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Pharmaceutical Manufacturing

Point Source Category

CONTRACTOR'S ENGINEERING REPORT FOR THE DEVELOPMENT OF EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS FOR THE PHARMACEUTICAL MANUFACTURING INDUSTRY POINT SOURCE CATEGORY

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SECTION I

EXECUTIVE SUMMARY

This document presents the technical data base to support effluent limitations guidelines for the pharmaceutical manufacturing point source category. The technologies to achieve these limitations are defined as best available technology economically achievable (BAT), best conventional pollutant control technology (BCT), and best available demonstrated technology (BADT). Sections III through VII of this document describe in detail the technical data and engineering analyses used to develop these technology options for the pharmaceutical manufacturing industry. A chart summarizing the overall technical effort is presented in Figure I-1.

The rationales by which the Agency selected the technology options for each of the proposed effluent limitations guidelines are presented in Sections VIII through XI. Effluent limitations guidelines based on the application of BAT and BCT are to be achieved by direct dischargers by July 1, 1984. New source performance standards (NSPS), based on BADT, are to be achieved by new facilities. Pretreatment standards for both existing sources (PSES) and new sources (PSNS), based on the application of BAT for those pollutants which are incompatible with or not susceptible to treatment in a POTW, are to be achieved by indirect dischargers. These effluent limitations guidelines and standards are required by Sections 301, 304, and 307 of the Clean Water Act of 1977 (P.L. 95-217).

[Note: The technical content of this report was prepared by Burns and Roe Industrial Services Corp. (BRISC) under contract to EPA. This revised issue was completed by BRISC under subcontract to Walk, Haydel and Associates, Inc. who contributed limited technical input and some editorial comments.]

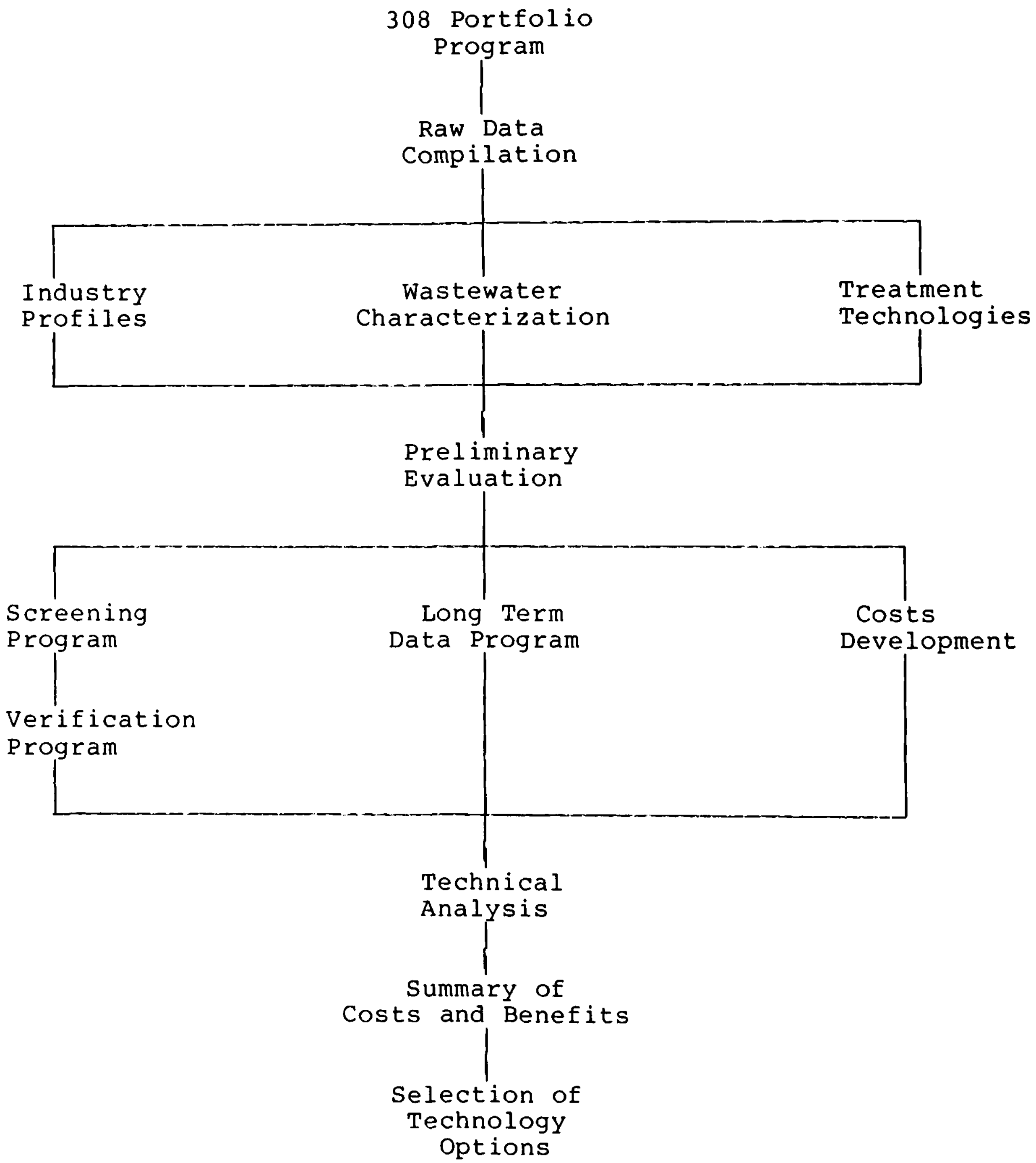
[Note: The remaining text, discussing the proposal of specific effluent limitations, is reserved for EPA.]

** In this report ug is equivalent to μg **

FIGURE I-1

PHARMACEUTICAL INDUSTRY

SUMMARY OF THE OVERALL TECHNICAL EFFORT



SECTION II

INTRODUCTION

PURPOSE AND AUTHORITY

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters," Section 101(a). By July 1, 1977, existing industrial dischargers were required to achieve "effluent limitations requiring the application of the best practicable control technology currently available" ("BPT"), Section 301(b)(1)(A); and by July 1, 1983, these dischargers were required to achieve "effluent limitations requiring the application of the best available technology economically achievable . . . . which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants" ("BAT"), Section 301(b)(2)(A). New industrial direct dischargers were required to comply with Section 306 new source performance standards ("NSPS"), based on best available demonstrated technology; and new and existing dischargers to publicly owned treatment works ("POTW's") were subject to pretreatment standards under Sections 307(b) and (c) of the Act. While the requirements for direct dischargers were to be incorporated into National Pollutant Discharge Elimination System (NPDES) permits issued under Section 402 of the Act, pretreatment standards were made enforceable directly against dischargers to POTW's (indirect dischargers).

Although section 402(a)(1) of the 1972 Act authorized the setting of requirements for direct dischargers on a case-by-case basis, Congress intended that, for the most part, control requirements would be based on regulations promulgated by the Administrator of EPA. Section 304(b) of the Act required the Administrator to promulgate regulatory guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of BPT and BAT. Moreover, Sections 304(c) and 306 of the Act required promulgation of regulations for NSPS, and Sections 304(f), 307(b), and 307(c) required promulgation of regulations for pretreatment standards. In addition to these regulations for designated industry categories, Section 307(a) of the Act required the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants. Finally, Section 501(a) of the Act authorized the Administrator to prescribe any additional regulations "necessary to carry out his functions" under the Act.

The EPA was unable to promulgate many of these regulations by the dates contained in the Act. In 1976, EPA was sued by several environmental groups, and in settlement of this lawsuit, EPA and the plaintiffs executed a "Settlement Agreement," which was approved by the Court. This agreement required EPA to develop a program and adhere to a schedule for promulgating, for 21 major industries, BAT effluent limitations guidelines, pretreatment standards, and new source performance standards for 65 "priority" pollutants and classes of pollutants. See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified March 9, 1979 (40)

On December 27, 1977, the President signed into law the Clean Water Act of 1977. Although this law makes several important changes in the federal water pollution control program, its most significant feature is its incorporation into the Act of several of the basic elements of the Settlement Agreement program for toxic pollution control. Sections 301(b)(2)(A) and 301(b)(2)(C) of the Act now require the achievement by July 1, 1984, of effluent limitations requiring application of BAT for "toxic" pollutants, including the 65 "priority" pollutants and classes of pollutants which Congress declared "toxic" under Section 307(a) of the Act. Likewise, EPA's programs for new source performance standards and pretreatment standards are now aimed principally at toxic pollutant controls. Moreover, to strengthen the toxics control program, Congress added Section 304(e) to the Act, authorizing the Administrator to prescribe "best management practices" ("BMP's") to prevent the release of toxic and hazardous pollutants from plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage associated with, or ancillary to, the manufacturing or treatment process.

In keeping with its emphasis on toxic pollutants, the Clean Water Act of 1977 also revised the control program for non-toxic pollutants. Instead of BAT for "conventional" pollutants identified under Section 304(a)(4) (including biological oxygen demand, suspended solids, fecal coliform, oil and grease, and pH), the new Section 301(b)(2)(E) requires achievement by July 1, 1984, of "effluent limitations requiring the application of the best conventional pollutant control technology" ("BCT"). The factors considered in assessing BCT for an industry include the costs of attaining a reduction in effluents and the effluent reduction benefits derived compared to the costs and effluent reduction benefits from the discharge of publicly owned treatment works (Section 304(b)(4)(B)). For nontoxic, nonconventional pollutants, Sections 301(b)(2)(A) and (b)(2)(F) require achievement of BAT effluent limitations within three years after their establishment or July 1, 1984, whichever is later, but not later than July 1, 1987.

This document presents the technical basis for the Agency's proposed effluent limitations, reflecting the application of BAT, BCT, NSPS, PSES, and PSNS for the pharmaceutical manufacturing point source category.

PRIOR EPA REGULATIONS

On November 17, 1976 the EPA promulgated interim final BPT regulations for the pharmaceutical manufacturing point source category in the Federal Register: 41 CFR 50676, Subparts A-E (27). The technical basis for these regulations was provided in a report, EPA 440/1-75/060, published in December 1976. This report is henceforth referred to as the 1976 Development Document (55).

OVERVIEW OF THE INDUSTRY

The following discussions present a general summary of the pharmaceutical manufacturing industry, including: 1) facilities covered by this study; 2) sources of information used; 3) various profiles of the industry; and 4) descriptions of the types of production processes.

Industry Definition

The Pharmaceutical Manufacturing Point Source Category is defined as those manufacturing plants covered by the following products, processes, and activities:

1. Biological products covered by Standard Industrial Classification Code No. 2831.

2. Medicinal chemicals and botanical products covered by SIC Code No. 2833.

3. Pharmaceutical products covered by SIC Code No. 2834.

4. All fermentation, biological and natural extraction, chemical synthesis, and formulation products which are considered as pharmaceutically active ingredients by the Food and Drug Administration, but which are not covered by SIC Code Nos. 2831, 2833, or 2834. As a possible addition, certain products of these types which are not regarded as pharmaceutically active ingredients may be included if they are manufactured by processes and result in wastewaters which closely correspond to those of a pharmaceutical product. Examples of compounds which fall into this situation are citric acid, benzoic acid, gluconic acid, fumaric acid and caffeine.

5. Cosmetic preparations covered by SIC Code No. 2844 which function as a skin treatment. This would exclude products such as lipsticks, eyeshadows, mascaras, rouges, perfumes and colognes, which serve to enhance appearance or to provide a pleasing odor, but do not provide skin care. In general, this would also exclude deodorants, manicure preparations, and shaving preparations which do not primarily function as a skin treatment.

6. The portion of a product with multiple end uses which is attributable to pharmaceutical manufacturing either as a final

pharmaceutical product, component of a pharmaceutical formulation or a pharmaceutical intermediate. As an alternate, products with pharmaceutical and non-pharmaceutical end uses may be entirely covered by this point source category.

7. Pharmaceutical research which includes biological, microbiological, and chemical research, product development, clinical and pilot plant activities. This includes animal farms at which pharmaceutical research is conducted or at which pharmaceutically active ingredients are tested on the farm animals. This does not include farms which breed, raise and/or hold animals for research at another site and at which no research or product testing takes place. This also does not include ordinary feedlot or farm operations using feed which contains pharmaceutically active ingredients, since the wastewater generated from these operations is probably of a non-pharmaceutical nature.

The following products or activities are specifically excluded from the pharmaceutical manufacturing category:

1. Surgical and medical instruments and apparatus covered by SIC Code No. 3841.

2. Orthopedic, prosthetic, and surgical appliances and supplies covered by SIC Code No. 3842.

3. Dental equipment and supplies covered by SIC Code No. 3843.

4. Medical laboratories covered by SIC Code No. 8071.

5. Dental laboratories covered by SIC Code No. 8072.

6. Outpatient care facilities covered by SIC Code No. 8081.

7. Health and allied services, not elsewhere classified, covered by SIC Code No. 8091.

8. Diagnostic devices not covered by SIC Code No. 3841.

9. Animal feeds which include pharmaceutically active ingredients such as vitamins and antibiotics. The major portion of the product is non-pharmaceutical, and thus the wastewater which results from the manufacture of feed is probably of a non-pharmaceutical nature.

10. Foods and beverages which are fortified with vitamins or other pharmaceutically active ingredients. The major portion of the product is non-pharmaceutical, and thus the wastewater which results from the manufacture of these products is probably of a non-pharmaceutical nature.

Under the regulation established for Best Practicable Control Technology Currently Available (BPT), the Pharmaceutical Manufacturing Point Source Category was grouped into five product or activity areas. This subcategorization was based on distinct differences in manufacturing processes, raw materials, products, and wastewater characteristics and treatability. The five subcategories that were selected are:

1. Subcategory A - Fermentation Products
2. Subcategory B - Biological and Natural Extraction Products
3. Subcategory C - Chemical Synthesis Products
4. Subcategory D - Formulation Products
5. Subcategory E - Pharmaceutical Research

Industry Data Base

EPA used three basic sources in acquiring data to support new regulations for the pharmaceutical manufacturing point source category. These sources include:

1. Data acquired from the industry under Section 308 of the Federal Water Pollution Control Act Amendments of 1972 (PL92-500) and the Clean Water Act of 1977 (PL95-217). This approach included first, the distribution of 308 Portfolios to a representative sample of the industry population and second, wastewater sampling of candidate plants which were selected in accordance with certain criteria, as discussed in Section III.

2. Information acquired through an open literature search. A major portion of this effort has been performed by The Research Corporation of New England (TRC). Some of the important literature sources were: documents prepared by the Pharmaceutical Manufacturers Association (PMA); the Executive Directory of U.S. Pharmaceutical Industry, Third Edition, Chemical Economics Services, Princeton, New Jersey; (51) and the Directory of Chemical Producers - U.S.A., Medicinals, Stanford Research Institute, Menlo Park, California. (50).

3. Data acquired from EPA regional offices, state and other government offices, and pharmaceutical plant visits.

308 Portfolio for Pharmaceutical Manufacturing

The objectives of the 308 Portfolio for Pharmaceutical Manufacturing were as follows:

1. To obtain information for the construction of a comprehensive industry profile.

2. To obtain information on production, wastewater generation, and wastewater treatment at existing facilities to expand the data base for guidelines development.

3. To ascertain industry-specific problems which need to be considered in guidelines development.

4. To develop a list of candidate plants for priority pollutant sampling.

The 308 request was also used in part as a device to obtain input from the industry as to information that they felt would be important in this effort, and as a means to develop individual plant contacts to lay the foundations for future work.

The 308 Portfolio for Pharmaceutical Manufacturing, presented in Appendix A, was developed by EPA and Burns and Roe Industrial Service Corp. (BRISC) in cooperation with the PMA Environmental Task Force during the spring and summer of 1977. During the same period, a distribution mailing list was formulated. Since EPA was concerned about obtaining quality responses from pharmaceutical firms, the 308 Portfolios initially were sent only to PMA member firms and to nonmember plants included in previous EPA guidelines work. This decision was based on the following reasons:

1. PMA members probably had the resources to provide quality responses to the 308 Portfolio.

2. Development and distribution of the 308 Portfolio could in part be assisted and coordinated by the PMA.

3. Many of the essential contacts had already been established with the PMA.

4. The Agency felt that the 308 Portfolio need cover only a statistically representative sample of pharmaceutical plants in the United States. The PMA has members which range from small one-plant firms to firms with as many as 25 plants or firms with several large pharmaceutical manufacturing operations. The PMA members are principally manufacturers of prescription pharmaceuticals, medical devices and diagnostics. However, PMA member firms also produce a significant portion of the over-the-counter drugs on the market. These members account for approximately 90 to 95 percent of the U.S. sales of prescription products and about 50 percent of the total free world's output. These figures include only ethical pharmaceuticals and do not include over-the-counter drugs or proprietary pharmaceuticals (51). For the purposes of the 308 Portfolio the PMA member firms were judged to provide a statistically representative distribution.

The PMA List of Administrative Officers of the Member Firms and Associates, October 1976 Edition, which contains 130 member firms, was used as a basis for the mailing list. Many of the 130 members are subsidiaries or divisions of common member or nonmember parent firms. Table II-1 summarizes the original 308 Portfolio distribution and response. Of the 442 portfolios that were mailed, a total of 431 were returned. One hundred-five of these were from non-pharmaceutical/non-manufacturing plants, while another 50 were duplicates of plants already covered. Also, for the purpose of this study, EPA decided to de-emphasize pharmaceutical research (Subcategory E), since this activity does not fall within the SIC Code Nos. 2831, 2833, and 2834, which were identified in the Consent Decree. Therefore, the 32 plants that had only Subcategory E operations were also segregated from the survey. Thus, a total of 244 pharmaceutical manufacturing plants are presently included in the (original) 308 data base. They are listed in Appendix B.

<u>Supplemental 308 Portfolio</u>

Since August 1977, EPA has identified more than 500 additional facilities that may be part of this industry. The open literature file developed by TRC identified a total of 990 pharmaceutical sites in the United States. The data file was reviewed by BRISC and PEDCo, an EPA contractor with process design and construction experience in the pharmaceutical industry. This led to a revised listing of more than 500 plant sites of approximately 400 companies which were not included in the original 308 Portfolio distribution, but which are possible producers of pharmaceutical active ingredients.

Although EPA knew that this segment of the industry (principally comprised of non-PMA member companies) accounts for only a small fraction of sales (5-10 percent), the total wastewater volume was unknown. The Agency also expected that these plants are small producers, upon which BAT regulations could have a major impact. In an effort to define the entire pharmaceutical population, obtain a more complete profile of the industry, and confirm the assertion that the PMA member firms included in the initial survey do indeed statistically represent the industry, a Supplemental 308 Portfolio for Pharmaceutical Manufacturing was developed during the fall of 1978. This survey, presented in Appendix C, is an abbreviated form of the original 308 Portfolio, and was distributed to 540 possible pharmaceutical sites in April 1979. Table II-1 presents a summary of the Supplemental 308 Portfolio distribution program. Of the 540 supplemental portfolios, 355 were returned. After accounting for the 128 non-pharmaceutical/non-manufacturing plants, 4 duplicate portfolios, and 3 Subcategory E only plants, 220 plants were identified as pharmaceutical manufacturers. They are listed in Appendix D.

The end result of the two questionnaire mailings was a comprehensive pharmaceutical industry data base containing 464 manufacturing plants. Throughout later sections of this report the discussions refer to 308 Portfolio data. Where this occurs, the text and tables are referring to the comprehensive data base of 464 plants.

Industry Profile

The objective of the 308 Portfolios was to obtain information from pharmaceutical manufacturing facilities and develop an industry profile, including plant size, age, location, and production activities. Appendix E lists each of the 464 manufacturing plants contained in the comprehensive EPA data base by plant code number (assigned for identification purposes), applicable manufacturing subcategories, manufacturing employment, and year of operational start-up. Plants with code numbers in the 12000 series are from the original 308 Portfolio survey, while those with 20000 series numbers are from the Supplemental 308 Portfolio survey. Table II-2 shows the geographical distribution of the industry and the number of manufacturing plants by state and EPA region. Also shown are the average number of manufacturing employees per plant and average plant start-up year. (In some instances the data were not broken down by state to avoid the possibility of disclosing individual plant data). The geographical distribution of the industry is also displayed in Figure II-1.

As can be seen in Table II-2, most of the pharmaceutical industry is located in the eastern half of the United States. Of the 464 manufacturing plants in the comprehensive data base, almost 80 percent are in the East. A closer examination shows that New Jersey, with about 16 percent, and Region II, with approximately 36 percent, are the largest pharmaceutical manufacturing state and EPA region, respectively. Considering plant age, the data show that Regions II, III, V, and VII (the Northeast and Midwest) have generally older plants than Regions IV, VI, VIII, and IX (the South and West). This is due to the recent trend to locate plants in the "Sunbelt" of the United States. An important point is that Puerto Rico has close to 10 percent of the industry. Data from the 308 Portfolio survey support other available information that indicates that Puerto Rico is becoming a major pharmaceutical manufacturing center.

Table II-3 breaks down the industry by manufacturing subcategory. The top portion lists the various subcategory combinations and the number of plants in each, whereas the bottom portion shows the total number of plants having each of the individual manufacturing subcategories. Subcategory D, the formulating/mixing/compounding subcategory, is by far the most numerically prevalent pharmaceutical manufacturing operation with 80 percent of the industry engaged in this activity. Breaking this down further, it can be seen that most of the plants have operations in only Subcategory D, while the remainder also have Subcategory A, B, and/or C operations in addition to Subcategory D.

Table II-4 summarizes the total number of batch, continuous, and semi-continuous manufacturing operations by subcategory for the entire pharmaceutical industry. This information shows that batch-type production is by far the most common type of manufacturing technique for each of the four subcategories.

Production Processes

The wastewater characteristics of this industry are directly related to the production processes used. Therefore, a review of the pharmaceutical operations will be informative in evaluating alternatives for effluent limitations. The following discussions present this information by the production subcategories developed for the BPT guidelines.

Fermentation

Fermentation is an important production process in pharmaceutical manufacturing. This is the basic method used for producing most antibiotics and steroids. The fermentation process involves three basic steps: inoculum and seed preparation, fermentation, and product recovery.

Production of a fermentation pharmaceutical begins with spores from the plant master stock. The spores are activated with water, nutrients and warmth, and then propagated through the use of agar plates, test tubes, and flasks until enough mass is produced for transfer to the seed tank. In less critical fermentations, a single seed tank may serve several fermenters. In these instances, the seed tank may be sterilized and inoculated only when contamination occurs. In this type of operation, the seed tank may never be completely emptied, such that the seed remaining serves as the inoculum for the next seed batch.

Fermentation normally is a batch process, although most large operations are highly automated requiring few operators. At the end of each batch cycle, the broth is discharged, and the fermenter is washed down with water and sterilized with live steam. Raw materials, which have also been sterilized, are then charged into the vessel. When optimum conditions are met, the microorganisms in the seed tank are then charged into the fermenter, and fermentation begins.

The discharging of a batch constitutes the most significant waste stream from this process, and is normally referred to as spent beers. Spent beers contain a large amount of organic material, protein, and other nutrients. In fungi processes, the broth is filtered to remove the mycelia (remains of the microorganisms) before product recovery. The mycelia is a solid waste material which is almost one-third protein. After a fermentation cycle from 12 hours to one week, depending on the process, the broth is ready to be filtered and held for product recovery. There are three common methods of product recovery: solvent extraction, direct precipitation, and ion exchange or adsorption.

