contractor and the EPA protocol methods were followed. Quantitation was accomplished by a calibration curve calculation. In summary, the sample and standards were digested in an acid media then either aspirated into the flame of an atomic absorption spectrometer or placed in the light path of a flameless atomic absorption spectrometer. The absorption is directly related to the concentration in the sample.

Traditional or Classical Parameters

The traditional parameters of interest were:

- BOD
- COD
- TSS
- TOC
- Oil and Grease
- Total Phenol

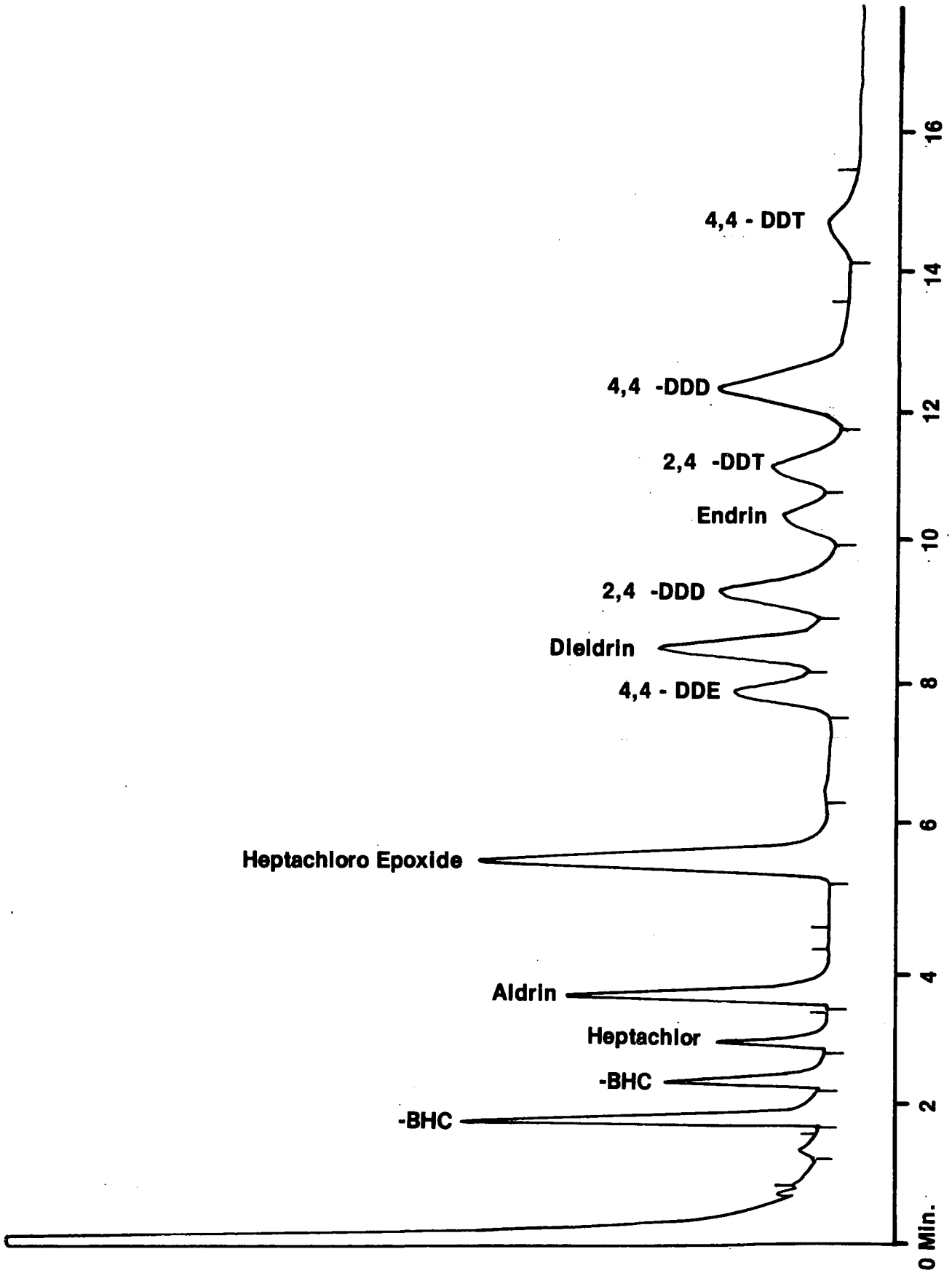

Figure B - 3. Pesticide Mixed Standard

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 per kilogram
cubic feet per minute	cfm	0.028	cu m/min	cubic meters per minute
cubic feet per second	cfs	1.7	cu m/min	cubic meters per 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 Farenheit	°F	0.555(°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liter
gallon per minute	gpm	0.0631	l/sec	liters per second
gallon per ton	gal/ton	4.173	l/kkg	liters per metric ton
horsepower	hp	0.7457	kw	kilowatts
inches	in	2.54	cm	centimeters
pounds per square inch	psi	0.06803	atm	atmospheres (absolute)

Actual conversion, not a multiplier

CONVERSION TABLE

Multiply (English Units)		by	To Obtain (Metric Units)	
English Unit	Abbreviation	Conversion	Abbreviation	Metric Unit
million gallons per day	MGD	3.785	cu m/day	cubic meters per day
pounds per square inch (gauge)	psi	(0.06805 psi + 1)*	atm	atmospheres
pounds	lb	0.454	kg	kilograms
board feet	b.f.	0.0023	cu m, m^3	cubic meters
ton	ton	0.907	kkg	metric ton
mile	mi	1.609	km	kilometer
square feet	ft^2	0.0929	m^2	square meters

* Actual conversion, not a multiplier