Solvent extraction is a recovery process whereby an organic solvent is used to remove the pharmaceutical product from the aqueous broth and form a more concentrated, smaller volume solution. Also, by virtue of its removal from the fermentation beers, with subsequent extractions, the product is separated from any contaminants. Following the solvent extraction step, further removal of the product from the solvent can be by either precipitation, distillation, or further extraction processes. Normally, solvents used for product recovery are recovered and reused. However, small portions left in the aqueous phase during the solvent "cut" can appear in the plant's wastewater stream. From the published literature (42), the typical processing solvents used in fermentation operations were identified as: benzene; chloroform; 1,1 dichloroethylene; and 1,2 trans-dichloroethylene.

Direct precipitation consists of first precipitating the product from the aqueous broth, filtering the broth, then extracting the product from the solid residues. Particular priority pollutants identified by the literature (42) and known to be used in the precipitation process are copper and zinc.

Ion exchange or adsorption involves the removal of the product from the broth using a solid material, either ion exchange resin, adsorptive resin or activated carbon. The product is recovered from the solid phase with the use of a solvent and then recovered from the solvent.

Disinfectants used to clean fermentation equipment can contribute to the pollutant load from fermentation processes. Although steam is used to sterilize most equipment, many instruments cannot withstand these high temperatures. Although there is no published information indicating the disinfecting agents that are used, a number of priority pollutants, such as phenol, can be used for this purpose.

Sometimes a fermentation batch can become infested with a phage, a virus that attacks microorganisms. Although phage infestations are rare in a well-operated plant, when they do occur they bring about very large wastewater discharges in short periods of time. Usually these batches are discharged early and may be higher in nutrient pollutant concentration than spent broth.

Another fermentation wastewater source is the control equipment that is sometimes installed to clean waste fermentation off-gas. The air and gas vented from the fermenters usually contain odiferous substances and large quantities of carbon dioxide. Treatment is often necessary to deodorize the gas before its release to the atmosphere. Although some plants employ incineration methods, others use liquid scrubbers. The blowdown from these scrubbers may contain absorption chemicals, light soluble organic compounds, and heavier insoluble organic oils and waxes. Wastewater from this source is unlikely to contain priority pollutants, however.

As noted above, the sources of wastewater from fermentation operations are: (1) spent fermentation beers; (2) floor and equipment wash waters; (3) chemical wastes, such as spent solvents from the extraction processes; and (4) barometric condenser water. Of these, the spent fermentation beer is by far the most significant waste discharge.

The pollution contribution of the spent beer arises from the fact that it contains substantial food materials, such as sugars, starches, protein, nitrogen, phosphate, and other nutrients. Methods for treating the fermentation wastes are generally biological in nature. Although the spent beers, even in a highly concentrated form, can be satisfactorily handled by biological treatment systems, it is much better and less likely to upset the system if the wastes are first diluted to some degree. Dilution normally results from the equalization of fermentation wastes with the other waste streams. As a result, a satisfactory biological reduction of the contaminants can be achieved.

There was not a great deal of pollutant information for the fermentation operations in the current 308 pharmaceutical data base. However, from that which was available, a preliminary analysis could be performed. Generally speaking, wastewaters from fermentation operations are characterized by high BOD, COD, and TSS concentrations, large flows, and a pH range of about 4.0 to 8.0.

Biological and Natural Extraction

Many materials used as pharmaceuticals are derived from the extraction from natural sources. These sources include the roots and leaves of plants, animal glands, and parasitic fungi, such as ergot. These products have numerous pharmaceutical applications, calling for diverse physiological activity, from tranquilizers and allergy relief medications to insulin and morphine.

Included in this process grouping is blood fractionation, which involves the production of plasma and its derivatives.

Despite their diversity, all extractive pharmaceuticals have a common characteristic. They are too complex to synthesize commercially. They are either very large molecules, or they are optically active in which only one of several stereoisomers has pharmacological value. However, extraction is still an expensive manufacturing process since it requires the collection and processing of very large volumes of specialized plant or animal matter to produce very small quantities of products.

The process of extracting pharmaceutical substances has been developed to handle such a low ratio of product weight to raw material weight. In fact, in comparison with the amount of raw material brought into an extraction facility, the amount of product is negligible.

The extraction process consists of a series of operating steps in which, following almost every step, a significant reduction in the volume of material being handled occurs. In some processes, the reductions may be in orders of magnitude, and the complex final purification operations may be conducted on quantities of materials only a few thousandths of the material handled in earlier steps. Therefore, neither continuous processing methods nor conventional batch methods are suitable for extraction processing. Instead, a unique processing method has been developed which can be described as assembly-line small scale batch. Material is transported in portable containers through the plant in batches of 75 to 100 gallons. A continuous line of these containers is sent past a series of operating stations. At each station, operators perform specific tasks on each batch in turn. As the volume of material being handled decreases, individual batches are continually combined to maintain reasonable operating volumes, and the line moves more slowly. When the volume is reduced to very small quantity, the containers used also become smaller, with laboratory size equipment used in many cases.

An extractive plant may produce one product for a few weeks, then simply by changing the logistical movement of pots and redefining the tasks to be conducted at each station, a plant can convert quickly to the manufacture of a different product.

Wastes from an extraction plant will be essentially equal to the weight of raw material. Solid wastes will represent the largest pollutant load; however, solvents used in the processing steps will cause both air and water emissions. When solvents are used on the assembly line, power ventilation systems are required, causing atmospheric emissions.

The nature of the products of the pharmaceutical industry dictates that any manufacturing facility be maintained at a standard of cleanliness that is higher than most industrial operations. Most of these plants are cleaned frequently, and detergents and disinfectants will be a normal constituent in the wastewater.

As in the fermentation process, a small number of priority pollutants were identified by the published literature (41), as being used in the manufacturing of extractive pharmaceuticals. Metallic ions, such a lead and zinc, are known to be used as precipitating chemicals. Phenol was identified as an equipment sterlizing chemical, as well as an active ingredient. Otherwise, the literature noted that priority pollutants are found to be used only as processing solvents. Some which were identified as solvents were: benzene; 1,2 dichloroethane; and chloroform.

Solvents are used in two ways in extraction operations. From both plant and animal sources, fats and oils often are removed which would otherwise contaminate the products. These "defatting" extractions use an organic liquid to dissolve the fat while not dissolving the product material. Solvents are also used to extract the product itself. Plant alkaloids, when treated with an alkali, become soluble in selected organic solvents such as benzene, chloroform, or 1,2 dichloroethane.

Ammonia is used in many extraction operations. It is necessary to regulate the pH of water solutions from both animal and plant sources to achieve separation of valuable components from waste materials. Ammonium salts are used as buffering chemicals and aqueous or anhydrous ammonia is used as an alkalizing reagent. The high degree of water solubility of ammonium salts prevents unwanted precipitation of salt, and ammonia does not react chemically with animal or plant tissue. Other basic materials, such as hydroxides and carbonates of alkali metals, do not have these advantages.

The principal sources of wastewater from biological/natural extraction operations are: (1) spent raw materals, such as waste plasma fractions, spent eggs, spent media broth, plant residues, etc.; (2) floor and equipment washwaters; (3) chemical wastes, such as spent solvents; and (4) spills.

In general, the bulk of the spent raw materials is collected and sent to an incinerator or landfill. Likewise, the spent solvents are recovered with the non-recoverable portions being incinerated or landfilled. However, in both cases, portions of the subject materials find their way into a plant's wastewater. Also, floor and equipment washings and spills contribute to the ordinary waste discharge.

Although pollutant information for the biological/natural extraction operations in the pharmaceutical data base was minimal, that which was available lent itself to a preliminary analysis. Generally, wastewaters from biological/natural extraction processes are characterized by low BOD, COD and TSS concentrations, small flows, and pH values of approximately 6.0 to 8.0.

Chemical Synthesis

Most of the compounds used as drugs today are prepared by chemical synthesis, generally by a batch process. The basic equipment item is the conventional batch reaction vessel, which is one of the most standardized equipment designs in industry.

Generally, the vessel is equipped with a motor-driven agitator and an internal baffle and is made of either stainless steel or glass-lined carbon steel and contains a carbon steel outer shell suitable for either cooling water or steam. Vessels of this type are made in many different sizes, with capacities ranging from 0.02 to 11.0 m^3 or more.

The basic vessels may be fitted with many different attachments. Baffles usually contain temperature sensors to measure the temperature of the reactor contents. An entire reactor may be mounted on load cells to accurately weigh the reactor contents. Dip tubes are available to introduce reagents into the vessels below the liquid surface. One of the top nozzles may be fitted with a floodlight and another with a glass cover to enable an operator to observe the reactor contents. Agitators may be powered by two-speed motors or by variable-speed motor drives. Typically, batch reactors are installed with only the top heads extending above the operating floor of the plant, thereby providing the operator with simplified access for loading and cleaning.

With other suitable accessories, these vessels can be used in many different ways. Solutions can be mixed, boiled, and chilled in them. By addition of reflux condensation, complete reflux operations are possible. By application of a vacuum, they can become vacuum evaporators. Solvent extraction operations can be conducted in them, and by operating the agitator at slow speed, they serve as crystallizers.

Synthetic pharmaceutical manufacture consists of using one or several of these vessels to perform in a step-by-step fashion the various operations necessary to make the product. Following a definite recipe, the operator (or increasingly, a programmed computer) adds reagents, increases or decreases the flow rate of cooling water, chilled water, or steam, and starts and stops pumps to transfer the reactor contents into another similar vessel. At the appropriate steps in the process, solutions are pumped through filters or centrifuges, or pumped into solvent recovery headers or into waste sewers.

The vessels, with an assembly of auxiliary equipment, are usually arranged into independent process units; a large pharmaceutical plant may contain many such units. Each unit may be suitable for the manufacture, or partial manufacture, of many different pharmaceutical compounds. Only with the highest volume products is the equipment "dedicated," or modified to be suitable for only one process.

Each pharmaceutical is usually manufactured in a "campaign" in which one or more process units is employed for a few weeks or months to manufacture enough of this compound to satisfy its projected sales demand. Campaigns are usually tightly scheduled, with detailed coordination extending from procurement of raw materials to packaging and labeling of the product. For a variable period of time, therefore, a process unit actively manufactures a specific compound. At the end of this campaign, another is scheduled to follow. The same equipment and operating personnel are used to make a completely different product, utilizing different raw materials, executing a different recipe, and creating different wastes.

The available literature (43) for this subcategory indicated that the synthesized pharmaceuticals industry uses a wide variety of priority pollutants as reaction and purification solvents. Water was reported as being used more often than would be expected in an industry whose products are organic chemicals. However, benzene and toluene were the most widely used organic solvents since they are stable compounds that do not easily take part in chemical reactions. Other similar ring-type compounds such as xylene, cyclohexane, and pyridine were also reported as being used in the manufacture of synthesized pharmaceuticals and unwanted side reactions.

Solvents serve several functions in a chemical synthesis. As noted previously, solvents dissolve gaseous, solid, or viscous reactants to bring all reactants into close molecular proximity. They serve to transmit heat to or from the reacting molecules. By physically separating molecules from each other, they slow down some reactions that would otherwise take place too rapidly, resulting in excessive temperature increases and unwanted side reactions.

Other less obvious characteristics of solvents, however, have a possible environmental significance. One of these is the use of a solvent in the control of reaction temperature. It is common practice in any batch-type synthesis process to select a solvent whose boiling point is the same as the desired reaction temperature. Heat is then applied to the reaction mass at a rate sufficient to keep the mixture continuously boiling. Vapors that rise from the reaction vessel are condensed, and the liquefied solvent is allowed to drain back into the reaction vessel. Such refluxing prevents both overheating and overcooling of the reactor contents, and in addition can automatically compensate for variations in the rate of release or absorption of chemical energy. However, solvent vapor may escape from the reflux condensers, causing an air pollution problem.

Essentially all production plants will operate solvent recovery facilities that purify contaminated solvent for reuse. These facilities usually contain distillation columns and may also include extraction facilities where still another solvent is used to separate impurities. Many of the wastes from the synthetic pharmaceutical industry will be discharged from these solvent recovery facilities. The wastes are normally not wastewaters, but are anhydrous organic compounds withdrawn from the base of a distillation column or as a residue from a solvent extraction operation. Most often they are thick, tarry, dark colored mixtures that are made fluid by discarding also a small amount of the solvent being recovered.

In processes that require completely water-free solvents and reactants, additional losses of solvent usually occur since complete dehydration is difficult.

One other loss of solvent is likely to occur in most plants. Bulk storage is most often in an unpressurized tank that is only partially filled. The level of the liquid in the tank rises and falls as liquid is added to the tank or removed from it. The vapor in the tank above the surface of the liquid is therefore exhausted when the liquid level is rising, and as the level falls, fresh air (or nitrogen from a padding system) is introduced. The tank is said to "breathe," and even if no liquid is added or removed, it continues to breathe as a result of temperature and barometric pressure changes. Each time a tank "exhales," the released vapor is saturated with solvent vapor; rather large quantities of solvent can be lost to the atmosphere through this mechanism. The impact of these atmospheric emissions was studied by EPA and is discussed at the end of this section of the report.

Chemical synthesis operations also produce large quantities of pollutants normally measured as BOD and COD. Wastewater is generally produced with each chemical modification that requires the filling and emptying of the batch reactors. These wastewaters can contain the unreacted raw materials, as well as some solvents.

Compared to the others, the effluent from chemical synthesis operations is the most difficult to treat because of the many types of operations and chemical reactions, such as nitration, amination, halogenation, sulfonation, alkylation, etc. The production steps may generate acids, bases, cyanides, metals, and many other pollutants. In some instances, process solutions and vessel wash waters may also contain residual solvents. Sometimes, this wastewater is incompatible with biological treatment systems. Although it is possible to acclimate the bacteria to the various substances, there may be instances where certain chemical wastes are too concentrated or too toxic to make this feasible. Thus, it may be necessary to equalize and/or chemically pretreat a process wastewater prior to conventional treatment.

Primary sources of wastewater from chemical synthesis operations are: (1) process wastes, such as spent solvents, filtrates, centrates, etc.; (2) floor and equipment wash waters; (3) pump seal waters; (4) wet scrubber spent waters; and (5) spills.

From the available information on chemical synthesis operations in the pharmaceutical data base, wastewaters from these processes can be characterized as having high BOD, COD and TSS concentrations, large flows, and extremely variable pH, ranging from 1.0 to 11.0.

Formulation

Although pharmaceutical active ingredients are produced in bulk form, they must be prepared in dosage form for use by the consumer. Pharmaceutical compounds can be formulated into tablets, capsules, liquids or ointments, as described below.

Tablets are formed by blending the active ingredient, filler, and binder. Tablets are produced from the mixture in a tablet press machine. Some tablets are coated by tumbling with a coating material and drying. The filler (usually starch, sugar, etc.) is required to dilute the active medicinal to the proper concentration, and binder (such as corn syrup or starch) is necessary to bind the tablet particles together. A lubricant, such as magnesium stearate, may be added for proper tablet machine operation. The dust generated during the mixing and tableting operation is collected and is usually recycled directly to the same batch. Broken tablets are generally collected and recycled to the granulation operation in a subsequent lot. After the tablets have been coated and dried, they are bottled and packaged.

Capsules are produced by first forming the hard gelatine shell. These shells are produced by machines that dip rows of rounded metal dowels into a molten gelatine solution and then strip the capsules from the dowels after the capsules have cooled and solidified. Imperfect empty capsules are remelted and reused, if possible, or sold for glue manufacture. Most pharmaceutical companies purchase empty capsules from a few specialist producers.

The active ingredient and any filler are then mixed before being poured by machine into the empty gelatine capsules. The filled capsules are then bottled and packaged. As in the case of tablet production, some dust is generated. This is recycled and small amounts disposed of. Some glass and packaging waste from broken bottles and cartons results from this operation.

Liquid preparations can be formulated for injection or oral use. In either case, the liquid is first weighed and then dissolved in water. Injectable solutions are heat sterilized or bulk sterilized by filtration and then poured into sterilized bottles. Oral liquid preparations are bottled directly without the sterilization steps.

Wastewaters are generated by general cleanup operations, spills, and breakage. Bad batches may create a solid waste disposal problem.

As described above, mixing/compounding/formulation operations' primary objective is to convert the manufactured products into a final, usable form. The necessary production steps have typically small wastewater flows, because very few of the unit operations use water in a way that would cause a wastewater generation. The primary use of water in the actual formulating process is for cooling water in the chilling units and for equipment and floor wash.

Sources of wastewater from mixing/compounding/formulation operations are: (1) floor and equipment wash waters; (2) wet scrubbers; (3) spills; and (4) laboratory wastes. The use of water to clean out mixing tanks can flush materials of unusual quantity and concentration into the plant sewer system. The washouts from recipe kettles, which are used to prepare the master batches of the pharmaceutical compounds, may contain inorganic salts, sugars, syrup, etc. Dust fumes and scrubbers used in connection with building ventilation systems or, more directly, on dust and fume generating equipment, can be another source of wastewater depending on the characteristics of the material being removed from the air stream. In general, these wastewaters are readily treatable by biological treatment systems.

An analysis of the pollutant information in the pharmaceutical data base shows that wastewaters from mixing/compounding/formulations operations normally have low BOD, COD and TSS concentrations, relatively small flows, and pH values of 6.0 to 8.0.

FIGURE II-1
PHARMACEUTICAL INDUSTRY
GEOGRAPHICAL DISTRIBUTION

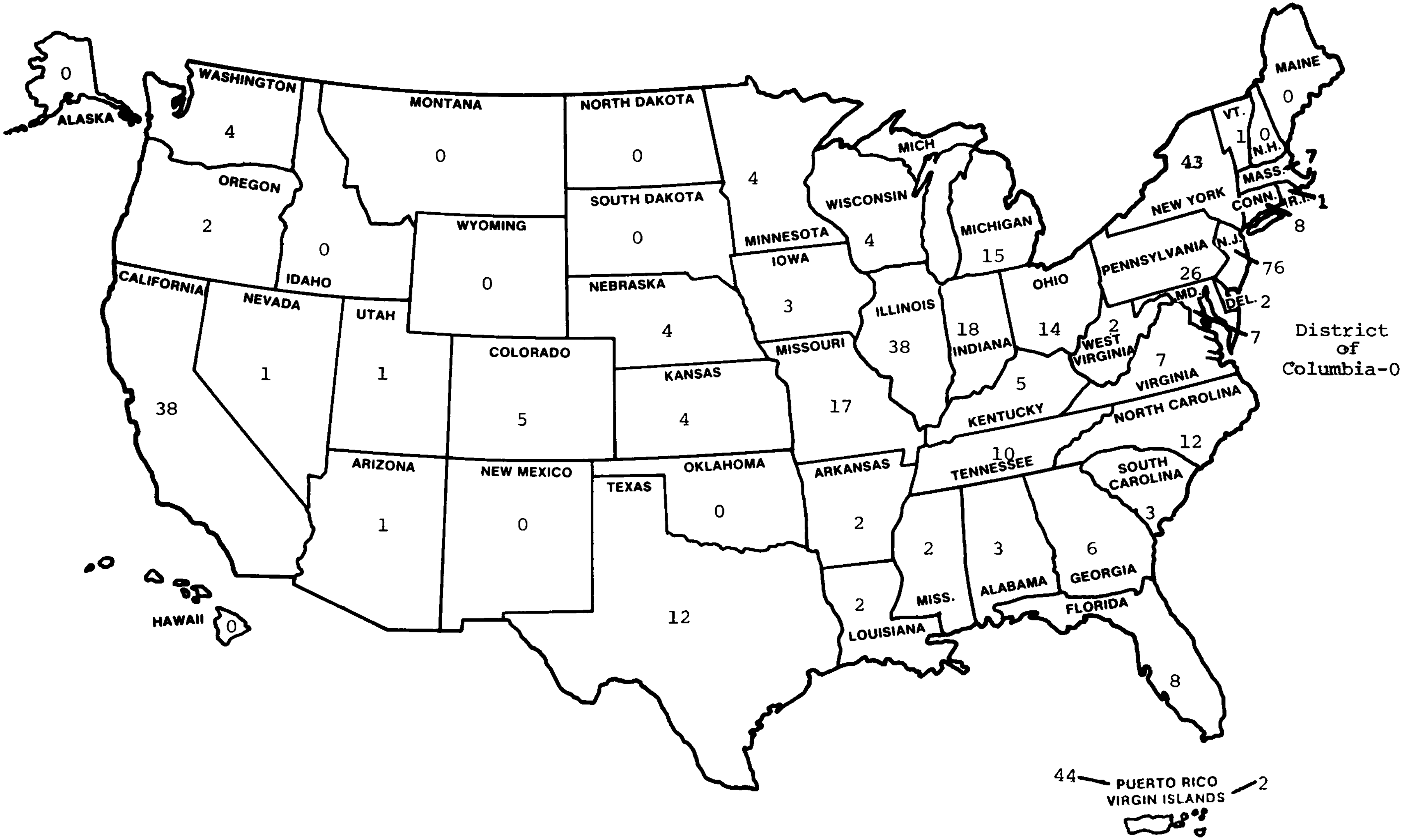


TABLE II-1

PHARMACEUTICAL SUMMARY

SUMMARY OF 308 PORTFOLIO MAILING

	Original 308's	Supplemental 308's	Comprehensive Data Base
Portfolios Distributed:	442	540	982
Plants in the Initial Mailing	396	523	919
"Additional" Plants Included in Survey	46	17	63
Portfolios Not Returned:	-11	-185	-196
Portfolio Processing:	-187	-135	-322
Duplicate Portfolios	-50	-4	-54
Non-Mfg. (Non-Pharm.) Portfolios	-105	-128	-233
Exclusively Research (Subcategory E) Portfolios	-32	-3	-35
Manufacturing Portfolios:	244[a]	220[b]	464

(a) These plants are listed in Appendix B.
(b) These plants are listed in Appendix D.

TABLE II-2

PHARMACEUTICAL INDUSTRY
GEOGRAPHICAL DISTRIBUTION

Location	Number of Plants	Percent of Total Plants	Average Number Employees Per Plant	Average Plant Start-up Year(1)
EASTERN U.S.	368	79.2	268	1952
Connecticut	8	1.7	195	1963
Maine	0	0.0	-	-
Massachusetts	7	1.5	77	1961
New Hampshire	0	0.0	-	-
Rhode Island	1	0.2	(2)	(2)
Vermont	1	0.2	(2)	(2)
REGION 1	17	3.6	161	1960
New Jersey	76	16.4	346	1950
New York	43	9.3	211	1943
Puerto Rico	44	9.5	216	1970
Virgin Islands	2	0.4	13	-
REGION 2	165	35.6	239	1956
Delaware	2	0.4	121	1965
Maryland	7	1.5	65	1938
Pennsylvania	26	5.6	370	1949
Virginia	7	1.5	138	1950
West Virginia	2	0.4	151	-
District of Columbia	0	0.0	-	-
REGION 3	44	9.4	267	1950
Alabama	3	0.6	15	1958
Georgia	6	1.3	189	1956
Florida	8	1.7	95	1967
Mississippi	2	0.4	759	1949
North Carolina	12	2.6	456	1971
South Carolina	3	0.6	87	1968
Tennessee	10	2.2	301	1940
Kentucky	5	1.1	12	-
REGION 4	49	10.5	250	1962
Illinois	38	8.2	305	1951
Indiana	18	3.9	664	1944
Ohio	14	3.0	203	1929
Michigan	15	3.2	423	1933
Wisconsin	4	0.9	54	1957
Minnesota	4	0.9	41	-
REGION 5	93	20.1	351	1943

TABLE II-2 (cont'd)

PHARMACEUTICAL INDUSTRY
GEOGRAPHICAL DISTRIBUTION

Location	Number of Plants	Percent of Total Plants	Average Number Employees Per Plant	Average Plant Start-up Year(1)
WESTERN U.S.	96	20.8	152	1962
Arkansas	2	0.4	1558	1970
Louisiana	2	0.4	9	-
Oklahoma	0	0.0	-	-
Texas	12	2.6	127	1967
New Mexico	0	0.0	-	-
REGION 6	16	3.4	291	1968
Iowa	3	0.6	77	1963
Kansas	4	0.9	123	1954
Missouri	17	3.7	108	1943
Nebraska	4	0.9	201	1962
REGION 7	28	6.1	117	1951
Colorado	5	1.1	96	1967
Utah	1	0.2	(2)	(2)
Wyoming	0	0.0	-	-
Montana	0	0.0	-	-
North Dakota	0	0.0	-	-
South Dakota	0	0.0	-	-
REGION 8	6	1.3	162	1968
Arizona	1	0.2	(2)	(2)
California	38	8.2	139	1967
Nevada	1	0.2	(2)	(2)
Hawaii	0	0.0	-	-
REGION 9	40	8.6	137	1967
Alaska	0	0.0	-	-
Idaho	0	0.0	-	-
Oregon	2	0.4	25	-
Washington	4	0.9	33	1955
REGION 10	6	1.3	30	1955

(1) Since data concerning plant start-up year were not solicited from the Supplemental 308 plants, the figures were calculated using only the (original) 308 plants' responses.

(2) Employment and start-up year figures are not presented to avoid disclosing individual plant data.

TABLE II-3

PHARMACEUTICAL INDUSTRY
SUBCATEGORY BREAKDOWN

Manufacturing Subcategory Combination	Number of Plants	Percent of Total Plants
A only	4	0.9
A B	1	0.2
A B C	2	0.4
A B C D	8	1.7
A B D	4	0.9
A C	3	0.6
A C D	10	2.2
A D	5	1.1
B only	21	4.5
B C	12	2.6
B C D	9	1.9
B D	23	5.0
C only	47	10.1
C D	42	9.1
D only	271	58.4
Not Available	2	0.4
Total Plants	464	100.0

Individual Manufacturing Subcategory	Number of Plants in Subcagetory	Percent of Totals
A	37	6.0
B	80	12.8
C	133	21.3
D	372	59.6
Not Available	2	0.3
Total Number of Subcategories	624*	

* This represents the total number of subcategories covered by the 464 manufacturing plants.

TABLE II-4

PHARMACEUTICAL INDUSTRY
PRODUCTION OPERATION BREAKDOWN

Type of Operation	Number of Operations Subcategory A	B	C	D	Total	Percent of Total Oper.
Batch	32	76	129	359	596	87.0
Continuous	3	0	14	16	33	4.8
Semi-continuous	11	9	19	17	56	8.2
Total Number of Operations	46	85	162	392	685*	100.0
Percent of Total Operations	6.7	12.4	23.6	57.2	100.0	
Percent of Subcategory Which is Batch	69.6	89.4	79.6	91.6	87.0	

* Since each individual subcategory within a plant may be comprised of more than one type of operation, this figure will be greater than the total number of subcategories.

NOTE: The above data apply to 462 manufacturing plants. For two plants no information was available on their subcategories and types of production operations.

SECTION III

WASTE CHARACTERIZATION

INTRODUCTION

As a result of past studies, particularly the 1976 Development Document, the EPA had available a limited amount of data which characterized the wastewater discharges of the pharmaceutical manufacturing industry. However, not only were some of these data outdated, but for the most part, they were related only to "traditional" pollutant parameters, such as BOD, COD, and TSS. Information on the 65 toxic pollutants or classes of toxic pollutants was almost nonexistent. Therefore, in order to fill this void the Agency instituted a number of programs aimed at gathering the necessary data on both toxic and traditional pollutants from the pharmaceutical industry. Each of the data gathering programs is discussed in detail in this section.

The aforementioned list of 65 toxic pollutants or classes of toxic pollutants potentially includes thousands of specific compounds. However, for purposes of rulemaking, the Agency has selected 129 specific toxic (often called priority) pollutants for analysis. The 129 priority pollutants are listed in Table III-1.

308 PORTFOLIO SURVEY

As can be seen in Section II, the 308 Portfolio Survey was an invaluable source of information for developing various profiles of the pharmaceutical manufacturing industry. Similarly, this survey proved to be a major source of data for waste characterization purposes. Not only did it provide more recent and detailed information on traditional pollutant parameters and wastewater flow characteristics, but the 308 Portfolio was the first major source of data on the use and/or generation of priority pollutants by this industry.

Since one purpose of the 308 survey was directed at quantifying the nature and extent of priority pollutants in the pharmaceutical industry, the results from the 308 Portfolio program are discussed below.

Information on the industry's traditional pollutant and wastewater flow characteristics obtained by the 308 Portfolio will be discussed later in this section.

Of the 464 pharmaceutical manufacturing plants in the comprehensive 308 Portfolio data base, 212 provided responses to the questions concerning priority pollutants. From these plants a total of 115 different priority pollutants were identified. Methylene chloride, phenol, toluene, chloroform, and zinc were most frequently reported with 94, 90, 79, 73, and 69 manufacturing plants identifying them in the 308 Portfolios, respectively.

Eighty-two of the above 115 pollutants were designated as being used as raw materials for a manufacturing operation. However, only ten were used by 25 or more manufacturing plants. These were: benzene, carbon tetrachloride, chloroform, methylene chloride, phenol, toluene, copper, cyanide, mercury, and zinc. Methylene chloride was the most extensively used with 90 manufacturing plants indicating it as a raw material, followed by toluene with 78, phenol with 74, and chloroform with 69.

Eighty-seven priority pollutants were designated as intermediate or final materials from a manufacturing operation. However, none were produced by ten or more manufacturing plants. In fact, phenol was the largest with nine manufacturing plants indicating its presence in an intermediate or final product, followed by benzene, carbon tetrachloride, and chloroform with four each.

Six priority pollutants were identified as being analyzed in the effluents of the manufacturing plants, but were not designated as a raw or final material. They were: N-nitrosodimethylamine; N-nitrosodi-n-propylamine; 4,4' DDE; 4,4' DDD; endrin; and heptachlor. Also, with respect to the other 109 indicated priority pollutants, the majority of raw and final material counts did not add to the "Identified By 308" counts. The above are probably the result of: (1) regulatory actions requiring these pollutants be sampled for; (2) incomplete 308 Portfolio responses; (3) pollutants resulting from chemical "side" reactions; and/or (4) pollutants resulting from the mixing of pharmaceutical and non-pharmaceutical wastewaters. It is reasonably certain that the first group is the result of (4), while the majority of the latter group is probably due to (1) and (2).

The comprehensive data base indicates that, although the pharmaceutical manufacturing industry uses/produces a large number of priority pollutants, broad usage of specific chemical compounds is limited.

Table III-2 summarizes the priority pollutant data, submitted by the 212 (out of 464) manufacturing plants in the comprehensive 308 Portfolio survey.

PEDCo REPORTS

Concurrent with the efforts to profile the pharmaceutical manufacturing industry using the 308 Portfolio survey, PEDCo Environmental, Inc., undertook a study to detail the various manufacturing processes/steps that are used in the production of fermentation, extractive, and synthesized pharmaceuticals.

In their studies PEDCo examined recent industry data and selected those products that comprise the major areas of production for each of the three manufacturing subcategories, i.e. A, B, and C. With these major product lines as a base, they then consulted all available literature describing the step-by-step procedures to be used in the production of each substance. As a result, PEDCo was able to identify certain priority pollutants that were known to be used by the pharmaceutical industry. These pollutants are listed in Table III-3.

Because of the size and complexity of the industry and the myriad of products manufactured, it was impossible for a study of this kind to identify every priority pollutant that could be used. The competitive nature of the industry and the fact that many products are still produced under patents make much of the necessary data unavailable.

RTP STUDY

In December 1978, EPA's Office of Air Quality Planning and Standards at Research Triangle Park published a document (70) providing guidance on air pollution control techniques for limiting emissions of volatile organic compounds from the chemical formulation subcategory of the pharmaceutical industry.

As part of this study, the Pharmaceutical Manufacturers Association (PMA) surveyed pharmaceutical plants to determine estimates of the ten largest volume volatile organic compounds that each company purchased and the mechanism by which they leave the plant, i.e., sold as product, sent to the sewer, or emitted as an air pollutant.

Table III-4 presents a summary of the results of this survey. Twenty-five of the twenty-six reporting companies indicated that their ten largest volume volatile organics accounted for 80 to 100 percent of their total plant usage. (The other company stated that the ten highest volume compounds only accounted for 50 percent.) It should be noted that these 26 companies accounted for 53 percent of the domestic sales of ethical pharmaceuticals in 1975.

Included in the list of 46 compounds presented in Table III-4 are seven priority pollutants. These compounds are as follows: methylene chloride, toluene, chloroform, benzene, carbon tetrachloride, trichloroethane and dichlorobenzene.

Table III-5 presents a summary and analysis of the data outlined in Table III-4. As can be seen, priority pollutants represent approximately 27 percent of the total volatile organic usage in the segment of the industry analyzed. However, priority pollutants represent only 13 percent of the total mass discharge of volatile organics to the plant sewers. This indicates a tighter control over the discharge of toxic materials than with other organic materials.

Table III-5 also indicates that discharge of volatile organics to the sewer represents only a small fraction (16.7 percent) of the total discharge. In fact, priority pollutants are discharged to the sewer in even smaller quantities (9.7 percent).

In summary, the RTP report indicates that although the pharmaceutical industry has a large involvement with volatile organic materials, including some toxic compounds, there is presently tight control over their discharge to the environment via plant sewers.

WASTEWATER SAMPLING PROGRAMS

Most of the priority pollutant information from the aforementioned reports and surveys was qualitative in nature, although the 308 Portfolio did provide some quantitative data. Therefore, in order to obtain a statistically-significant amount of priority pollutant data, the EPA instituted the screening and verification sampling programs. In these data gathering efforts a number of plants were selected for sampling, which were felt to be representative of the pharmaceutical manufacturing industry as a whole. And by using the analytical results from the sampling, the Agency had available a complete and representative data base with which to characterize the levels of the 129 priority pollutants in the industry's wastewaters. Details on the Agency's screening and verification, wastewater sampling programs are discussed in detail below:

Quantitative data for the traditional pollutants, BOD, COD, and TSS, were obtained with the priority pollutants. These data will be discussed later in this section, after the discussion on priority pollutants.

Screening Program

The screening program for the pharmaceutical manufacturing industry was developed to obtain analytical data which could be used to determine the presence of priority pollutants and to characterize their nature and extent in the industry's wastewater. In addition, the screening program served to cross-check the information on the treatment efficiencies of various end-of-pipe technologies, as they relate to priority pollutant removal.

Development of Screening Plant Candidates

In order to prepare a list of pharmaceutical manufacturing plants for the screening program, specific criteria were developed which served as the basis for the selection process. Each candidate plant was subjected to these criteria to determine its acceptability as a screening candidate. The object of the selection process was to prepare an optimal list of candidates which was representative of the pharmaceutical industry in terms of production methods, product lines, wastewater characteristics, treatment technology, and other characteristics, yet also comprised a minimum number of sites. Brief discussions of each criterion used in the selection process are presented in the paragraphs that follow:

One of the major criteria for selecting candidate plants for the screening program was concerned with the pharmaceutical plant's subcategory or type of production operation. Four different types of production operations are utilized in the making of pharmaceutical products. They are fermentation, biological/natural extraction, chemical synthesis, and mixing/compounding/formulation. Because of the distinct characteristics of each operation, the properties of a plant's wastewater will be influenced by the operation(s) employed at the site. Since the majority of pharmaceutical manufacturing plants employ more than one type of production operation at a particular site, the goal of the selection process was to choose plants that would not only cover the above four categories, but also provide a satisfactory production operation mix, i.e., provide various combinations of the above four subcategories. Also, past experience indicated that subcategories A and C were more likely to have priority pollutants present than subcategories B and D. Therefore, the selection process concentrated on obtaining plants with these production operations. The end result would be that the screening list would have relatively more subcategory A and C plants than would be representative of the pharmaceutical industry as a whole.

Another important criterion of the selection process dealt with the type of treatment at the plant, since the final effluent quality of any wastewater discharge will be dependent upon the treatment used. For the screening program, the goal was to try to select those plants that had significant treatment. In this analysis, significant treatment was defined as treatment beyond equalization, neutralization, and primary sedimentation; namely, biological, physical-chemical, or other treatment. Therefore, the end result would be that the screening list would reflect a relatively higher degree of treatment compared to the pharmaceutical industry as a whole.

As stated previously, the purpose of the screening program was to determine the nature and extent of priority pollutants in the pharmaceutical industry's wastewaters. Probably the most important factor affecting the presence of these pollutants in a plant's effluent is the use of them as raw materials in the production operation. Thus, to optimize the screening program, the selection process concentrated on selecting those plants that used a large number of different priority pollutants in their operations.

Some pharmaceutical plants indicated that they had performed their own wastewater sampling over a period of time. Information of this kind was thought to be important, since it could provide background information on the plant's effluent quality and assist in the analyses of the sampling data gathered during the screening program. Therefore, consideration was given to those facilities known to have historical sampling data.

The amount of wastewater discharged by a particular pharmaceutical manufacturing plant is dependent upon many factors. Some of the more important factors are: type of production operation, product line, plant size, treatment costs, etc. For the screening program, it was thought to be desirable to select plants which discharged varying quantities of wastewater. In this way, the screening could ascertain the effect of small and large flows on priority pollutant levels and also be relatively representative of the pharmaceutical industry as a whole. However, since it was necessary for a plant to have a wastewater flow in order to be sampled, the screening list would obviously be biased from the total industry with respect to plants having zero (or very low) wastewater flows.

Another criterion for selecting plant candidates had to do with company ownership of the particular manufacturing plant. The goal was to minimize, wherever possible, the number of plants operated by a single company. First, this would avoid "biasing" the screening data because of a particular company's operating procedures. Second, it would minimize the resource impact (personnel, time, costs, etc.) of sampling on an individual company.

Although these criteria were not as significant as the others in the selection of plant candidates, it was felt to be desirable to consider each manufacturing plant's geographic location, age, number of employees, etc. For plant location and age, the selection process tried to obtain a good variety of facilities reflecting the total pharmaceutical manufacturing industry.

With respect to plant employment, the selection process, in order to satisfy the more important criteria, tended to emphasize larger facilities, because past experience indicated that the larger plants generally had more complex operations. Thus, the screening list would tend to contain more of the larger manufacturing plants than the pharmaceutical industry as a whole.

The development of the final list of pharmaceutical plants to comprise the screening program was accomplished in a step-wise fashion. For each plant, the BPT data file, 308 Portfolio, federal and state government documents, and other available information were reviewed in order to prepare a preliminary screening list. This list was frequently reviewed and revised on the basis of the aforementioned criteria in an attempt to develop an optimal final list. The goal was to ensure that the final list of screening plants maximized the specified criteria, yet comprised a minimum number of plants to be sampled.

The end result of the selection process was that 26 pharmaceutical manufacturing plants comprised the final screening list. Pertinent data on the selected plants are shown in Table III-6. Also, Table III-7 presents a comparison of the 26 screening plants versus the total pharmaceutical manufacturing population of 464 plants. From these tables, it can be seen that the screening plant selection process achieved the desired goals.

Screening Protocol

Following the final selection of the 26 screening plants, preparations were made for the actual sampling activities. The sampling protocol (60), developed by EPA, served as the basis for the collection and analysis of screening samples at the subject pharmaceutical manufacturing sites. An overview of the screening methods is discussed below.

The general rule was to obtain 24-hour samples wherever possible. In some instances, this was altered to accommodate a particular aspect of the plant to be screened. Certain facilities had batch operations and/or did not operate "around-the-clock." For these situations, samples of less than 24 hours, generally 8 hours, were collected. On the other extreme, some facilities had varying operations which showed fluctuating characteristics over a period longer than 24 hours. Here a longer sampling time was warranted, generally on the order of 48 hours. In summary, the screening program was directed toward gathering 24-hour samples. To cover certain unique situations, this time was increased or decreased as necessary. No significant impact was expected from these modifications, since the major goal of the screening program was only to identify the presence and typical levels of priority pollutants in the wastewaters of the pharmaceutical manufacturing industry.

The types of samples collected during the screening program, again, were based upon the sampling protocol developed by EPA. To identify these priority pollutants, classified as acid or base/neutral extractables and metals, composite samples were obtained. For the volatile organics and phenols portion of the priority pollutants, grab samples were taken.

Two sampling locations were of specific interest, namely, the influent and effluent of the plants' wastewater treatment systems. The influent to the treatment system was important in the analyses to determine the levels of priority pollutants generated by the various pharmaceutical manufacturing operations. The effluent from the treatment system was critical in determining the effect of the various treatment systems on the removal of priority pollutants and the resultant levels reaching the receiving waters.

In addition to the above, samples were usually collected at other locations throughout a particular facility. This was done to obtain supplementary information on a specific operation or treatment step or to ensure that certain characteristics, unique to a certain plant, were adequately covered. Some examples of these sample locations are: intake water, specific production wastewaters, holding tanks, cooling water, etc. The end result was that more detailed information for each screening plant was made available for the analyses on the fate of priority pollutants in pharmaceutical wastewaters.

Verification Program

As previously mentioned, the screening program was developed to obtain analytical data which could be used to determine the presence of priority pollutants and to characterize their nature and extent in the pharmaceutical industry's wastewaters. Having obtained these data, the EPA then selected five of the screening plants for the verification program. The purpose of the verification program was to confirm the data obtained during the screening program and to quantify the concentrations, loadings, and percent reductions of those pollutants found at significant levels during the screening program.

The final list of pharmaceutical plants to comprise the verification study is given in Table III-8. EPA developed this list by selecting those plants that satisfied one or more of the following criteria:

- Those plants with "BPT" type treatment systems;
- Those plants that use cyanide as a raw material; and
- Those plants with in-plant control measures such as cyanide destruction, steam stripping, and solvent recovery.

In addition, EPA selected plants that would not only cover the four subcategories, but also provide a satisfactory production operation mix, i.e., provide various combinations of the subcategories at each plant.

Verification Protocol

Prior to verification sampling, preliminary grab samples were collected from the verification sampling locations to determine the applicability of the planned analytical methods. However, the data obtained from these grab samples were not used to quantify effluent levels or to calculate percent removals achieved by the treatment systems.

The results of analyzing the screening visit samples were usually discussed with operating personnel in relation to priority pollutants used by the plant as either raw, intermediate, or final products. These results and the data obtained from the aforementioned grab samples were used to determine the final verification sampling locations and to define the priority pollutant verification analyses to be performed.

For a detailed discussion of the sampling methods employed in the verification program, the reader is referred to the sampling protocol (60). With respect to sampling time, the verification program was directed toward gathering three days of 24-hour samples. Where automatic composite samples were not feasible, manual composite samples were obtained for analysis of acid and base/neutral extractables, metals, and conventional and non-conventional pollutants. Grab samples were taken for analysis of volatile organics, phenols, and cyanides. Some wastewater streams were grab sampled once for analysis of all parameters.

The analysis of verification samples was performed under a detailed quality assurance/quality control procedure. The procedure required analyses of duplicate extractions for samples collected on the first day of verification sampling. Samples taken on the second and third days of verification sampling were extracted and analyzed, spiked with appropriate amounts of pollutants and reanalyzed. Spike recoveries were calculated from the data generated during these analyses. The spiking and reanalysis requirement was deleted if the original pollutant concentration was below the detectable limit. Another requirement was that samples not analyzed, spiked, and re-extracted within 72 hours of sample collection were subjected to an additional spiking, holding, and analysis. This requirement was designed to determine whether the pollutants degrade during storage.

As in the case of the sampling programs, two sampling locations were of specific interest, namely, the influent to and effluent from each plant's wastewater treatment systems. The influent to the treatment system was important in the analyses to determine the levels of priority pollutants generated by the various pharmaceutical manufacturing operations. The effluent from the treatment system was critical in determining the effect of the various treatment systems on the removal of priority pollutants and the resultant levels reaching the receiving waters.

In addition to the above, samples were usually collected at other locations throughout a particular facility. This was done to obtain supplementary information on a specific operation or treatment step or to ensure that certain characteristics, unique to a plant, were adequately covered. Examples of these sampling locations are: intake water, cooling water, specific production wastewaters, etc. The end result was that a more detailed analysis of the fate of priority pollutants for each verification plant was available. Since a goal of the verification program is to quantify those pollutants found during the screening program, the sampling locations for the two programs were the same in most instances.

Screening/Verification Results

The major objective of the screening and verification programs was to define, using the analytical sampling results, the important priority pollutants in the wastewaters of the pharmaceutical manufacturing industry. One of the most important criteria in making this determination was the frequency at which the priority pollutants appeared in the raw wastewaters of the 26 plants that were sampled. (The total number sampled equals 26, since the five verification plants were also sampled under the screening program.) Table III-9 summarizes the number of times each priority pollutant was found at the screening/verification plants. The reader is referred to Appendix F for a presentation of the raw analytical results for each of the 26 plants that were sampled.

As can be seen in Table III-9, 60 priority pollutants were detected in the wastewater of at least one of the 26 screening/verification plants. However, only 13 were found at ten or more plants. They are phenol, benzene, chloroform, ethylbenzene, methylene chloride, toluene, chromium, copper, lead, mercury, nickel, zinc and cyanide. Phenol was the only significant acid extractable, being found 15 times. Methylene chloride was the most often detected volatile organic, being found 22 times. Finally, chromium, copper and zinc were the major metals, being found 24 times each. No significant base/neutral extractables were detected at the screening/verification plants. Bis (2-ethylhexyl) phthalate was not considered to be important, because its presence was probably the result of contamination from the tubing used to collect the wastewater samples.

PRIORITY POLLUTANT RAW WASTE CHARACTERISTICS

After finalizing the above data bases, work could begin on analyzing the raw waste characteristics of the pharmaceutical manufacturing industry. Since the major emphasis of this study was directed toward priority pollutants, these data were examined first. The initial step in the analysis was to compare the various data base results and see if any of the information agreed. Table III-10 presents a summary of the "major" priority pollutants identified by each of the four data bases, i.e., RTP Study, PEDCo Reports, 308 Portfolio, and Screening/Verification. As can be seen in this table, there is good agreement among the data bases as to which priority pollutants are most significant in terms of their presence in the industry's wastewaters: particularly between the 308 Portfolio and screening/verification data bases. Both of these data bases contained analytical results which could be used to quantify the specific priority pollutant levels in the industry. In order to define the industry's priority pollutant raw waste load (RWL) characteristics analyses performed on these data are discussed below.

Table III-11 presents the results of an analysis performed on the screening/verification data. The 13 priority pollutants listed were selected from Table III-9 based upon the criterion that a priority pollutant was defined as "major" if it was identified in the wastewaters of ten or more of the 26 screening/verification plants. All of the listed statistics were calculated for each pollutant, using the raw analytical sampling results published in Appendix F.

The results of a similar analysis, performed on the 308 Portfolio data, are presented in Table III-12. In this instance, the 13 priority pollutants listed were selected from Table III-2, based upon the criterion: a priority pollutant was identified as "major" if it was identified in the wastewaters of 25 or more of the 464 manufacturing plants. The raw 308 Portfolio data, published in Appendix G, were used to calculate the statistics listed in Table III-12.

Table III-13 compares the median RWL values for 12 of the 13 "major" priority pollutants identified by the two data bases. (Although each data base defined 13 priority pollutants as being "major," only 12 could be directly compared. This is because ethylbenzene was not a major pollutant in the 308 Portfolio data base, while carbon tetrachloride was not a major one in the screening/verification data base.) As can be seen in Table III-13, the RWL levels, derived from the two data bases, compare very well. The slightly lower screening/verification values may be due to the fact that this data (1978-79) is more recent than the 308 Portfolio data (1976-77) and reflects the industry's attempts to reduce or eliminate the use of these compounds in production.

After thoroughly reviewing and evaluating the raw data and statistical results, the screening/verification data base was thought to be the most appropriate source of information for selecting "major" priority pollutants, since it is more recent data and the nature and scope of the sampling programs were specifically directed at collecting priority pollutant data. However, in the future the Agency may amend this list of 13 "major" priority pollutants, based upon other selection criteria. Median values were selected because they minimized the statistical impact of a few extremely small and/or large values in the data base. A close examination of each screening/verification plant revealed that priority pollutant levels are more the result of plant operating procedures, e.g. solvent recovery, rather than levels of production. Thus, the median values were felt to be more representative of the pharmaceutical industry as a whole.

With the median values from the screening/verification data selected as being most appropriate, the final analysis dealt with comparing the variation of priority pollutant raw waste loads across each of the four individual subcategories. For example, are the RWL characteristics of subcategory A the same as those in subcategory B or C or D and vice versa? Table III-14 summarizes the priority pollutant raw waste load concentrations for each of the single subcategories and compares them with the results of the analysis for all subcategories combined.

Very little priority pollutant data were available which could be directly tied to a particular subcategory, except for the plants that had only single subcategory production. Therefore, for this comparison the priority pollutant RWL data from a multiple subcategory, screening/verification plant were used in each of the single subcategory analyses for which the plant had a subcategory operation. For example, data from an ABD plant were used in the A, the B, and the D subcategory calculations. As a result, the data from the appropriate multiple subcategory plants and the particular single subcategory plants were combined in order to calculate the priority pollutant median RWL values for each individual subcategory. (In the case of the analysis for all subcategories combined data from all of the plants, regardless of subcategory, were compiled and the priority pollutant median RWL values were calculated.)

As can be seen in Table III-14, in most instances the results do not vary significantly from one subcategory to another and in general compare favorably with the values from all subcategories combined. Based upon this observation and the fact that the analysis of all subcategories combined utilizes a statistically larger data base, it was felt that for purposes of regulatory evaluation the priority pollutant median values from all subcategories would best represent the raw waste load characteristics of the individual subcategories in the pharmaceutical industry as a whole.

TRADITIONAL POLLUTANT RAW WASTE CHARACTERISTICS

Although the major emphasis of this project was directed at defining and quantifying the priority pollutant characteristics of this industry, the Agency was also deeply interested in the traditional pollutant parameters, namely BOD, COD, and TSS. A study of these pollutants was critical to the development of potential regulations for the control of conventional pollutants. As with priority pollutants, only two data bases had specific information with which to analyze the industry's raw waste characteristics in terms of these three pollutants: 308 Portfolio and screening/verification data bases. Discussions of the analyses performed on these data bases in order to quantify the pharmaceutical industry's traditional raw waste load characteristics are presented below:

Based upon information from previous studies, particularly the 1976 Development Document for BPT regulations, it was known that the BOD, COD, and TSS characteristics of this industry showed significant variations across the four individual subcategories. This premise is different than in the case of priority pollutants, where the aforementioned analyses could not positively demonstrate any significant variations in priority pollutant levels across the four subcategories. Therefore, in the following determination of traditional raw waste characteristics, the calculations involved only individual subcategory analyses. No analysis for all subcategories combined was performed.

In conducting the individual subcategory analyses of BOD, COD, and TSS raw waste characteristics a problem similar to that in the priority pollutant analyses arose. Much of the traditional pollutant data could not be directly tied to a particular subcategory, except for the plants that had single subcategory production. This problem was not as severe in this instance, since some data were available on the individual subcategory operations within a few multiple subcategory plants. However, for those multiple subcategory plants that did not have specific data for an individual subcategory the same technique as used in the priority pollutant analyses was utilized. Data from a multiple subcategory plant were used in each of the single subcategory analyses for which the plant had a subcategory operation, e.g., a BCD plant's data were used in the B, the C, and the D subcategory calculations.

Table III-15 presents the results of an analysis of traditional pollutant raw waste loads, using the screening/verification data base. A similar analysis, using the 308 Portfolio data base, is presented in Table III-16. The raw analytical data used to prepare these tables are shown in Appendices F and H, respectively.

The mean or average values calculated for each subcategory's BOD, COD, and TSS raw waste loads are compared in Table III-17. As can be seen from this table, the results from each analysis compare favorably. However, as was the case for priority pollutants, the screening/verification traditional pollutant values are somewhat lower than those from the 308 Portfolio data base. Again, this is probably due to the fact that the screening/verification data (1978-79) are more recent than the 308 Portfolio data (1976-77) and reflect the industry's attempts to reduce, as much as possible, its traditional pollutant loads.

Upon reviewing and evaluating the raw data and calculated statistical results, the screening/verification data were selected as being representative. It is recent with respect to the traditional pollutants and directly correponds to the previously discussed priority pollutant results, i.e., both samples were collected at the same time and place. In addition, mean or average values were chosen because BOD, COD, and TSS levels are generally tied to a plant's level of production. Thus, the mean values would best account for all of the varying production levels and be more representative of the traditional pollutant raw waste load characteristics of the pharmaceutical industry as a whole.

WASTEWATER FLOW CHARACTERISTICS

The last parameter of importance in the waste characterization of the industry was the wastewater flow generated. These data, along with the priority and traditional pollutant raw waste concentrations, could then be used to determine the mass quantity of pollutants being generated by the pharmaceutical manufacturing industry. Because of a couple of important factors with regard to the data bases, the procedures used in the analysis of wastewater flows differed substantially from those used for priority and traditional pollutants. These are described below:

The first major difference involved the contents of the available data bases. In the previous analyses of RWL concentrations, the screening/verification data base was the primary information source with the 308 Portfolio data serving as a cross-check. However, in terms of wastewater flow, the screening/verification data base had almost no data, except for a few plants (generally the plants covered by verification sampling). Therefore, for purposes of analyzing the wastewater flow characteristics of the industry, the 308 Portfolio data base served as the primary (and only) information source.

As in the case of traditional pollutants, the information from the 1976 Development Document indicated that significant differences in wastewater generation could be expected among the four individual subcategories. Thus, it was decided to conduct analyses for the four individual subcategories. Herein lies the second major difference in data source. The 308 Portfolio data base contains a large amount of data, particularly with regards to flow data from single subcategory plants. As a result, it was felt that since enough single subcategory flow data were available, the analyses need not include data from the multiple subcategory plants; as was the case in the priority and traditional pollutant study. Therefore, flow data from only the single subcategory plants were used to define the wastewater flows representative of the industry.

Table III-18 presents the results of the wastewater flow analysis using the 308 Portfolio data base. The first step in the analysis was to determine the mean wastewater flow for each subcategory. This was accomplished by using those single subcategory plants that reported wastewater flow data. Next, the total number of direct and/or indirect discharges was determined for each subcategory. These data were obtained from Section VI and the reader is referred to it for more details. It should be noted that a few plants utilize a combination of direct and indirect discharge methods. In these cases the plant/subcategory was assumed to be one-half direct and one-half indirect for purposes of this analysis. By knowing the mean wastewater flow and the number of direct and indirect discharges for each subcategory, it was possible to estimate the total wastewater flow discharged by each subcategory and for the entire industry. As can be seen in Table III-18, this was estimated to be 65.2 MGD.

The final step in the analysis was to check the validity of the above estimate. All direct and indirect discharge flows in the 308 Portfolio data base were summed to obtain a total flow for the industry with a result of 60.4 MGD. In determining this number, only 75 percent of the 332 discharging plants provided wastewater flow data. Data from the remaining 25 percent of the plants were either unknown or not reported. After examining these plants more closely, it was found that, generally, they are the smaller manufacturing plants in the industry. Thus, the estimated total industry flow of 65.2 MGD compares favorably with the 60.4 MGD obtained by summing the individual plant flows available from the data base. In conclusion, the total flow of 65.2 MGD is felt to be representative of the pharmaceutical manufacturing industry as a whole.

All data used in characterizing the wastewater flows of each subcategory and the entire industry are shown in Appendix I.

TABLE III-1

LIST OF EPA-DESIGNATED PRIORITY POLLUTANTS

*No.	Compound
1B	acenaphthene
2V	acrolein
3V	acrylonitrile
4V	benzene
5B	benzidine
6V	carbon tetrachloride
7V	chlorobenzene
8B	1,2,4-trichlorobenzene
9B	hexachlorobenzene
10V	1,2-dichloroethane
11V	1,1,1-trichloroethane
12B	hexachloroethane
13V	1,1-dichloroethane
14V	1,1,2-trichloroethane
15V	1,1,2,2-tetrachloroethane
16V	chloroethane
17B	bis(chloromethyl) ether
18B	bis(2-chloroethyl) ether
19V	2-chloroethylvinyl ether
20B	2-chloronaphthalene
21A	2,4,6-trichlorophenol
22A	parachlorometa cresol
23V	chloroform
24A	2-chlorophenol
25B	1,2-dichlorobenzene
26B	1,3-dichlorobenzene
27B	1,4-dichlorobenzene
28B	3,3'-dichlorobenzidine
29V	1,1-dichloroethylene
30V	1,2-trans-dichloroethylene
31A	2,4-dichlorophenol
32V	1,2-dichloropropane
33V	1,3-dichloropropylene
34A	2,4-dimethylphenol
35B	2,4-dinitrotoluene
36B	2,6-dinitrotoluene
37D	1,2-diphenylhydrazine
38V	ethylbenzene
39B	fluoranthene
40B	4-chlorophenyl phenyl ether
41B	4-bromophenyl phenyl ether
42B	bis(2-chloroisopropyl) ether
43B	bis(2-chloroethoxy) methane
44V	methylene chloride
45V	methyl chloride
46V	methyl bromide
47V	bromoform
48V	dichlorobromomethane
49V	trichlorofluoromethane
50V	dichlorodifluoromethane
51V	chlorodibromomethane
52B	hexachlorobutadiene
53B	hexachlorocyclopentadiene
54B	isophorone
55B	naphthalene
56B	nitrobenzene
57A	2-nitrophenol
58A	4-nitrophenol
59A	2,4-dinitrophenol
60A	4,6-dinitro-o-cresol
61B	N-nitrosodimethylamine
62B	N-nitrosodiphenylamine
63B	N-nitrosodi-n-propylamine
64A	pentachlorophenol
65A	phenol
66B	bis(2-ethylhexyl) phthalate
67B	butyl benzyl phthalate
68B	di-n-butyl phthalate
69B	di-n-octyl phthalate
70B	diethyl phthalate
71B	dimethyl phthalate
72B	benzo(a)anthracene
73B	benzo(a)pyrene
74B	3,4-benzofluoranthene
75B	benzo(k)fluoranthane
76B	chrysene
77B	acenaphthylene
78B	anthracene
79B	benzo(ghi)perylene
80B	fluorene
81B	phenanthrene
82B	dibenzo(a,h)anthracene
83B	ideno(1,2,3-C,D)pyrene
84B	pyrene
85V	tetrachlorethylene
86V	toluene
87V	trichloroethylene
88V	vinyl chloride
89P	aldrin
90P	dieldrin
91P	chlordane
92P	4,4'-DDT
93P	4,4'-DDE
94P	4,4'-DDD
95P	alpha-endosulfan
96P	beta-endosulfan
97P	endosulfan sulfate
98P	endrin
99P	endrin aldehyde
100P	heptachlor
101P	heptachlor epoxide
102P	alpha-BHC
103P	beta-BHC
104P	gamma-BHC (lindane)
105P	delta-BHC
106P	PCB-1242
107P	PCB-1254
108P	PCB-1221
109P	PCB-1232
110P	PCB-1248
111P	PCB-1260
112P	PCB-1016
113P	toxaphene
114M	antimony (total)
115M	arsenic (total)
116	asbestos (fibrous)
117M	beryllium (total)
118M	cadmium (total)
119M	chromium (total)
120M	copper (total)
121	cyanide (total)
122M	lead (total)
123M	mercury (total)
124M	nickel (total)
125M	selenium (total)
126M	silver (total)
127M	thallium (total)
128M	zinc (total)
129B	2,3,7,8-tetrachloro-dibenzo-p-dioxin (TCDD)

* V - volatile organics
A - acid extractables
B - base/neutral extractables
P - pesticides
M - metals

TABLE III-2

PHARMACEUTICAL INDUSTRY

SUMMARY OF PRIORITY POLLUTANT INFORMATION: 308 PORTFOLIO DATA

Priority Pollutant	Number of Plants: Identified by 308	Usage as Raw Mat'l	Usage in Final Product
acenaphthene	1	0	1
acrolein	3	2	1
acrylonitrile	6	5	1
benzene	47	46	4
benzidine	2	2	0
carbon tetrachloride (tetrachloromethane)	30	27	4
chlorobenzene	14	11	1
1,2,4-trichlorobenzene	3	1	2
hexachlorobenzene	3	2	1
1,2-dichloroethane	17	16	2
1,1,1-trichloroethane	22	21	2
hexachloroethane	1	0	1
1,1-dichloroethane	2	1	1
1,1,2-trichloroethane	4	2	1
1,1,2,2-tetrachloroethane	5	4	2
chloroethane	7	6	2
bis(chloromethyl) ether	2	1	1
bis(2-chloroethyl) ether	2	1	1
2-chloroethyl vinyl ether (mixed)	2	1	1
2-chloronaphthalene	1	0	1
2,4,6-trichlorophenol	2	1	1
parachlorometa cresol	5	4	1
chloroform (trichloromethane)	73	69	4
2-chlorophenol	4	3	1
1,2-dichlorobenzene	8	7	2
1,3-dichlorobenzene	4	3	1
1,4-dichlorobenzene	2	1	1
3,3'-dichlorobenzidine	1	0	1
1,1-dichloroethylene	1	0	1
1,2-trans-dichloroethylene	1	0	1
2,4-dichlorophenol	3	2	3
1,2-dichloropropane	2	1	1
1,3-dichloropropylene (1,3-dichloropropene)	1	0	1
2,4-dimethylphenol	2	0	1
2,4-dinitrotoluene	1	1	1
2-6-dinitrotoluene	0	0	0
1,2-diphenylhydrazine	2	2	0
ethylbenzene	3	2	1
fluoranthene	1	0	1
4-chlorophenyl phenyl ether	0	0	0
4-bromophenyl phenyl ether	0	0	0
bis(2-chloroisopropyl) ether	1	0	1
bis(2-chloroethyoxy) methane	2	0	2
methylene chloride (dichloromethane)	94	90	2
methyl chloride (chloromethane)	17	16	1

TABLE III-2 (cont'd)

PHARMACEUTICAL INDUSTRY

SUMMARY OF PRIORITY POLLUTANT INFORMATION: 308 PORTFOLIO DATA

Priority Pollutant	Number of Plants: Identified by 308	Usage as Raw Mat'l	Usage in Final Product
methyl bromide (bromomethane)	10	9	1
bromoform (tribromomethane)	2	1	1
dichlorobromomethane	2	0	1
trichlorofluromethane	8	7	2
dichlorodifluoromethane	9	8	2
chlorodibromomethane	2	0	1
hexachlorobutadiene	1	0	1
hexachlorocyclopentadiene	1	0	1
isophorone	3	2	1
naphthalene	8	8	1
nitrobenzene	12	12	0
2-nitrophenol	3	1	1
4-nitrophenol	5	4	1
2,4-dinitrophenol	3	1	1
4,6-dinitro-o-cresoL	1	1	0
N-nitrosodimethylamine	1	0	0
N-nitrosodiphenylamine	1	0	1
N-nitrosodi-n-propylamine	1	0	0
pentachlorophenol	3	1	2
phenol	90	74	9
bis(2-ethylhexyl) phthalate	2	0	1
butyl benzyl phthalate	2	1	1
di-n-butyl phthalate	4	2	1
di-n-octyl phthalate	7	6	1
diethyl phthalate	14	13	2
dimethyl phthalate	4	3	0
1,2-benzanthracene	0	0	0
benzo (a)pyrene (3,4-benzopyrene)	1	0	1
3,4-benzofluoranthene	0	0	0
11,12-benzofluoranthene	0	0	0
chrysene	1	0	0
acenaphthylene	1	0	1
anthracene	2	1	1
1,12-benzoperylene	1	0	1
fluorene	1	0	1
phenanthrene	1	0	1
1,2'5,6-dibenzanthracene	1	0	1
indeno(1,2,3-C,D) pyrene	1	0	1
pyrene	1	0	1
tetrachloroethylene	9	8	1
toluene	79	78	3
trichloroethylene	16	14	3
vinyl chloride (chloroethylene)	2	2	0
aldrin	1	1	0
dieldrin	1	1	0

TABLE III-2 (cont'd)

PHARMACEUTICAL INDUSTRY

SUMMARY OF PRIORITY POLLUTANT INFORMATION: 308 PORTFOLIO DATA

Priority Pollutant	Number of Plants: Identified by 308	Usage as Raw Mat'l	Usage in Final Product
chlordane (technical mixture and metabolites)	1	1	0
4,4'-DDT	1	1	0
4,4'-DDE (P,P'-DDX)	1	0	0
4,4'-DDD (P,P'-TDE)	1	0	0
alpha-endosulfan	0	0	0
beta-endosulfan	0	0	0
endosulfan sulfate	0	0	0
endrin	1	0	0
endrin aldehyde	0	0	0
heptachlor	1	0	0
heptachlor epoxide	0	0	0
alpha-BHC	0	0	0
beta-BHC	0	0	0
gamma-BHC (lindane)	8	8	3
delta-BHC	0	0	0
PCB-1242 (arochlor 1242)	1	1	0
PCB-1254 (arochlor 1254)	1	1	0
PCB-1221 (arochlor 1221)	1	1	0
PCB-1232 (arochlor 1232)	1	1	0
PCB-1248 (arochlor 1248)	1	1	0
PCB-1260 (arochlor 1260)	1	1	0
PCB-1016 (arochlor 1016)	1	1	0
toxaphene	2	2	1
antimony (total)	7	4	1
arsenic (total)	20	9	1
asbestos (fibrous)	4	4	0
beryllium (total)	4	0	1
cadmium (total)	21	5	1
chromium (total)	36	17	2
copper (total)	54	37	2
cyanide (total)	47	34	1
lead (total)	27	11	1
mercury (total)	43	25	2
nickel (total)	31	17	3
selenium (total)	20	10	2
silver (total)	24	12	3
thallium (total)	3	1	2
zinc (total)	69	53	3
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)	0	0	0

TOTAL NUMBER OF PLANTS RESPONDING 212

TOTAL NUMBER OF PLANTS IN DATA BASE 464

TABLE III-3

PHARMACEUTICAL INDUSTRY

SUMMARY OF PRIORITY POLLUTANT INFORMATION: PEDCo REPORTS

Priority Pollutants Identified in:

Subcategory A[1]	Subcategory B[2]	Subcategory C[3]
benzene	benzene	benzene
chloroform	carbon tetrachloride	carbon tetrachloride
1,1-dichloroethylene	1,2-dichloroethane	chlorobenzene
1,2-trans-dichloroethylene	chloroform	chloroethane
phenol	methylene chloride	chloroform
copper	phenol	1,1-dichloroethylene
zinc	toluene	1,2-trans-dichloroethylene
	cyanide	methylene chloride
	lead	methyl chloride
	mercury	methyl bromide
	nickel	nitrobenzene
	zinc	2-nitrophenol
		4-nitrophenol
		phenol
		toluene
		chromium
		copper
		cyanide
		lead
		zinc

Total No. of Pollutants: 23

[1] Reference No. 42
[2] Reference No. 41
[3] Reference No. 43

TABLE III-4

PHARMACEUTICAL INDUSTRY

COMPILATION OF DATA SUBMITTED BY THE PMA FROM
26 MANUFACTURERS OF ETHICAL DRUGS: RTP STUDY

(metric tons)

Type of Volatile Organic Compound	Annual Purchase	Annual Disposition: Air Emissions	Sewer	Incineration	Contract Haul	Disposal*	Product	Solvent Recovery
Methylene Chloride	10,000	5,310	455	2,060	2,180	-	5	73,400
Skelly Solvent B	1,410	410	23	980	-	-	-	90
Methanol	7,960	2,480	3,550	1,120	410	30	340	-
Toluene+	6,010	1,910	835	1,590	1,800	-	-	23,850
Acetone+	12,040	1,560	2,580	4,300	770	-	2,210	40,760
Dimethyl Formamide+	1,630	1,350	60	380	120	-	-	5,100
Ethanol	13,230	1,250	785	915	200	-	10,000	7,570
Isopropanol+	3,850	1,000	1,130	1,150	470	25	3,090	3,880
Amyl Alcohol+	1,430	775	-	-	0	-	9	76,900
Ethyl Acetate	2,380	710	1,110	480	80	-	-	715
Chloroform	500	280	23	-	175	17	-	1,210
Benzene+	1,010	270	350	150	80	-	90	20,500
Ethyl Ether	280	240	12	-	30	-	-	110,800
Methyl Isobutyl Ketone+	260	260	-	-	-	-	65	6,160
Carbon Tetrachloride	1,850	210	120	1,510	-	-	-	-
Xylene+	3,090	170	510	1,910	140	-	3	9,400
Methyl Ethyl Ketone	260	170	30	60	-	-	-	6,460
Trichloroethane	135	135	-	-	-	-	-	-
Hexane+	530	120	-	100	475	-	-	25,670
Amyl Acetate	285	120	165	-	-	-	-	3,510
Isopropyl Acetate	480	105	45	230	-	-	-	1,840
Methyl Cellosolve	195	90	100	-	-	-	-	360
Butanol+	320	85	30	5	130	-	110	1,040
Isobutyraldehyde	85	40	40	-	-	-	-	145
Acetonitrile	35	30	6	-	-	-	-	125
Tetrahydrofuran	4	-	-	4	-	-	-	-
Isopropyl Ether	25	12	12	-	-	-	-	12
Acetic Acid	930	12	770	-	-	-	160	1,040
Acetic Anhydride	1,265	8	550	-	-	-	410	300

TABLE III-4 (cont'd)

PHARMACEUTICAL INDUSTRY

Type of Volatile Organic Compound	Annual Purchase	Annual Disposition: Air Emissions	Sewer	Incineration	Contract Haul	Disposal*	Product	Solvent Recovery
Dimethylacetamide	95	7	-	-	90	-		-
Formaldehyde	30	5	20	-	-	-	1	-
Dimethylsulfoxide	750	4	210	535	-	-	-	4,760
1,4-Dioxane	43	2	-	-	41	-	-	-
o-Dichlorobenzene	60	1	60	-	-	-	-	7,060
Diethyl Carbonate	30	1	20	-	-	-	7	-
Blenda (Amoco)	530	-	-	-	-	-	530	-
Ethyl Bromide	45	-	45	-	-	-	-	7,170
Cyclohexylamine	3,930	-	-	-	-	-	3,930	-
Methyl Formate	415	-	310	-	50	-	60	1,130
Formamide	440	-	290	-	110	-	30	-
Ethylene Glycol	60	-	60	-	-	-	-	60
Diethylamine	50	50	3	-	-	-	-	300
Freons	7,150	6	-	-	-	-	7,145	-
Diethyl-ortho Formate	54	-	21	-	-	-	33	-
Pyridine	3	-	3	-	-	-	-	-
Polyethylene Glycol 600	3	-	-	-	-	-	3	-
TOTALS	85,170	19,190	14,880	17,480	7,350	72	27,700	441,320

[1] Source - 26 member companies of the Pharmaceutical Manufacturers Association (PMA) reported these data which they feel represent 85 percent of the volatile organic compounds used in their operations; these reporting companies account for approximately 53 percent of the 1975 domestic sales of ethical pharmaceuticals.

*Deepwell or landfill.

[+] Annual disposition does not closely approximate annual purchase.

TABLE III-5

PHARMACEUTICAL INDUSTRY

SUMMARY OF VOLATILE ORGANIC COMPOUND EMISSION DATA: RTP STUDY

	Amount:	
Item:	Total Compounds (total of 46)	Priority Pollutants (total of 7)
Amount purchased (metric tons)	85,170	19,565
Amount discharged (metric tons)	86,142	19,595
Amount recovered within the plant (metric tons)	441,320	126,020
Total amount used in plant (sum of items 1 and 3) (metric tons)	526,490	145,585
Percent recovered	83.8%	86.6%
Percent of total used that is discharged	16%	13.5%
Percent of total used that is discharged to sewer	2.7%	1.3%
Percent of total discharged that is discharged to sewer	16.7%	9.7%

TABLE III-6

PHARMACEUTICAL INDUSTRY

CHARACTERISTICS OF THE 26 PLANTS SELECTED FOR SCREENING

Screening Code	Subcategory	Wastewater Treatment	Wastewater Flow (Mgal/d)	EPA Region	Startup Year	Employment
12015	D	Biological	0.08	III	1960	300 - 400
12022	A C	Biological	1.30	III	1951	100 - 200
12026	C	Biological	0.08	II	1950	0 - 100
12036	A	Biological	1.20	V	1948	100 - 200
12038	A B C D	Biological	1.00	V	1954	1000 - 1100
12044	A D	None	0.13	V	1938	800 - 900
12066	B C D	Biological	0.26	V	1953	600 - 700
12097	C D	Biological	0.10	V	1951	100 - 200
12108	A C D	None	0.14	II	N/A	300 - 400
12119	A D	Biological	0.05	II	1977	N/A
12132	A C	Biological	1.00	III	1941	300 - 400
12161	A C D	Biological	1.00	II	1969	900 - 1000
12204	A B C D	Biological	0.20	II	1907	2000 - 2100
12210	B C	Biological	0.01	IV	1973	100 - 200
12231	A D	Biological	0.50	II	1968	600 - 700
12236	C	Biological	0.90	IV	1952	200 - 300
12248	D	Biological	0.04	III	1961	800 - 900
12256	A B C D	Primary	30.00	I	1948	1200 - 1300
12257	A B C D	Biological	0.50	V	1965	2100 - 2200
12342	A C D	None	1.06	II	N/A	300 - 400
12411	B C D	Biological	0.35	IV	1970	700 - 800
12420	B D	Biological	0.17	V	1973	100 - 200
12439	C D	Biological	0.01	II	1974	100 - 200
12447	A B C D	Chemical	1.50	V	N/A	4000 - 4100
12462	A	Biological	0.30	VII	1972	0 - 100
12999*	C D	Chemical	0.45	VII	N/A	N/A

Subcategory Totals: A = 15
B = 9
C = 18
D = 19

* 308 Portfolio was not received from this plant

TABLE III-7

PHARMACEUTICAL INDUSTRY

COMPARISON OF SCREENING PLANTS
VERSUS TOTAL PHARMACEUTICAL MANUFACTURING POPULATION

Item	Screening Plants	Total Pharm. Mfr's.
Total Number of Plants	26	464
Subcategory		
A	57.7%	8.0%
B	34.6	17.2
C	69.2	28.7
D	73.1	80.2
Wastewater Quantity		
Less than 0.1 Mgal/d	23.1%	80.0%
0.1 to 1.0 Mgal/d	46.2	15.1
1.0 to 10.0 Mgal/d	26.9	4.3
Greater than 10.0 Mgal/d	3.8	0.6
EPA Region		
I	3.7%	3.7%
II	29.6	35.6
PR	14.8	9.5
III	14.8	9.5
IV	11.1	10.6
V	33.3	20.0
VI	0.0	3.4
VII	7.4	6.0
VIII	0.0	1.3
IX	0.0	8.6
X	0.0	1.3
Plant Age (1978 Basis)		
Less than 5 years	18.2%	16.2%(*)
5 to 10 years	18.2	22.7 (*)
10 to 25 years	22.7	27.8 (*)
25 to 50 years	36.4	19.9 (*)
50 to 100 years	4.5	12.0 (*)
Greater than 100 years	0.0	1.4 (*)
Employment		
Less than 100	8.4%	36.9%
100 to 500	45.8	41.0
500 to 1000	20.8	10.8
Greater than 1000	25.0	11.3

* Only (original) 308 Portfolio plants had these data and, thus, were used to calculate these figures.

TABLE III-8

PHARMACEUTICAL INDUSTRY

CHARACTERISTICS OF THE FIVE PLANTS SELECTED FOR VERIFICATION

PLANT CODE	SUBCATEGORY	MAJOR TREATMENT	COMMENTS
12026	C	Activated Sludge Aerated Lagoon Polishing Pond	Has Solvent Recovery
12038	ABCD	Activated Carbon Activated Sludge Aerated Lagoon Physical-Chemical Thermal Oxidation	Uses Cyanide; Has Steam Stripping; Has Solvent Recovery
12097	CD	Activated Sludge Physical-Chemical	Uses Cyanide; Has Solvent Recovery
12236	C	Activated Sludge	Uses Cyanide; Has Cyanide Destruction Has Solvent Recovery
12411	BCD	Aerated Lagoon	On-Site Incineration of Solvents

TABLE III-9

PHARMACEUTICAL INDUSTRY

SUMMARY OF PRIORITY POLLUTANT INFORMATION: SCREENING/VERIFICATION DATA

Priority Pollutant	Number of Times Found
acenaphthene	3
acrolein	0
acrylonitrile	0
benzene	16
benzidine	0
carbon tetrachloride	5
chlorobenzene	5
1,2,4-trichlorobenzene	0
hexachlorobenzene	0
1,2-dichloroethane	9
1,1,1-trichloroethane	9
hexachloroethane	0
1,1-dichloroethane	3
1,1,2-trichloroethane	3
1,1,2,2-tetrachloroethane	1
chloroethane	0
bis(chloromethyl) ether	0
bis(2-chloroethyl) ether	1
2-chloroethylvinyl ether	0
2-chloronaphthalene	0
2,4,6-trichlorophenol	2
parachlorometa cresol	0
chloroform	17
2-chlorophenol	2
1,2-dichlorobenzene	3
1,3-dichlorobenzene	0
1,4-dichlorobenzene	2
3,3'-dichlorobenzidine	0
1,1-dichloroethylene	7
1,2-trans-dichloroethylene	1
2,4-dichlorophenol	0
1,2-dichloropropane	0
1,3-dichloropropylene	1
2,4-dimethylphenol	3
2,4-dinitrotoluene	2
2,6-dinitrotoluene	0
1,2-diphenylhydrazine	1
ethylbenzene	12
fluoranthene	0
4-chlorophenyl phenyl ether	0
4-bromophenyl phenyl ether	0
bis(2-chloroisopropyl) ether	3
bis(2-chloroethoxy) methane	0
methylene chloride	22
methyl chloride	2
methyl bromide	1
bromoform	1
dichlorobromomethane	0
trichlorofluoromethane	3
dichlorodifluoromethane	0
chlorodibromomethane	0
hexachlorobutadiene	0
hexachlorocyclopentadiene	0
isophorone	2
naphthalene	1
nitrobenzene	1
2-nitrophenol	4
4-nitrophenol	3
2,4-dinitrophenol	0
4,6-dinitro-o-cresol	1
N-nitrosodimethylamine	0
N-nitrosodiphenylamine	1
N-nitrosodi-n-propylamine	0
pentachlorophenol	3
phenol	15
bis(2-ethylhexyl) phthalate	12
butyl benzyl phthalate	4
di-n-butyl phthalate	5
di-n-octyl phthalate	0
diethyl phthalate	4
dimethyl phthalate	0
benzo(a)anthracene	0
benzo(a)pyrene	0
3,4-benzofluoranthene	0
benzo(k)fluoranthane	0
chrysene	0
acenaphthylene	0
anthracene	1
benzo(ghi)perylene	0
fluorene	2
phenanthrene	1
dibenzo(a,h)anthracene	0
ideno(1,2,3-C,D)pyrene	0
pyrene	0
tetrachlorethylene	4
toluene	16
trichloroethylene	4
vinyl chloride	0
aldrin	0
dieldrin	0
chlordane	0
4,4'-DDT	0
4,4'-DDE	0
4,4'-DDD	0
alpha-endosulfan	0
beta-endosulfan	0
endosulfan sulfate	0
endrin	0
endrin aldehyde	0
heptachlor	0
heptachlor epoxide	0
alpha-BHC	0
beta-BHC	0
gamma-BHC	0
delta-BHC	0
PCB-1242	0
PCB-1254	0
PCB-1221	0
PCB-1232	0
PCB-1248	0
PCB-1260	0
PCB-1016	0
toxaphene	0
antimony (total)	9
arsenic (total)	6
asbestos (fibrous)	-
beryllium (total)	0
cadmium (total)	9
chromium (total)	24
copper (total)	24
cyanide (total)	13
lead (total)	17
mercury (total)	22
nickel (total)	15
selenium (total)	8
silver (total)	8
thallium (total)	7
zinc (total)	24
2,3,7,8-tetrachloro-dibenzo-p-dioxin (TCDD)	0

Total Number Of Plants In The Data Base: 26

TABLE III-10

PHARMACEUTICAL INDUSTRY

SUMMARY OF MAJOR* PRIORITY POLLUTANTS IDENTIFIED FROM MULTIPLE SOURCES OF INFORMATION

Priority Pollutant	RTP Study	PEDCo Reports	308 Portfolio	Screening & Verification Sampling Programs
Acid Extractables				
65 Phenol		X	X	X
Base Extractables				
25 1,2-Dichlorobenzene	X			
Volatile Organics				
4 Benzene	X	X	X	X
6 Carbon Tetrachloride	X	X	X	
11 1,1,1 - Trichloroethylene	X			
23 Chloroform	X	X	X	X
29 1,1-Dichloroethylene		X		
30 1,2-Trans-Dichloroethylene		X		
38 Ethylbenzene				X
44 Methylene Chloride	X	X	X	X
86 Toluene	X	X	X	X
Metals				
119 Chromium			X	X
120 Copper		X	X	X
122 Lead		X	X	X
123 Mercury			X	X
124 Nickel			X	X
128 Zinc		X	X	X
Others				
121 Cyanide		X	X	X

* For this table toxic compounds were defined as "major" priority pollutants in accordance with the following criteria for each data source:

RTP - The pollutant was reported by at least one plant (26 plants reporting)
PEDCo - The pollutant was found in two or more subcategories (130 plants studied).
308 - The pollutant was identified by 25 or more plants (464 plants surveyed).
Screening/Verification - The pollutant was detected at ten or more plants (26 plants sampled).

TABLE III-11

PHARMACEUTICAL INDUSTRY
ANALYSIS OF MAJOR PRIORITY POLLUTANT RAW WASTE LOAD CONCENTRATIONS (ug/l):
SCREENING/VERIFICATION DATA

Priority Pollutant	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
Acid Extractables						
65 phenol	15	10	16500	180	2418	5294
Volatile Organics						
4 benzene	16	5	4000	100	453	980
23 chloroform	17	5	145500	150	8984	351880
38 ethylbenzene	12	1	1600	20	171	453
44 methylene chloride	22	10	1700000	320	82232	367225
86 toluene	16	2	63500	515	5832	15773
Metals						
119 chromium	24	5	650	45	90	136
120 copper	24	16	3110	85	214	620
122 lead	17	5	500	50	90	130
123 mercury	22	0.1	50	0.8	3.6	10.6
124 nickel	15	10	630	50	157	209
128 zinc	24	29	1395	250	304	278
Others						
121 cyanide	13	7	1980	280	478	597

Total Number of Plants in the Data Base: 26

Notes:

The following criteria were used to select data points for this analysis:

1. If a specific influent value was reported, the data were used as the RWL.
2. If a specific effluent value was reported, then:
   a. For "less than" influent values, the detection limit was used as the RWL.
   b. For "not detected" influent values, the RWL was assumed to be zero (0).
   c. For plants with no treatment, the effluent value was used as the RWL.
3. If both influent and effluent values were "less than" and/or "not detected", the data were not used.

TABLE III-12

PHARMACEUTICAL INDUSTRY

ANALYSIS OF MAJOR PRIORITY POLLUTANT RAW WASTE LOAD CONCENTRATIONS (ug/l):
308 PORTFOLIO DATA

Priority Pollutant	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
Acid Extractables						
65 Phenol	12	21	8000	196	987	2264
Volatile Organics						
4 Benzene	3	6	800	130	312	427
6 Carbon Tetrachloride	1	50	50	50	50	0
23 Chloroform	4	50	11000	186	2856	5431
44 Methylene Chloride	6	4	22000000	502	37000000	9000000
86 Toluene	7	9	290000	780	48590	100000
Metals						
119 Chromium	15	4	2000	108	422	632
120 Copper	13	10	540	140	193	173
122 Lead	12	4	8400	80	817	2395
123 Mercury	10	0.1	35	0.8	6	10.8
124 Nickel	11	7	500	100	214	199
128 Zinc	18	5	120000	284	10373	28900
Others						
121 Cyanide	12	10	2300	200	510	543

Total Number of Plants in the Data Base: 34

Notes:

The following criteria were used to select data points for this analysis:

1. If a specific influent value was reported, the data were used as the RWL.
2. If a specific effluent value was reported, then:
   a. For "less than" influent values, the detection limit was used as the RWL.
   b. For "not detected" influent values, the RWL was assumed to be zero (0).
   c. For plants with no treatment, the effluent value was used as the RWL.
3. If both influent and effluent values were "less than" and/or "not detected," the data were not used.

TABLE III-13

PHARMACEUTICAL INDUSTRY

COMPARISON OF MAJOR PRIORITY POLLUTANT RAW WASTE LOAD CONCENTRATIONS (ug/l):

308 PORTFOLIO VERSUS SCREENING/VERIFICATION DATA

Priority Pollutant	Median RWL's (ug/l): 308 Portfolio (X)	Screen/Verification (Y)
Acid Extractables		
65 Phenol	196	180
Volatile Organics		
4 Benzene	130	100
6 Carbon Tetrachloride	50	*
23 Chloroform	186	150
38 Ethylbenzene	*	20
44 Methylene Chloride	502	320
86 Toluene	780	515
Metals		
119 Chromium	108	45
120 Copper	140	85
122 Lead	80	50
123 Mercury	0.8	0.8
124 Nickel	100	50
128 Zinc	284	250
Others		
121 Cyanide	200	280

Regression Coefficients (for 12 comparable priority pollutants):

Correlation:	0.946	$Y = mX + b$
Slope (m):	0.658	
Intercept (b)	20.4	

* Not a major priority pollutant according to the data base.

TABLE III-14

PHARMACEUTICAL INDUSTRY

COMPARISON OF PRIORITY POLLUTANT RAW WASTE LOAD CONCENTRATIONS (ug/l)
BY SUBCATEGORY: SCREENING/VERIFICATION DATA

Priority Pollutant	Median RWL's by Subcategory* (mg/l):				
	A	B	C	D	All
Acid Extractables					
65 Phenol	230	235	255	230	180
Volatile Organics					
4 Benzene	385	195	75	230	100
23 Chloroform	150	110	150	140	150
38 Ethylbenzene	20	15	20	15	20
44 Methylene Choloride	500	95	405	315	320
86 Toluene	310	630	745	700	515
Metals					
119 Chromium	55	100	20	55	45
120 Copper	100	85	70	95	85
122 Lead	65	45	65	45	50
123 Mercury	0.9	0.9	0.9	0.9	0.8
124 Nickel	70	130	50	65	50
128 Zinc	315	310	265	260	250
Others					
121 Cyanide	395	290	290	240	280

* For purposes of this comparison the data from a screening and verification plant were used in each of the single subcategory analyses for which the plant had a subcategory operation. For example: data from an A B D plant were used in the subcategory A, B, and D analyses.

TABLE III-15

PHARMACEUTICAL INDUSTRY

ANALYSIS OF TRADITIONAL POLLUTANT RAW WASTE LOAD CONCENTRATIONS (mg/l):
SCREENING AND VERIFICATION DATA

Traditional Pollutant by Subcateogry	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
BOD:						
A	13	833	5810	1900	2440	1685
B	5	27	3250	1090	1270	1238
C	13	27	6433	1428	2190	2034
D	9	500	3250	1425	1630	999
COD:						
A	12	1410	12840	4407	5180	3522
B	4	365	5251	1286	2050	2222
C	12	757	14267	3802	5160	4287
D	10	365	6841	2465	2780	2004
TSS:						
A	10	113	3480	900	1030	931
B	3	30	1200	316	512	610
C	12	15	3480	436	740	982
D	7	15	1200	316	370	402

Total Number of Plants in the Data Base: 26

Notes:

1. For purposes of this analysis, the data from a screening and verification plant were used in each of the single subcategory analyses for which the plant had a subcategory operation. For example: data from an A B D plant were used in the subcategory A, B, and D analyses.
2. Only reported data were used in the analysis. Assumed values for "less than, not detected, and unknown" data were not used.

TABLE III-16

PHARMACEUTICAL INDUSTRY

ANALYSIS OF TRADITIONAL POLLUTANT RAW WASTE LOAD CONCENTRATIONS (mg/l):
308 PORTFOLIO DATA

Traditional Pollutant by Subcateogry	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
BOD:						
A	13	497	8460	1551	2480	2323
B	15	4	7520	611	1600	2242
C	36	47	12374	1478	2480	3080
D	40	30	10670	1312	1970	2658
COD:						
A	9	430	16748	2978	5200	5477
B	11	10	12032	916	3200	4187
C	28	154	22250	3219	5270	5763
D	27	50	16748	2924	3860	4650
TSS:						
A	7	266	2264	650	910	728
B	10	3	1645	262	380	477
C	20	7	4483	258	630	1010
D	23	30	4128	273	560	874

Total Number of Plants in the Data Base: 61

Notes:

1. For purposes of this analysis the data from a 308 Portfolio plant were used in each of the single subcategory analyses for which the plant had a subcategory operation. For example: data from an A B D plant were used in the subcategory A, B, and D analyses.
2. Only reported data were used in the analysis. Assumed values for "less than, not detected, and unknown" data were not used.

TABLE III-17

PHARMACEUTICAL INDUSTRY

COMPARISON OF TRADITIONAL POLLUTANT RAW WASTE LOAD CONCENTRATIONS (mg/l): SCREENING/VERIFICATION VERSUS 308 PORTFOLIO DATA

	Mean RWL's (mg/l):		
Subcategory	BOD	COD	TSS
Screening/Verification (Y):			
A	2440	5180	1030
B	1270	2050	520
C	2190	5160	740
D	1630	2780	370
308 Portfolio (X):			
A	2480	5200	910
B	1600	3200	380
C	2480	5270	630
D	1970	3860	560

Regression Coefficients:

Correlation: 0.968 $Y = mX + b$
Slope (m): 0.912
Intercept (b): - 55.7

TABLE III-18

PHARMACEUTICAL INDUSTRY

ANALYSIS OF WASTEWATER FLOW CHARACTERISTICS [1]

Parameter	A	B	C	D	Total
Single Subcategory Plant Flows (Total)[2]	1.30 MGD	0.67 MGD	8.80 MGD	9.80 MGD	--
No. of Single Subcat. Plants w/Flow Data [2]	3	15	34	131	--
Mean Subcategory Flows	0.435 MGD	0.045 MGD	0.260	0.075	--
No. of Discharges (All Subcategories)[3]	35	71	106	259	471
Direct	10	9	23.5	37	79.5
Indirect	25	62	82.5	222	391.5
Estimated Total Subcategory Flows [4]	15.0 MGD	3.2 MGD	27.6 MGD	19.4 MGD	65.2 MGD
Sum of Raw Data Flows [5]	____	____	____	____	60.4 MGD

1 All data, used in this analysis, are from 308 Portfolio data base.

2 Available data from single subcategory only plants.

3 All subcategories having direct and/or indirect discharges. For combined direct-indirect plants, discharge was assumed to be one-half direct/one-half indirect. See Section VI for details.

4 Product of Mean Subcategory Flows and Number of Discharges

5 Sum of raw data flows for each plant in the data base. Note: This value is the result of data from three-fourths of all direct and indirect discharging plants. The flows from the remaining one-fourth of these plants are unknown.

SECTION IV

SUBCATEGORIZATION

INTRODUCTION

Like so many other industries being studied by the Agency's Effluent Guidelines Division, the pharmaceutical manufacturing point source category exhibited a number of diverse characteristics within itself. Thus, a subcategorization review was needed to define the similarities and differences among the plants in the industry. With this information the EPA could then determine where separate regulations might be necessary.

PREVIOUS SUBCATEGORIZATION

In the 1976 Development Document a number of factors were considered for the purpose of evaluating differences within the pharmaceutical manufacturing industry. Some of the factors examined were:

1. Plant size, age, and location
2. Employment
3. Raw materials
4. Manufacturing processes
5. Products
6. Nature of wastes generated
7. Treatability of wastewaters
8. Housekeeping practices

After carefully reviewing each of the above, the 1976 Development Document concluded that from a wastewater standpoint the types of manufacturing processes used were the most significant factor for subcategorizing the industry. As a result, for purposes of establishing BPT guidelines the pharmaceutical industry was grouped into five subcategories according to the following manufacturing processes:

A. Fermentation
B. Biological Extraction
C. Chemical Synthesis
D. Mixing, Compounding and Formulating
E. Research

The 1976 Development Document summarized the wastewater characteristics of each of the above subcategories as follows:

A. Fermentation processes are very large water users. With the spent beers being the major source, these wastewaters are characterized by very high BOD, COD, and suspended solids levels.

B. Biological extraction processes, on the other hand, are very small water users. Also, the concentrations of BOD, COD, and suspended solids in these wastewaters are low.

C. Chemical synthesis processes, like fermentation, are characterized as large water users with high pollutant loadings. However, both the flows and BOD, COD, and suspended solids levels are usually lower than those from fermentation.

D. Formulation processes are also small water users. In addition, these wastewaters have very low BOD, COD, and suspended solids concentrations.

E. Research activities can produce wastewaters with a wide range of pollutant loadings. However, the volume of these wastewaters is usually extremely low.

FUTURE SUBCATEGORIZATION

One of the first tasks of the present project was to analyze all of the newly acquired data to check the previous subcategorization of the industry. The purpose of this exercise was not only to confirm the conclusions of the previous study, but to examine the possibility of further sub-dividing the existing subcategories. Also, since the previous study dealt only in terms of traditional pollutants, an analysis was needed to determine the appropriate subcategorization scheme for priority pollutants.

After examining the information in Sections II and III of this report, it appeared that the 1976 Development Document's subcategorization scheme, i.e. wastewater flow and traditional pollutant loads related to the types of manufacturing processes employed, was still the best method of accounting for variations within the pharmaceutical industry. Therefore, the previously defined four principal subcategories (research activity was de-emphasized, because of its relative insignificance) were felt to be the most appropriate for purposes of any future regulatory evaluations.

In terms of the subcategorization analysis for priority pollutants, the information in Sections II and III of this report provide different results. A close examination of the data revealed that priority pollutant loads are not related to the type of manufacturing process used. In fact, none of the previously stated factors appeared to adequately describe any differences within the industry. Priority pollutants in the industry seem to be governed by each plant's individual preference for using them. Therefore, one overall main category, covering the entire industry, was felt to be the best subcategorization scheme for purposes of evaluating any future priority pollutant regulations.

SECTION V

SELECTION OF POLLUTANT PARAMETERS

INTRODUCTION

A considerable effort was expended by the Agency to find and quantify the presence of priority (toxic) pollutants and traditional (conventional and nonconventional) pollutants in the wastewaters of the pharmaceutical manufacturing industry. The results of that effort are presented in Section III of this document, describing the waste characteristics of the industry.

The Settlement Agreement in Natural Resources Defense Council, Inc. v. Train, 8ERC 2120 (D.D.C. 1976), modified March 9, 1979, requires that effluent limitations and standards be established for each of the 65 toxic pollutants or classes of toxic pollutants, unless the Administrator determines that it should be excluded from rulemaking under Paragraph 8 of the subject Agreement. Likewise, the Clean Water Act of 1977 (P.L. 95-217) not only upholds the above requirements, but also requires the Administrator to establish effluent limitations and standards for non-conventional and conventional pollutants, i.e. BAT, BCT, and Pretreatment standards.

PRIORITY POLLUTANTS

By examining the information in Section III of this report, it can be seen that 115 of the total 129 priority pollutants were identified in the wastewaters of the pharmaceutical industry. From an administration or enforcement standpoint, however, the adoption of effluent limitations and standards for each of the above priority pollutants would be a regulatory nightmare. Although the Settlement Agreement and the Clean Water Act of 1977 discussed the control of only 65 toxic pollutants or classes of toxic pollutants, it was felt that a burdensome number of regulations also would result by this approach. Therefore, an alternative regulatory approach should be developed.

After reviewing all of the data from Section III, 13 priority pollutants were designated as being significant because of their dominant occurrence in the industry's wastewater. These compounds are listed in Table V-1, along with a brief summary of their presence in the pharmaceutical industry. Although the EPA can establish limitations for all 13 priority pollutants, an alternative would be to select surrogates or indicators to represent these compounds for purposes of developing effluent guidelines. This decision would best be made by the EPA after a detailed review by the appropriate divisions within the agency and after further analysis of additional data presently being compiled within the EPA.

TRADITIONAL POLLUTANTS

After examining the available data on the pharmaceutical industry, a wide variety of traditional pollutants were found in its wastewaters. Only the pollutants covered by existing BPT regulations, however, are thought to warrant continued regulation. These are the conventional pollutants, BOD and TSS, and the non-conventional pollutant COD. They are also listed in Table V-1.

CHARACTERISTICS OF SIGNIFICANT POLLUTANTS

Presented below are brief summaries (108) of the important environmental characteristics of the pollutants which were thought to be significant in the pharmaceutical manufacturing industry.

Phenol - Although it appears to be less toxic than the chlorinated phenols and certain substituted phenols, its toxicity to microorganisms, plants, aquatic organisms and mammals, including man, has been demonstrated. Phenol also has been reported to exhibit carcinogenic activity in mice. These findings, together with potential pollution from waste sources and the possible chlorination of phenol, present in drinking water sources, indicate that phenol is potentially hazardous to aquatic and terrestrial life.

Benzene - The solubility and volatile nature of benzene indicate possible environmental mobility. Benzene has been detected at various concentrations in lakes, streams, and drinking water. Benzene may bioaccumulate in living organisms and appears to accumulate in animal tissues that exhibit a high lipid content or represent major metabolic sites such as the liver and the brain. Benzene is suspected of being a human carcinogen. Studies, for example, of the effect of benzene vapors on humans indicate a relationship between chronic benzene poisoning and a high incidence of leukemia.

Chloroform - Many studies have shown chloroform to be toxic to organisms at various levels of the food chain; in higher organisms it exhibits both temporary and lasting effects. Several studies indicate that chloroform is carcinogenic to rats and mice. Human exposure to chloroform can lead to liver and renal damage, and depression of the central nervous system. Epidemiological studies in humans hint that there may be a relationship between cancer incidence and ingestion of water containing chloroform.

Ethylbenzene - Exposure to ethylbenzene has been shown to adversely affect both aquatic and human life. The compound can affect fish by direct toxic action and by imparting a taste to fish flesh. In man and in animals, ethylbenzene is an irritant of mucous membranes.

Methylene Chloride - Methylene chloride has not generally been regarded as highly toxic, but poisonings, primarily from inhalation exposures, have been reported. Methylene chloride affects the functioning of the central nervous system. It is also irritating to mucous membranes (eyes, respiratory tract) and skin. In addition, it results in production of carbon monoxide as a metabolite which interferes with oxygen transfer and transport. Gynecologic problems in female workers exposed for long periods to methylene chloride vapors have been reported. In pregnant women, chronic exposure resulted in methylene chloride passing through the placenta into the fetus. Methylene chloride was also found in milk of lactating women after a few hours into a work shift.

Toluene - Freshwater aquatic studies indicate that toluene is toxic to fish. Several marine studies indicate that toluene is toxic to marine bacteria, phytoplankton, and marine fish. A study using mice showed that toluene is a central nervous system depressant that can cause behavioral changes, as well as loss of consciousness and death at high concentrations. Human exposure to toluene for a two year period has led to cerebellar disease and impaired liver function.

Chromium - The level of chromate ions that would have no effect on man appear to be so low as to prohibit determination. The toxicity of chromium salts to fish and other aquatic life varies widely with the species, temperature, pH, valence of the chromium, and synergistic or antagonistic effects, especially those of hard water. Studies show that trivalent chromium is more toxic to fish of some types than is hexavalent chromium. Other studies show opposite effects. Fish food organisms and other lower forms of aquatic life are extremely sensitive to chromium; it also inhibits the growth of algae. Therefore, both hexavalent and trivalent chromium must be considered potentially harmful to particular fish or organisms. Fish appear to be relatively tolerant of chromium, but some aquatic invertebrates are quite sensitive.

Copper - The toxicity of copper to aquatic life is dependent on the alkalinity of the water, as the copper ion is complexed by anions present, which in turn affects toxicity. At lower alkalinity copper is generally more toxic to aquatic life. Other factors affecting toxicity include pH, the presence of organic compounds, and the species tested. Relatively high concentrations of copper may be tolerated by adult fish for short periods of time; the critical effect of copper appears to be its higher toxicity to young or juvenile fish.

Lead- Lead is a toxic material that is foreign to humans and animals. The most common form of lead poisoning is called plumbism. Lead can be introduced into the body from an atmosphere containing lead or from food and water. Lead cannot be easily excreted and is cumulative in the body over long periods of time, eventually causing lead poisoning. In humans lead poisoning can cause congestion of the lungs, liver, spleen, and kidneys. Lead exposure has been reported to decrease reproductive ability in man.

It has also been shown to cause disturbances in blood chemistry, neurological disorders, kidney damage, and adverse cardiovascular effects. Lead has also caused the formation of tumors in rats and mice.

Mercury - In humans, mercurials have been associated with neurological disorders, sensory impairment, tremors, buccal ulceration, gastro-intestinal complaints and multisystem involvement due to general encephalopathy. Mercurials will damage the bronchial epithelium and interrupt respiratory function in freshwater invertebrates. Rainbow trout will suffer loss of equilibrium, and trout fry are more susceptible to mercury poisoning than fingerlings. Mercurial compounds may interfere with receptor membranes in fish. Nonhuman animals have been shown to suffer central nervous system damage as well as teratogenesis and spontaneous tumorigenesis. There are no data available on the teratogenicity or mutagenicity of inorganic mercury in human populations. Furthermore, there is no evidence of mercury exposure producing carcinogenicity.

Nickel - Studies of the toxicity of nickel to aquatic life indicate that tolerances vary widely and are influenced by species, pH, synergistic effects, and other factors. Available data indicate that nickel is toxic to aquatic plant life, affects the reproduction of some freshwater crustacea, and can kill various marine larvae.

Zinc- Toxic concentrations of zinc compounds cause adverse change in the morphology and physiology of fish. Acutely toxic concentrations induce cellular breakdown of the gills, and possibly the clogging of the gills and mucous. 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. In general, salmonids are most sensitive to elemental zinc in soft water; the rainbow trout is the most sensitive in hard waters. In tests with several heavy metals, the immature aquatic insects seem to be less sensitive than many tested fish. Although available data are sparse on the effects of zinc in the marine environment, zinc does accumulate in some species. Toxicities of zinc in nutrient solutions have been demonstrated for a number of plants. In humans, zinc ingestion has produced no clinical symptoms at daily intakes of 150 mg/day for as long as six months. Food poisoning has been reported from ingestion of a meal estimated to contain nearly 1,000 ppm of zinc and another case among people who had drunk punch containing zinc at a concentration of 2,200 ppm.

Cyanide - Cyanide toxicity is essentially an inhibition of oxygen metabolism, i.e., rendering the tissues incapable of exchanging oxygen. The cyanogen compounds are true noncumulative protoplasmic poisons since they arrest the activity of all forms of animal life. Cyanide shows a very specific type of toxic action.

It inhibits the cytochrome oxidase system which facilitates electron transfer from reduced metabolites to molecular oxygen. Cyanides are more toxic to fish than to lower aquatic organisms such as midge larvae, crustaceans, and mussels. Toxicity to fish is a function of chemical form and concentration, and is influenced by the rate of metabolism (temperature), the level of dissolved oxygen, and pH. Also, cyanides are known to be degraded by the human liver to the less toxic thiocyanate and despite their high levels of acute toxicity they are not known to be chronically toxic to humans.

Biochemical Oxygen Demand (BOD) - The BOD of a waste adversely affects the dissolved oxygen resources of a body of water by reducing the oxygen available to fish, plant life, and other aquatic species. It is possible to reach conditions which totally exhaust the dissolved oxygen in the water, resulting in anaerobic conditions and the production of undesirable gases such as hydrogen sulfide and methane. The reduction of dissolved oxygen can be detrimental to fish populations, fish growth rate, and organisms used as fish food. A total lack of oxygen due to excessive BOD can result in the death of all aerobic aquatic inhabitants in the affected area.

Water with a high BOD may indicate the presence of decomposing organic matter and associated increased bacterial concentrations that degrade its quality and potential uses. High BOD may increase algae concentrations and blooms which result from increased nutrients made available from decaying organic matter.

Total Suspended Solids (TSS) - TSS may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension they increase the turbidity of the water, reduce light penetration, and impair the photosynthetic activity of aquatic plants.

Aside from any toxic effect attributable to substances leached out by water, suspended solids may kill fish and shellfish by causing abrasive injuries, by clogging gills and respiratory passages, by screening out light, and by promoting and maintaining the development of noxious conditions through oxygen depletion. Suspended solids also reduce the recreational value of the water.

Chemical Oxygen Demand (COD) - COD compounds which can be more resistant to biological oxidation are becoming of greater and greater concern, not only because of their slow but continuing oxygen demand on the resources of the receiving water, but also because of their potential health effects on aquatic and human life. Some of these compounds have been found to have carcinogenic, mutagenic, and similar adverse effects, either singly or in combination. Concern about these compounds has increased as a result of demonstrations that their long life in receiving waters -- the result of a slow biochemical oxidation rate -- allows them to contaminate downstream water intakes. The commonly used systems of water purification are not effective in removing these types of materials, and disinfection (such as chlorination) may convert them into even more hazardous materials.

TABLE V-1

PHARMACEUTICAL INDUSTRY
SUMMARY OF SIGNIFICANT POLLUTANT PARAMETERS

Pollutant Category	Raw Material* (No. of Plants)	Final Product* (No. of Plants)	Identified in Wastewater+ (Percentage of All Plants)
PRIORITY POLLUTANTS:			
Acid Extractables			
Phenol	74	9	58%
Volatile Organics			
Benzene	46	4	62%
Chloroform	69	4	65%
Ethylbenzene	2	1	46%
Methylene Chloride	90	2	85%
Toluene	78	3	62%
Metals			
Chromium	17	2	92%
Copper	37	2	92%
Lead	11	1	65%
Mercury	25	2	85%
Nickel	17	3	58%
Zinc	53	3	92%
Others			
Cyanide	34	1	50%
CONVENTIONALS:			
BOD	N/A	N/A	100%
TSS	N/A	N/A	100%
NONCONVENTIONALS:			
COD	N/A	N/A	100%

* From 308 Portfolio data base
\+ From Screening/Verification data base

SECTION VI

CONTROL AND TREATMENT TECHNOLOGY

INTRODUCTION

This section addresses the control and treatment technologies which are currently used or available to remove or reduce those wastewater pollutants generated by the pharmaceutical manufacturing industry. Although the industry's wastewaters are known to vary in quantity and quality, all should be readily treatable by the techniques presented herein. In identifying appropriate control and treatment technologies the Agency assumed that each manufacturing plant had installed or would install the equipment necessary to comply with limitations based on BPT. Thus, the technologies described below are those which can further reduce the discharge of pollutants into navigable waters or POTW systems. They are divided into two broad classes: in-plant and end-of-pipe technologies.

The final item of importance in this section is the discharge methods employed by the industry. Since the ultimate receiving point of a plant's wastewater can be critical in determining the overall treatment effort required, information on the types of discharges can be very important in the selection of appropriate control and treatment technologies. A summary of the types of discharge methods used by the pharmaceutical industry is presented at the end of this section.

IN-PLANT SOURCE CONTROLS

The intent of in-plant source controls is to reduce or eliminate the hydraulic and/or pollutant loads which are generated by specific sources within the overall manufacturing process. By implementing controls at the source, the impact on and requirements of subsequent downstream treatment systems can be minimized.

Many of the newer pharmaceutical manufacturing plants are being designed with the reduction of water use and subsequent minimization of contamination as part of the overall planning and plant design criteria. Improvements also have been made in existing plants to better control their manufacturing processes and other activities with regard to their environmental aspects. Some examples of in-plant source controls that have been effective in reducing pollution loads are:

1. Production processes have been modified or combined and reaction mixtures have been concentrated, reducing waste loads, as well as increasing yields. Processes have also been reviewed and revised to reduce the number of toxic substances used.

2. Attempts are made to concentrate and segregate wastes at their source, minimizing or eliminating wastes where possible. New process equipment is designed to produce effluents requiring no further treatment.

3. Several techniques have been employed by various Subcategory A plants in an effort to reduce the volume of fermentation wastes discharged to end-of-pipe treatment systems. These include concentration of "spent beer" wastes by evaporation and dewatering and drying of waste mycelia. The resulting dry product in some instances has sufficient economic value as an animal feed supplement to offset part of the drying cost.

4. Several plants have installed automatic TOC monitoring instrumentation and others have utilized pH and TOC monitoring to permit early detection of process upsets which may result in excessive discharges to sewers.

5. The recovery of waste solvents is a common practice among plants using solvents in their manufacturing processes. However, several plants have instituted further measures to reduce the amount of waste solvent discharge. Such measures include incineration of solvents that cannot be recovered economically and of "bottoms" from solvent recovery units, and design and construction of solvent recovery columns to strip solvents beyond the economical recovery point.

6. The use of barometric condensers can result in significant water contamination, depending upon the nature of the materials entering the discharge water stream. As an alternative, several plants are using surface condensers to reduce hydraulic or organic loads.

7. Water-sealed vacuum pumps often create water pollution problems. Several plants are using a recirculation system as a means of greatly reducing the amount of water being discharged.

8. Reduction of once-through cooling water by recycling through cooling towers is used in numerous plants and results in decreased total volume of discharge.

9. Stormwater runoff from manufacturing areas can contain significant quantities of pollutants. Separation of stormwater is practiced throughout the industry and often facilitates the isolation and treatment of contaminated runoff.

IN-PLANT TREATMENT

Besides implementing source controls to reduce or eliminate the waste loads generated within the manufacturing process itself, another alternative is available. In-plant treatment is directed at removing certain pollutant parameters before they are combined with the plant's overall wastewaters and subsequently diluted. In a general sense in-plant treatment processes are end-of-pipe treatment within the plant itself, designed to treat specific waste streams. Although in-plant technologies can remove a variety of pollutants, their principal applications are for the treatment of toxic or priority pollutants. In the pharmaceutical manufacturing industry three classes of priority pollutants are of particular importance. As indicated in Section III, the major priority pollutants are: solvents, metals, and cyanide. Thus, the discussions presented below on in-plant technologies concern the treatment of these three classes of pollutants.

The 308 Portfolio data base was the principal source of information relative to the use of in-plant treatment by the pharmaceutical industry. However, before continuing, certain points regarding the 308 Portfolio data base must be clarified. Specific information on the use of in-plant treatment was requested only by the Supplemental 308 Portfolio. Information on in-plant technologies was not specifically requested in the (original) 308 Portfolio. (At the time of the original 308 mailing, data on in-plant treatment was not thought to be a critical item. This philosophy was changed prior to the Supplemental 308 mailing). However, some in-plant treatment information was obtained for the (original) 308 Portfolio plants. It was gathered via three mechanisms: 1) some plants provided "additional" data or comments on the questionnaire, relative to in-plant treatment; 2) a small amount of information was gathered over the telephone; 3) the wastewater sampling programs discussed in Section III identified the use of a few in-plant technologies.

Table VI-1 presents a summary of the in-plant treatment technologies identified from the various data bases, along with the number of plants that employ each process. A listing of each plant's treatment system, including in-plant treatment, is presented in Appendix J.

Cyanide Destruction Technologies

Present cyanide treatment processes that have been demonstrated to be effective are based upon two fundamental techniques: chemical oxidation and thermal/pressure treatment. Chemical oxidation is a reaction in which one or more electrons are transferred from the chemical being oxidized to the chemical initiating the transfer (oxidizing agent). As a result of the valence change, the oxidized substance can then react to form a more desirable compound. Thermal/pressure treatment is the application of high temperature and high pressure in order to break down chemical bonds. The end result is that the substance is broken down into submolecular form permitting reactions to more desirable compounds. Technologies using the above two techniques, which have been shown to be effective in reducing cyanide concentrations in industrial process wastewaters, are discussed below. The use of cyanide treatment in the pharmaceutical industry is summarized in Table VI-1.

Chlorination

Destruction of cyanide by oxidation with either chlorine gas under alkaline conditions or with sodium hypochlorite is a very common method to treat industrial wastewaters containing cyanide. Although more costly, sodium hypochlorite is less hazardous and simpler to handle. The oxidation procedure can be approximated p5 by the following two step chemical reaction:

(1) $Cl_2 + NaCN + 2NaOH = NaCNO + 2NaCl + H_2O$

(2) $3Cl_2 + 6NaOH + 2NCNO = 2NaHCO_3 + N_2 + 6NaCl + 2H_2O$

Cyanide is oxidized to cyanate completely and rapidly at a pH of about 9.5 to 10.0 as shown in equation (1). Usually 30 minutes are required to insure a complete reaction. The oxidation of cyanide to cyanate is accompanied by a marked reduction in the volatility and a thousand fold reduction in toxicity.

However, since cyanate may revert back to cyanide under some conditions, additional chlorine is provided to oxidize cyanate to carbon dioxide and nitrogen as shown in Equation 2, above. At pH levels around 9.5 to 10.0 several hours are required for the complete oxidation of the cyanate, but only one hour is necessary at pH between 8.0 and 8.5. Also, excess chlorine must be provided to break down cyanogen chloride, a highly toxic intermediate compound formed during the oxidation of cyanate.

Theoretically, oxidation of one part of cyanide to cyanate requires 2.73 parts of chlorine, but in practice, 3 to 4 parts of chlorine are used. Complete oxidation of one part cyanide to carbon dioxide and nitrogen gas theoretically requires 6.82 parts of chlorine, but nearly 8 parts are normally necessary in practice. The chlorine required in practice is higher than the theoretical amount because other substances in the wastewater compete for the chlorine.

Soluble iron interferes seriously with the alkaline chlorination of cyanide wastes. Iron and cyanide form an extremely stable complex, and chlorine is ineffective in oxidizing such complexes. Similar difficulties result from formation of nickel cyanides. Ferrocyanides are reported treatable by alkaline chlorination at temperatures of 71°C (160°F) and a pH of about 12.0.

Ammonia interferes with the chlorine oxidation process, and the demand is increased by the formation of chloramines. When cyanide is only being oxidized to cyanate, it is usually not economical to remove the ammonia by breakpoint chlorination, which requires almost 10 parts of chlorine per part of ammonia. Complete cyanate formation can be accomplished by allowing an extra 15 minutes contact time. When complete oxidation of the cyanide is to be accomplished, the ammonia must be removed by breakpoint chlorination so that a free chlorine residual can be maintained to break down the cyanogen chloride.

An example of a cyanide destruction system using chlorination is shown in Figure VI-1.

When considering some of the advantages of the chlorination process, it can be seen why this technology has received widespread application. First, it is a relatively low cost system and does not require complicated equipment. It also fits well into the flow scheme of a wastewater treatment facility. The process will operate effectively at ambient conditions and is well suited for automatic operation, minimizing labor requirements.

The chlorination process, however, is not without limitations or disadvantages. For example, toxic, volatile intermediate reaction products can be formed. Thus, it is essential to properly control pH to ensure that all reactions are carried to their end point. Also, for waste streams containing other oxidizable matter, the chlorine may be consumed in oxidizing these materials and interfere with the treatment of the cyanide. Finally, for those systems using gaseous chlorine, a potentially hazardous situation exists when it is stored and handled.

The oxidation of cyanide-bearing wastewaters using chlorine is a classic technology. However, its use by the pharmaceutical industry is limited to a few plants. From the study to develop BPT regulations for the electroplating industry (109), conducted by the EPA's Effluent Guidelines Division, it was shown that cyanide levels around 40 ug/l are achievable by in-plant chlorination processes.

Ozonation

Although they are excellent from a biological standpoint, air and oxygen are not considered to be effective chemical agents in the treatment of industrial wastewaters. However, ozone (allotropic form of oxygen) is a good oxidizing agent and can be used to treat process wastewaters which contain cyanide. In fact, it oxidizes many cyanide complexes that are not broken down by chlorine, for instance, iron and nickel complexes. Ozonation is primarily used to oxidize cyanide to cyanate and to oxidize phenols and chromophores to a variety of nontoxic products.

With traces of copper and manganese, as catalysts, cyanide is reduced to very low levels independent of starting concentrations and form of the complex. The oxidation of cyanide by ozone to cyanate occurs in about 15 minutes at a pH of 9.0 to 10.0, but the reaction is almost instantaneous in the presence of traces of copper. The pH of the cyanide waste is often raised to 12.0 so that complete oxidation occurs before the pH drops to 8.0 in the process.

Oxidation of cyanate to the final end products, nitrogen and bicarbonate, is a much slower and more difficult process, unless catalysts are present. Therefore, since ozonation will not readily effect further oxidation of cyanate, it is often coupled with independent processes, such as dialysis or bio-oxidation.

As with the chlorination process, ozonation has its advantages and disadvantages. Like chlorination, the ozonation process is well suited to automatic control and will operate effectively at ambient conditions. Also, the reaction product (oxygen) is beneficial to the treated wastewater. Since the ozone is generated on-site, procurement, storage, and handling problems are eliminated.

The ozonation process does have its drawbacks. First, it has relatively higher capital and operating costs than chlorination. And like chlorination, interference is possible, if other oxidizable matter is present in the waste stream. Finally, in most cases the cyanide is not effectively oxidized beyond the cyanate level.

The use of the ozonation treatment process is beginning to receive more and more usage. Its initial applications in the metal finishing industry have shown it to be quite effective for cyanide removal.

Alkaline Pyrolysis

Removal of cyanide from process wastewaters can be accomplished without the use of strong oxidizing chemicals. For the alkaline pyrolysis system, the principal treatment action is based upon the application of heat and pressure. In this process, a caustic solution is added to the cyanide-bearing wastewaters to raise the pH to between 9.0 and 12.0. Next, the wastewater is transferred to a continuous reactor, where it is subjected to temperatures of about 165 to 185^{o}C (329 to 365^{o}F) and pressured from approximately 90 to 110 psig. The breakdown of cyanide in the reactor is generally accomplished with a residence time of about 1.5 hours.

An example of an alkaline pyrolysis system for treating cyanide-bearing wastewaters is shown in Figure VI-2.

The absence of chemicals in this process eliminates procurement, storage, and handling problems. As with other cyanide processes, alkaline pyrolysis is well suited to automatic control.

However, since the process employs heat and pressure (and related equipment), it has a relatively higher cost. Also, the system tends to be more appropriate for smaller wastewater flows.

As was the case with chlorination, only a few plants in the pharmaceutical industry reported using alkaline pyrolysis for cyanide treatment. But, the data available from these plants indicated that the cyanide levels, achievable by this technology, are similar to those from the chlorination process.

Metals Removal Technologies

Proven metals treatment technologies are based upon two basic techniques: reduction/precipitation and filtration. Reduction/precipitation involves the adjustment of pH to a point where the metallic substances become insoluble in water and subsequently settle out. The reduction step is necessary for those metals, such as chromium, that are highly soluble in the high valence state. Filtration can then be used to polish the clarified wastewaters to further remove the precipitated metallic hydroxides. Treatment technologies using the above two techniques, which have been demonstrated to be effective in reducing metals concentrations in industrial process wastewaters, are discussed below. The use of metals treatment in the pharmaceutical industry is summarized in Table VI-1.

Chemical Reduction

Some metals, chromium in particular, must be reduced from their high valence states before they can be precipitated. The most common method in use presently is to perform the reduction chemically. Chemical reduction is a reaction in which one or more electrons are transferred to the chemical being reduced from the chemical initiating the transfer (reducing agent). Since chromium is the predominant metal requiring reduction, it will be discussed in this report.

As noted above, the main application of chemical reduction in the treatment of industrial wastewater is in the reduction of hexavalent chromium to trivalent chromium. The reduction enables the trivalent chromium to be separated from solution in conjunction with other metal salts by precipitation. Sulfur dioxide, sodium bisulfite, sodium metabisulfite, and ferrous sulfate form strong reducing agents in aqueous solution and are, therefore, useful in industrial waste treatment facilities for the reduction of hexavalent chromium to trivalent chromium. Gaseous sulfur dioxide is probably the most widely used agent in this process. The reactions involved may be illustrated as follows:

(1) $3SO_2 + 3H_2O = 3H_2SO_3$

(2) $3H_2SO_3 + 2H_2CrO_4 = Cr_2(SO_4)_3 + 5H_2O$

The above reaction is favored by low pH. A pH of 2.0 to 3.0 is normally required for situations requiring complete reduction. At pH levels above 5.0, the reduction rate is slow. Oxidizing agents such as dissolved oxygen and ferric iron interfere with the reduction process by consuming the reducing agent.

An example of a chromium reduction system for treating process wastewaters containing chromates is presented in Figure VI-3.

The principal advantage of this process is its demonstrated effectiveness. In all of its applications within industry, chemical reduction has successfully treated high valence metals. In addition, the process is well suited to automatic control. Chemical reduction processes also operate at ambient conditions.

However, chemical reduction is not without some limitations. Careful pH control is required for effective reduction. In addition, when waste streams contain other reducible matter, the reducing agent may be consumed in reducing these materials and interfere with the treatment of the metals. Finally, for those systems using sulfur dioxide, a potentially hazardous situation exists when it is stored and handled.

The chemical reduction of chromium wastes with sulfur dioxide is a well-known and widely accepted treatment technology in numerous plants employing chromium or other high valence compounds in their manufacturing operations. Data from the previously cited EPA study (109) indicated that chromium levels below 500 ug/l can be achieved from in-plant chromium reduction processes.

Alkaline Precipitation

Alterations in the pH of a plant's wastewater occur throughout its flow scheme as alkaline and acidic waste streams are mixed. Generally the wastewater is acidic and thus not suitable for metals removal. Consequently, chemicals must be added in order to raise the pH, so that dissolved heavy metals become insoluble and are subsequently precipitated.

To accomplish this pH adjustment and precipitation, lime is added to the wastewater to increase the pH above 8.0. This decreases the solubility of the metal, which precipitates as a metal hydroxide. The precipitated metal is often removed by a clarification step.

If substantial sulfur compounds are present in the wastewater, caustic soda (sodium hydroxide) may be used instead of lime to prevent the precipitation of calcium sulfate, which increases the sludge volume. Treatment chemicals for adjusting pH prior to clarification may be added to a rapid mix tank, a mix box, or directly to the clarifier, especially in batch clarification. If metals such as cadmium and nickel are in the wastewater, a pH in excess of 10.0 is required for effective precipitation. This pH, however, is unacceptable for discharged wastewater, and the pH must therefore be reduced by adding acid. The acid is usually added as the treated wastewater flows through a small neutralization tank prior to discharge.

An example of a metals removals system using alkaline precipitation is shown in Figure VI-4.

Some advantages of alkaline precipitation are as follows: The process is a proven technology. It is well suited to automatic control and will operate at ambient conditions. Also, in many instances preceding treatment steps adjust the waste (especially pH) so as to aid the alkaline precipitation process. The end result is that the costs associated with this technology may be substantially lower.

However, alkaline precipitation does have some drawbacks. As with some of the other technologies, chemical interference is possible in the treatment of mixed wastes. In addition, this process generates relatively high quantities of sludge, requiring disposal.

Alkaline precipitation is another classic technology being used by many industries, although its usage in the pharmaceutical industry has been limited. Again, the EPA study to develop BPT regulations for the electroplating industry (109) indicated that the alkaline precipitation process is capable of achieving the following approximate levels: 300 ug/l for chromium and zinc; 200 ug/l for copper; 100 ug/l for lead, and 500 ug/l for nickel.

<u>Sulfide Precipitation</u>

In this process, heavy metals are removed as a sulfide precipitate. Sulfide is supplied by the addition of a very slightly soluble metal sulfide which has a solubility somewhat greater than that of the sulfide of the metal to be removed. Normally, ferrous sulfide is used. It is fed into a precipitator where excess sulfide is retained in a sludge blanket that acts both as a reservoir of available sulfide and as a medium to capture colloidal particles.

The process equipment required includes a pH adjustment tank, a precipitator, a filter, and pumps to transport the wastewater. The filter is optional and may be a standard, dual media pressure filter.

The process is applicable for treatment of all heavy metals. It offers a distinct advantage in the treatment of wastewater containing hexavalent chromium. The ferrous sulfide acts as a reducing agent at a pH of 8.0 to 9.0 and this reduces the hexavalent chromium and then precipitates it as a hydroxide in one step without pH adjustment. Therefore, hexavalent chromium wastes do not have to be isolated and pretreated by reduction to the trivalent form.

Sulfide precipitation will effectively treat all metals in a waste stream, and it does not require the preceding step of chromium reduction. This helps minimize treatment costs. With respect to the generated sludge, it has been found that sulfide sludges are less subject to leaching than hydroxide sludges. This results in minimal sludge disposal problems.

Although the sludge handling problems are minimized, sulfide precipitation does generate greater sludge volumes. Thus, there is a trade off of less leaching versus larger storage requirements. Also, when compared to alkaline precipitation, sulfide precipitation has relatively higher chemical costs.

Full size industrial units are presently being produced and are in use at several manufacturing facilities. Treated levels, obtainable with sulfide precipitation, are very similar to those for alkaline precipitation; with this technology being more effective for some metals and less effective for others.

Activated Carbon Adsorption

Adsorption is defined as the adhesion of dissolved molecules to the surface of solid bodies with which they are in contact. Those molecules retained in the interior of any solid are subjected to equal forces in all directions, whereas molecules on the surface are subjected to unbalanced forces. This results in an inward force which can only be satisfied if other molecules become attached to the surface. Granular activated carbon particles have two properties which make them effective and economical as adsorbents. First, they have a high surface area per unit volume which results in faster, more complete adsorption and second they have a high hardness value which lends itself to reactivation and repeated use.

The adsorption process typically uses preliminary filtration or clarification to remove insolubles. Next, the wastewaters are placed in contact with carbon so adsorption can take place. Normally, two or more beds are used so that adsorption can continue while a depleted bed is reactivated. Reactivation is accomplished by heating the carbon to 870 to 980°C (1600 to 1800°F) to volatize and oxidize the dissolved contaminants. Oxygen in the furnace is normally controlled at less than 1 percent to effect selective oxidation of contaminants.

The equipment necessary for an activated carbon adsorption treatment system consists of the following: a preliminary clarification and/or filtration unit to remove the bulk of the metallic solids; two or three columns packed with activated carbon; and pumps and piping. When regeneration is employed, a furnace, quench tanks, spent carbon tank, and reactivated carbon tank are generally required.

An example of an activated carbon adsorption unit is shown in Figure VI-5.

Activated carbon adsorption systems have consistently produced effluents of extremely high quality. Not only has it been demonstrated to be effective in metals removal, but activated carbon adsorption will also remove traditional pollutants as well as many organic priority pollutants.

Although it is a very efficient process, activated carbon does have some limitations. First, it has higher capital and operating costs than most of the other metal removal technologies. In addition, the waste stream may require preliminary treatment to minimize plugging of the carbon granules with suspended material.

Activated carbon adsorption systems have been in full scale commercial use for years, but its application for metals removal is relatively new.

Diatomaceous Earth Filtration

Diatomaceous earth filtration, combined with pH adjustment and precipitation, is an alternative to clarification treatment. The diatomaceous earth filter is used to remove metal hydroxides and other solids from the wastewater and provides an effluent of high quality.

A diatomaceous filter is comprised of a filter, a filter housing and associated pumping equipment. The filter element consists of multiple peat screens which are coated with diatomaceous earth. The size of the filter is a function of flow rate and desired operating time between filter cleanings.

Normal operation of the system involves pumping a mixture of diatomaceous earth and water through the screen leaves. This deposits the diatomaceous earth filter media on the screens and prepares them for treatment of the wastewater. Once the screens are completely coated, the pH adjusted wastewater can be pumped through the filter. The pH adjustment and precipitation tank perform the same functions in this system as in clarification, i.e., they transform dissolved metal ions into suspended metal hydroxides. The metal hydroxides and other suspended solids are removed from the effluent in the diatomaceous earth filter. The buildup of solids in the filter increases the pressure drop across the filter. At a certain pressure, the wastewater is stopped, the filter is cleaned, and the cycle is repeated.

The principal advantage to using a diatomaceous earth filter is the reduction in size of the waste treatment system compared to a system using a clarifier. The filter system can be installed within an existing plant structure even in cases where very little free floor space is available. The filter system's performance is comparable to that of a clarifier. One additional advantage is that the sludge removed from the filter is much drier than that removed from a clarifier (approximately 50 percent solids). This high solids content can significantly reduce the cost of hauling and landfill.

The major disadvantage to the use of a filter system is its higher operation and maintenance costs. In some cases this increase in O&M costs is offset by the lower capital costs required when considering land and outside construction.

Filters with similar operating characteristics to those described above are in common use by many industrial plants. In most cases a filtration system will improve the performance of the various precipitation technologies.

Solvent Recovery Technologies

As outlined in previous sections of this report, solvents are used extensively in the pharmaceutical manufacturing industry. However, due to the economic value, solvents are generally recovered and reused in the manufacturing processes. Solvent recovery operations typically employ techniques such as decantation, evaporation, distillation, and extraction. In many cases a plant uses only one solvent, making its recovery in a pure form rather easy. However, when a large number of different solvents are used, then recovery operations can become quite complex. Sometimes, rather than trying to separate out the individual materials, it is more economical to dispose of the recovered solvent mixture by incineration, landfilling, deep-well injection, or contract disposal.

Even if solvent recovery operations are utilized, the wastewater that remains after the solvents have been separated will still contain small amounts of these materials. In terms of in-plant technologies only one treatment process has been demonstrated to be effective in solvent removal: steam stripping. A discussion of this in-plant treatment process is presented below. The use of solvent treatment in the pharmaceutical industry is summarized in Table VI-1.

Steam Stripping

Steam stripping is a variation of distillation whereby steam is used as both the heating medium and driving force for the removal of volatile materials. Steam is added at the bottom of a tower and the wastewater being treated is fed at either the middle or near the top of the unit. As the steam passes through the wastewater, volatile materials are vaporized and removed with the steam, which exits the top of the tower.

In packed columns, the column is packed with materials that are inert and corrosion resistant. Packing materials have shapes that maximize the surface area for a given volume. Materials of construction for packing include steel, porcelain, stoneware and plastic. In tray towers, the column contains a series of trays which contain bubble caps or sieve perforations to allow for liquid-vapor contact.

The tower bottoms will contain only trace quantities of volatile materials. Tower overheads will contain the volatile materials removed along with condensed steam. If more than one compound has been removed, then further separation may be desired. Separation techniques include selective condensation, extraction and distillation.

An example of a steam stripping unit for removing solvents from process wastewaters is shown in Figure VI-6.

Steam stripping of organic-bearing wastewaters has been used to a limited extent in pharmaceutical manufacturing as well as in other industries. A preliminary study (72) by the EPA's Organic Chemical Branch has shown that very low pollutant levels are obtainable when steam stripping is used as an in-plant technology. With respect to the major priority pollutants in the pharmaceutical industry the study has shown that the following, approximate results can be obtained: 50 ug/l for benzene, 1,2 dichloroethane, chloroform, ethylbenzene, methylene chloride, and toluene; and 25 percent removal for phenol.

END-OF-PIPE TREATMENT

As opposed to in-plant treatment processes, which are used to treat specific pollutants in segregated waste streams, end-of-pipe technologies are usually designed to treat a number of pollutants in a plant's overall wastewater discharge. Although their most common applications are for the treatment of traditional pollutants, this study also evaluated the impact of these technologies on the removal of priority pollutants. In selecting end-of-pipe treatment processes for consideration as BAT, BCT, NSPS, PSES, and PSNS technologies, only those that would follow primary treatment were examined.

As in the case of in-plant treatment, the 308 Portfolio data base was the principal source of information for identifying the use of end-of-pipe treatment by the pharmaceutical industry. This information was requested by both 308 Portfolio mailings. As a cross-check for accuracy and completeness, the 308 Portfolio responses were compared with information available from the other data bases.

Table VI-2 presents a summary of the end-of-pipe technologies identified by the various data bases, along with the number of plants that employ each process. A listing of each plant's end-of-pipe treatment system is presented in Appendix J.

Biological Treatment

Biological treatment is the principal treatment method by which the majority of pharmaceutical manufacturing plants are now meeting existing BPT regulations. Therefore, this technology would be one of the first steps toward compliance with future BAT, BCT, and NSPS guidelines. Also, since many pharmaceutical plants have indirect discharges to POTW's and therefore, may not provide as high a degree of treatment as direct dischargers, biological treatment could be an important technology in meeting future PSES and PSNS guidelines.

Although it is discussed as one end-of-pipe treatment alternative, biological treatment actually encompasses a number of specific technologies, such as: activated sludge, trickling filters, aerated lagoons, rotating biological contactors, etc. Numerous publications are available for each of the biological treatment technologies, describing all aspects of the operations, advantages and limitations, etc. Therefore, for the sake of brevity, discussions of these specific treatment processes will not be presented in this report. Although each has its own unique characteristics, they are all based on one fundamental principle. All of the treatment processes rely on biological microorganisms for the removal of oxygen-demanding compounds. The use of biological treatment in the pharmaceutical industry is summarized in Table VI-2.

Besides the direct utilization of the treatment processes mentioned above, biological treatment can also encompass two other variations in the application of this technology, sometimes referred to as biological enhancement. Generally, these variations are accomplished by two methods: (1) modifications can be made in the conventional biological treatment itself, or (2) the conventional processes can be combined into a multistage system. Examples of modified conventional treatment are pure oxygen activated sludge, and biological treatment with powdered activated carbon. On the other hand, multi-stage biological treatment could be trickling filter-activated sludge, activated sludge rotating biological contactor, aerated lagoon-polishing pond, or any combination of two or more conventional biological treatment processes.

Some examples of typical biological enhancement configurations are shown in Figure VI-7.

Priority Pollutants

Just as it was for the raw waste load analyses in Section III, the screening/verification data base was the principal source of data for evaluating the performance of biological treatment. To analyze the priority pollutant effluent levels from this technology the procedures and assumptions that were used are similar to those used in the RWL determinations: In particular, no distinction was made on the impact of the different subcategories on biological treatment (if there were no significant variations in the RWL's or influents across the subcategories, none were expected in the effluents) and the median results were thought to be the more representative results. The only major difference was that a screening/verification plant had to have biological treatment to be considered in the following analyses.

Because the application of biological treatment could be accomplished in two ways, i.e. conventional treatment or enhancement, the priority pollutant effluent levels from both alternatives were evaluated. Table VI-3 presents the results of the analysis, performed on the screening/verification data, with respect to single-stage (conventional) biological treatment, while Table VI-4 presents a similar analysis for multistage (enhanced) biological treatment.

Upon comparing the median results from these two tables, virtually no difference could be noted between the performances of either biological alternative. (Note: Since the principal purpose of all types of biological treatment is the removal of traditional rather than toxic pollutants, it was anticipated that the two results would not show any significant differences). Therefore, in an attempt to supplement this comparison a separate analysis was conducted for purposes of evaluating enhanced biological treatment. For this supplemental analysis, plants achieving greater than 95 percent BOD removal were used as surrogates for multistage biological treatment, because it was thought that their performance would also be representative of enhanced biological treatment. The results of the analysis are presented in Table VI-5.

After examining the data in Tables VI-3, 4, and 5, the following observations were made: First, the results showed that no statistically significant differences in the priority pollutant levels, achievable by either biological alternative (conventional or enhanced) could be specifically defined. Second, the analytical results from the multi-stage systems appear to be closely related to the results from the single-stage systems. Therefore, in order to resolve these apparent discrepancies, the following assumptions were made: Since the multistage analytical results were similar to those from the single-stage analysis, both sets of data were combined and reanalyzed. This not only maximized the use of available data for analyzing the performance of biological treatment, but the results were thought to be more representative of the priority pollutant effluent levels being achieved by the industry as a whole. Table VI-6 presents the results of the analysis of priority pollutant effluent levels from all biological treatment, using data from both single-stage and multistage biological plants in the screening/verification data base. Thus, although multistage biological treatment was defined as biological enhancement, for this section of the study its data were used as if it were a conventional technology.

The next assumption dealt with quantifying the priority pollutant effluent levels for biological enhancement. Since neither the multistage analysis nor the surrogate analysis could document that lower levels were achievable by this biological treatment alternative, the median values from Table VI-6, the analysis of all biological treatment, were selected as being representative also of biological enhancement. Thus, for the purposes of this study the priority pollutant effluent levels achievable by conventional biological treatment and enhanced biological treatment were assumed to be the same.

As a cross-check, a similar analysis was conducted on the priority pollutant effluents levels from all biological treatment processes available from the 308 Portfolio data base. These results are presented in Table VI-7. As can be seen in Table VI-8 which presents a statistical comparison of the median values from Tables VI-6 and 7, the results from both data bases compare rather well. The discrepancies between the results of two analyses are probably due to the time differential between the data bases (screening/verification data are 1978-79, while 308 Portfolio data are 1976-77), which could reflect the industry's attempts to lower its priority pollutant discharges.

In conclusion, the screening/verification data were thought to be more appropriate for this study, since they are more recent information and the nature and scope of the sampling programs were specifically directed at gathering priority pollutant data. Therefore, the median priority effluent levels from all biological treatment, as shown in Table VI-6, were selected as being representative of the performance of conventional and enhanced biological treatment in the pharmaceutical industry as a whole.

Traditional Pollutants

In the case of end-of-pipe technologies, an evaluation of traditional pollutant removals is just as important as one for priority pollutants. This is particularly true with respect to biological treatment, since it is specifically designed to treat most traditional pollutants.

Prior to conducting the analysis of this technology, a number of important procedures and assumptions were developed. They are discussed below.

Like the RWL determinations, the impact of the various production subcategories was expected to be a significant factor in biological treatment performance. So, the screening/verification data, pertaining to biological treatment effluents, was segregated by individual subcategory prior to analysis. Another assumption, probably the most important, dealt with the two types of biological treatment, namely conventional treatment and biological enhancement. As in the case of priority pollutants, a review of the screening/verification data base indicated that the effluent levels from the multistage biological plants were no better than those from single-stage biological plants. Thus, the single-stage and multistage biological effluent data were combined for the analysis of conventional biological treatment. As a result, although multistage biological treatment was defined as biological enhancement in this section of the study its data was again used as if it was a conventional technology.

Table VI-9 presents the results of the analysis of traditional pollutant effluent levels by subcategory from all (conventional) biological treatment, using data from both single-stage and multistage biological plants in the screening/verification data base. Like the similar RWL analyses, the mean or average results were felt to be the more representative values for traditional pollutants.

The 308 Portfolio data base was also analyzed for traditional pollutant effluent levels from all (conventional) biological treatment, as a method for cross-checking the screening/verification data base results. Table VI-10 presents the results of analyzing the 308 Portfolio data. As can be seen from Table

VI-11, which shows a statistical comparison of the mean values from Tables VI-9 and 10, the results from the 308 Portfolio analysis support the results of the screening/verification analysis. Again, as discussed above, the discrepancies between the results are probably due to the time differential between the two data bases, which could reflect the industry's attempts to lower its traditional pollutant discharge.

Since the screening/verification data for the multistage biological plants appeared to be more representative of conventional biological treatment, a new methodology had to be developed for the analysis of biological enhancement. In the area of traditional pollutant control, the analysis of conventional biological treatment was principally directed at quantifying: "What is the industry doing today?" On the other hand, the analysis of biological enhancement tried to examine: "What more can the industry do?" Therefore, to perform this analysis the following approach was taken.

Another of the Agency's data gathering programs was to request long-term traditional pollutant data from the industry. As opposed to the screening/verification data which were obtained by a few days of sampling and the 308 Portfolio data which were annualized data, the long term data consisted of raw daily or weekly influent and effluent data, covering a period of one year, obtained from 22 plants with some type of biological treatment. Summaries of the long-term data are presented in Appendix K. Therefore, for purposes of "predicting what the industry can achieve" in the way of traditional pollutant control by biological enhancement, the long-term data were selected as being the best available.

Both the priority pollutant and traditional pollutant analyses of biological treatment, conducted above, showed that multistage biological plants more closely represented conventional rather than enhanced treatment. Thus, the same types of plants in the long term data base would probably yield the same conclusion. To circumvent this problem it was decided to approach the analysis via a surrogate parameter. The surrogate selected was the same as the one chosen for the analysis of priority pollutant biological enhancement, namely, those plants achieving greater than 95 percent BOD removal. These would be the better performing plants, and therefore, better represent the results achievable by biological enhancement.

Table VII-12 presents the results of analyzing the long term effluent data from plants achieving greater than 95 percent BOD removals, i.e., plants representing biological enhancement. Also shown in this table is the individual plant data and were obtained from Appendix K used in the analysis. Again, the mean or average effluent values were thought to be the more meaningful values for traditional pollutant. Note that for this analysis subcategory evaluations were not thought to be significant. It was assumed that the effluent from conventional treatment (which would precede a biological enhancement technology) would provide relatively uniform pollutant concentrations to any downstream technologies, negating the impact of the varying waste characteristics of each individual subcategory.

Filtration

Another technology for end-of-pipe treatment is filtration. Used as a polishing step, its principal function is to provide for the removal of suspended solids to a level not achievable by end-of-pipe biological technologies alone. A description of this end-of-pipe treatment is presented below. The use of filtration treatment in the pharmaceutical industry is summarized in Table VI-2.

Filtration is a basic solids removal technology in water and wastewater treatment. Silica sand, anthracite coal, garnet, etc. are among the most common media used in this technology, with gravel serving as a support material. The above media may be used separately or in combinations. Multimedia filters may be arranged in relatively distinct layers by virtue of balancing the forces of gravity, flow, and buoyancy on the individual particles. This is accomplished by selecting appropriate filter flow rates, media grain size, and media densities.

This technology can be further defined in terms of major operating characteristics. The most common filtration system is the conventional gravity filter which normally consists of a deep bed of granular media in an open-top tank. The direction of flow through the filter is downward and the flow rate is dependent solely on the hydrostatic pressure of the water above the filter bed. Another type of filter is the pressure filter. In this case the basic approach is the same as a gravity filter, except the tank is enclosed and pressurized.

As wastewater is processed through the filter bed, the solids collect in the spaces between the filter particles. Periodically, the filter media must be cleaned. This is accomplished by backwashing the filter (reversing the flow through the filter bed). The flow rate for backwashing is adjusted such that the bed is expanded by lifting the media particles a given amount. This expansion and subsequent motion provides a scouring action which effectively dislodges the entrapped solids from the media grain surfaces. The backwash water fills the tank up to the level of a trough below the top lip of the tank wall. The backwash is collected in the trough and fed to a storage tank and recycled into the waste treatment stream. The backwash flow is continued until the filter is clean.

Auxiliary filter cleaning is sometimes employed in the upper few inches of filter beds. This is conventionally referred to as surface wash and is in the form of water jets just below the surface of the expanded bed during the backwash cycle. These jets enhance the scouring action in the bed by increasing the agitation.

An example of a filtration unit is shown in Figure VI-8.

The principal advantages of filtration are: Generally, filtration units have low capital and operating costs. No treatment chemicals are required, which eliminates procurement, storage, and handling problems and costs. Most units require very little space, and increases in wastewater flow can easily be accommodated by installing additional filters. Finally, filtration units are one of the best performers in terms of solids removal.

Filters require a higher level of operator skill, due to control and backwashing requirements. If the proper operation of the units is not maintained, fouling of the filters can be a problem. In some instances, certain types of pollutants may deteriorate the filter media.

Priority Pollutants

None of the plants in the screening/verification data base had data available on the performance of filtration in removing priority pollutants, nor did the 308 Portfolio data base. As a result, a surrogate approach, similar to the one for biological enhancement, was developed for purposes of analyzing priority pollutant effluent levels from this technology.

Upon reviewing the screening/verification data base, it was found that a few plants had very low BOD effluent levels, which could be expected from the use of filtration. Therefore, in order to evaluate the performance of this technology, priority pollutant data from those plants achieving BOD effluent levels of less than 50 mg/l were analyzed. The results of this surrogate analysis are presented in Table VI-13. In lieu of actual sampling data from filtration systems, these results were the best that could be obtained from the existing data bases.

Realizing that the results in Table VI-13 were obtained by analyses of surrogate parameters and not filtration specifically, a further review was warranted. The next step was to review the above results with those from Table VI-6 representing all biological treatment. As can be seen from these tables, the priority pollutant levels from (assumed) filtration are no better than all biological treatment. Therefore, because: 1) the analysis of filtration was conducted with surrogate parameters; 2) the filtration results were somewhat higher than all biological treatment; and 3) it was desirable to maximize the use of the screening/ verification data base, it was decided that the median effluent levels from Table VI-6 would better represent the performance of filtration technology in terms of priority pollutants.

The result of all of the preceding analyses was that each of the end-of-pipe treatment technologies, conventional biological, biological enhancement, and filtration, could be expected to yield similar priority pollutant effluent levels.

Traditional Pollutants

As in the case of previously discussed analysis of biological enhancement, the long term data base served as the principal source of data for evaluating the performance of filtration technology in achieving traditional pollutant removals. Upon examining this data base it was found that only two plants employed filtration in their treatment systems; not enough to provide meaningful results. Therefore a surrogate approach had to be devised.

For the analysis of priority pollutants those plants achieving BOD effluents of less than 50 mg/l were selected as surrogate to filtration. However, for traditional pollutants a slightly different approach was taken. After examining the results in Table VI-12, it was found that the average BOD effluent concentration from plants with biological enhancement was 39 mg/l. Therefore, since filtration is supposed to provide additional treatment after biological enhancement, it was decided to select plants from the long term data base with enhanced biological treatment, that had BOD effluent levels of less than 39 mg/l, and use them as surrogates in the filtration technology analysis.

The results of this surrogate analysis are presented in Table VI-14, along with the individual plant data which were obtained from Appendix K. Since two plants had filtration, the average of their results are shown in parentheses next to the mean values obtained from the surrogate analyses, for purposes of comparison.

ULTIMATE DISPOSAL

In any evaluation of control and treatment technologies one of the most important considerations is the ultimate disposal methods used by the industry. Whether or not a plant is a direct discharger to surface waters, indirect discharger to publicly owned treatment works (POTW), or a zero discharger, can be a critical factor in determining what types of technologies are most appropriate for controlling its waste discharge. Table VI-15 summarizes the methods used by the pharmaceutical manufacturing industry for the ultimate disposal of its process wastewaters. This table was prepared from a listing of each plant's individual disposal techniques, presented in Appendix L.

As can be seen in Table VI-15, approximately one-eighth of the 464 manufacturing plants have direct discharges. Seven of these plants also have indirect discharges, while another nine use zero discharge methods for some of their smaller waste streams. The majority of the industry are indirect discharges. Almost five-eighths of the plants in the 308 Portfolio data base discharge to POTW's. As noted above, seven of these also have direct discharges, but another 25 use zero discharge techniques for some of their smaller waste streams. Finally, over one-fourth of the manufacturing plants use strictly zero discharge methods, such as contract disposal, evaporation, ocean dumping, recycling, etc. However 75 percent of the zero discharges were classified as such, because they generated no process wastewaters requiring disposal.

FIGURE VI-1

CYANIDE DESTRUCTION SYSTEM - CHLORINATION

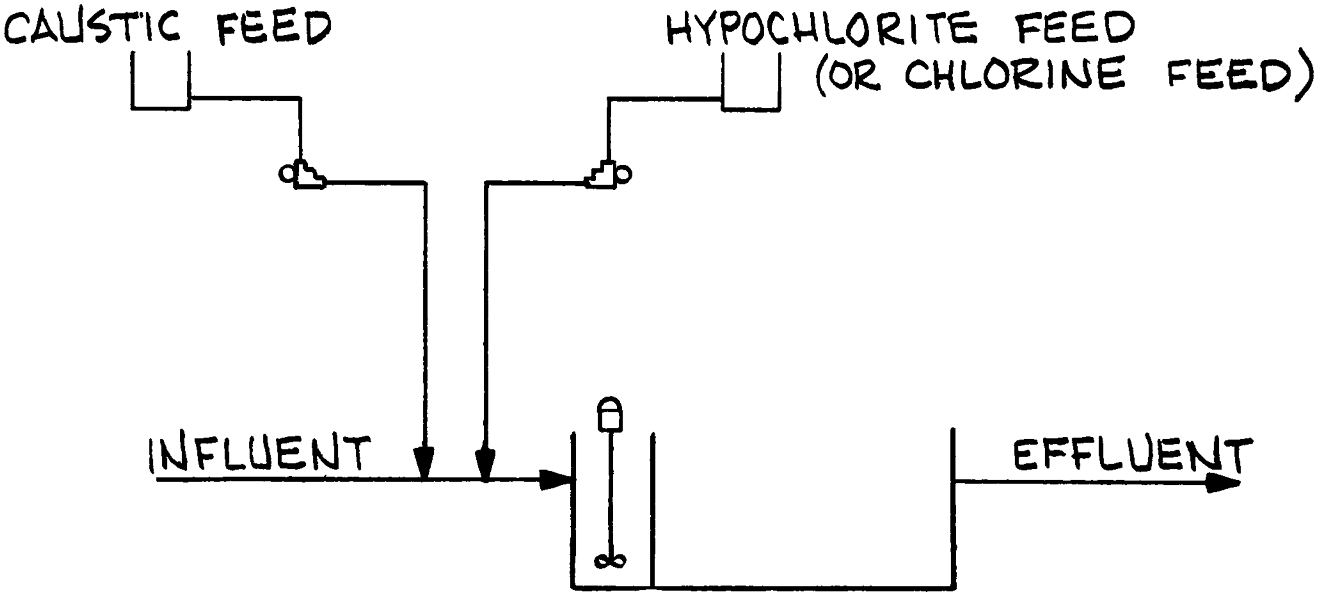


FIGURE VI-2

CYANIDE DESTRUCTION SYSTEM - ALKALINE PYROLYSIS

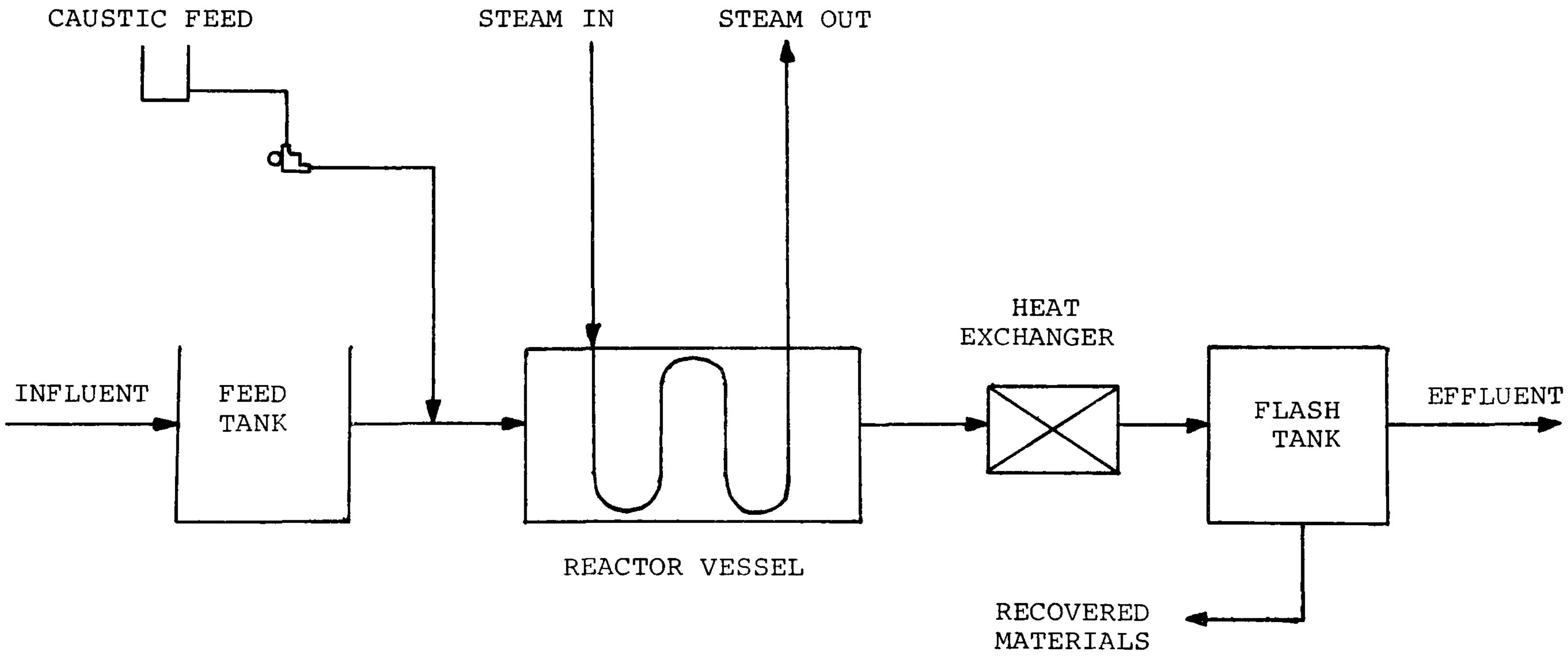


FIGURE VI-3

CHROMIUM REDUCTION SYSTEM

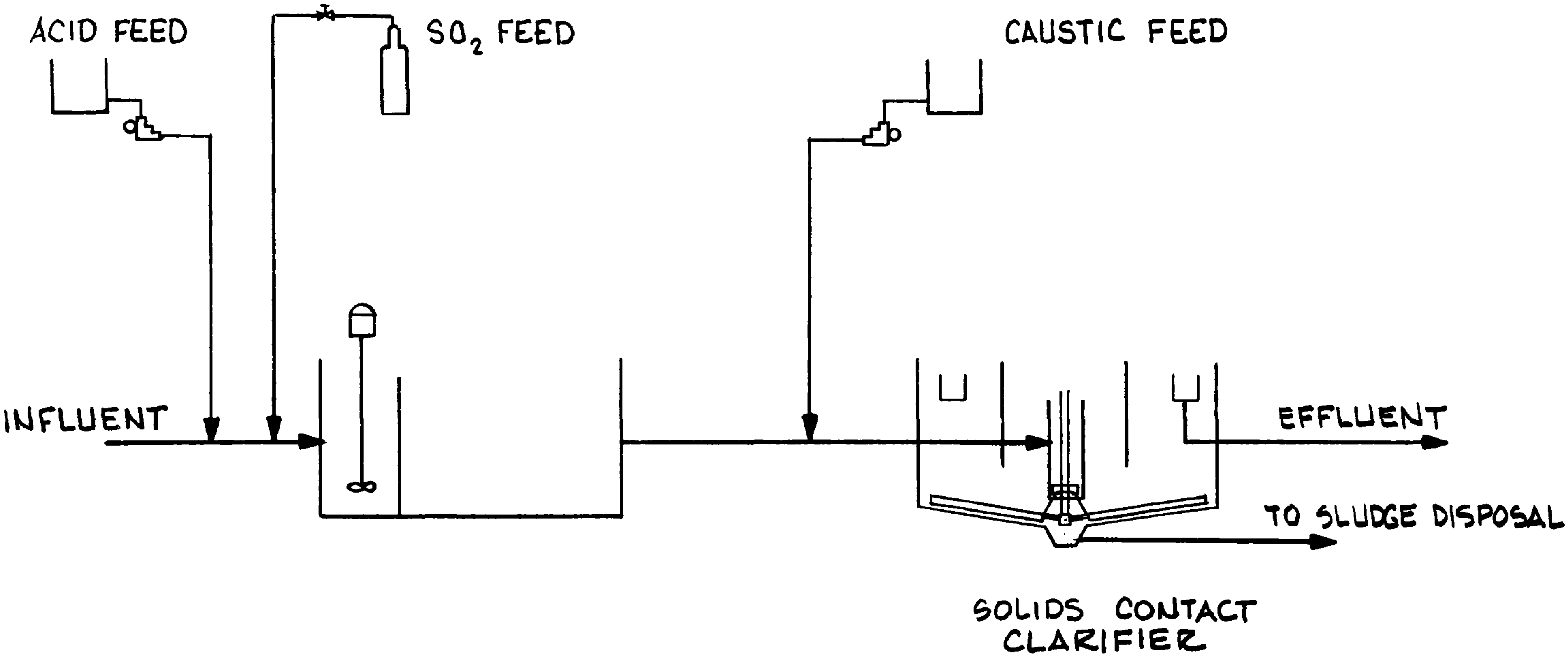
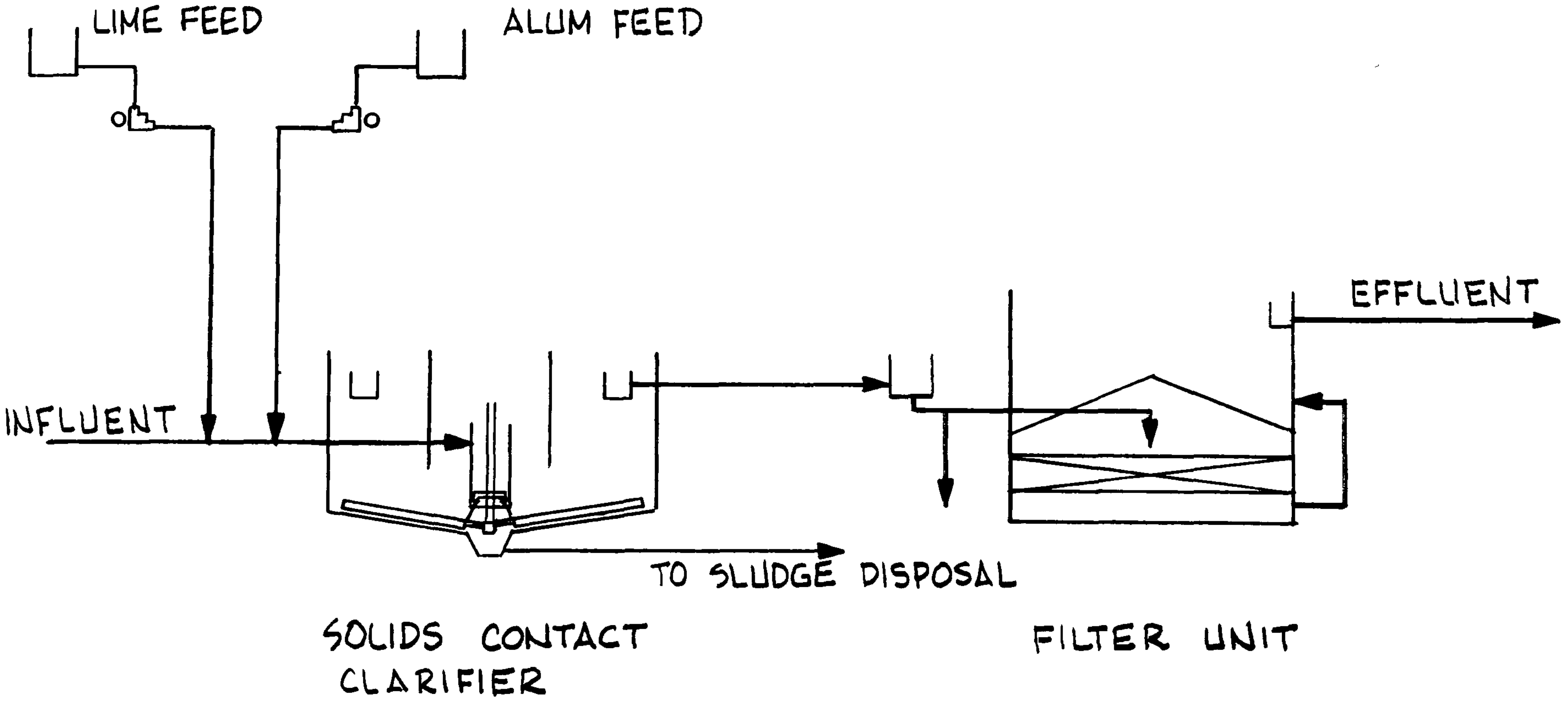


FIGURE VI-4

METALS REMOVAL SYSTEM--ALKALINE PRECIPITATION



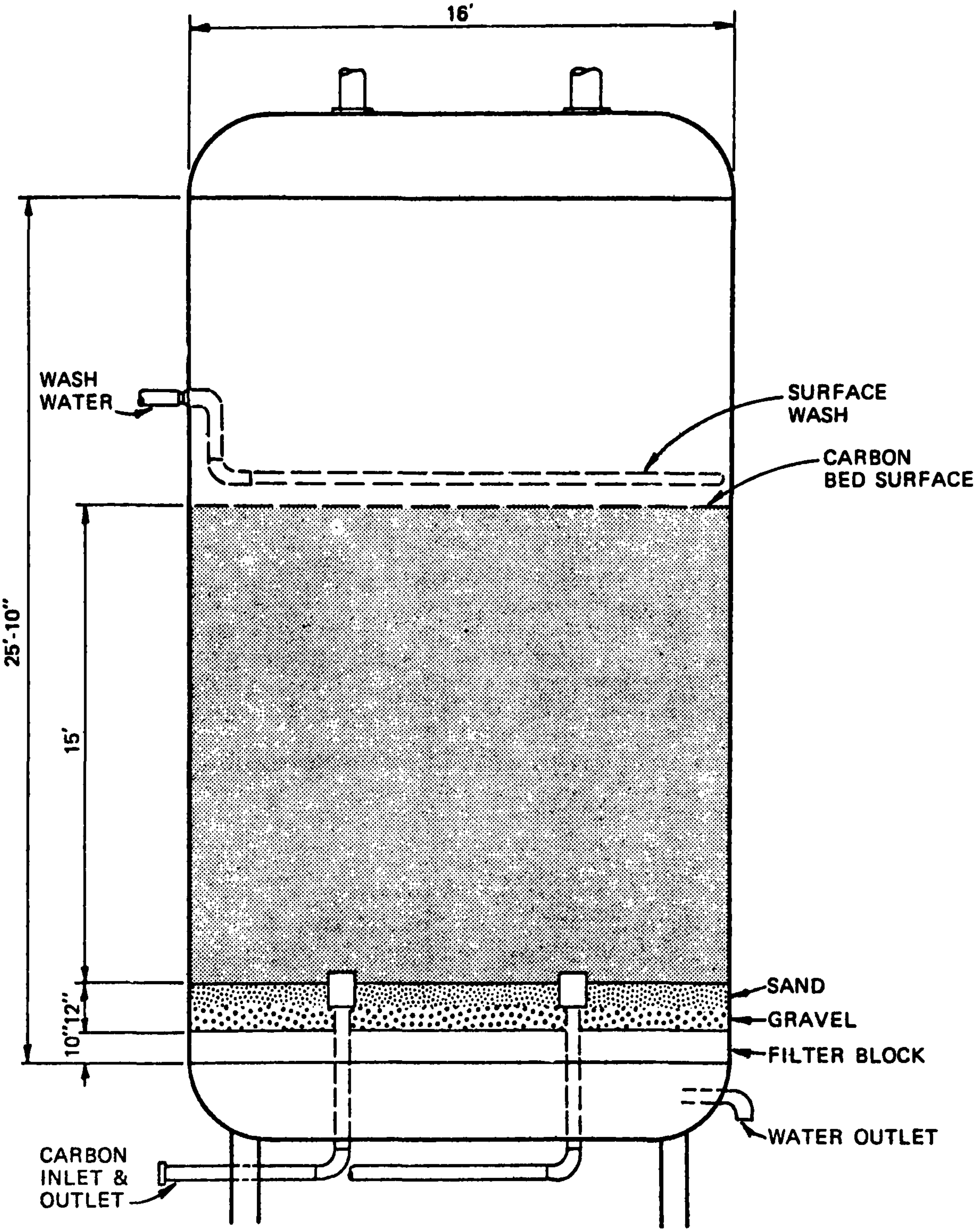


FIGURE VI-5

ACTIVATED CARBON ADSORPTION UNIT

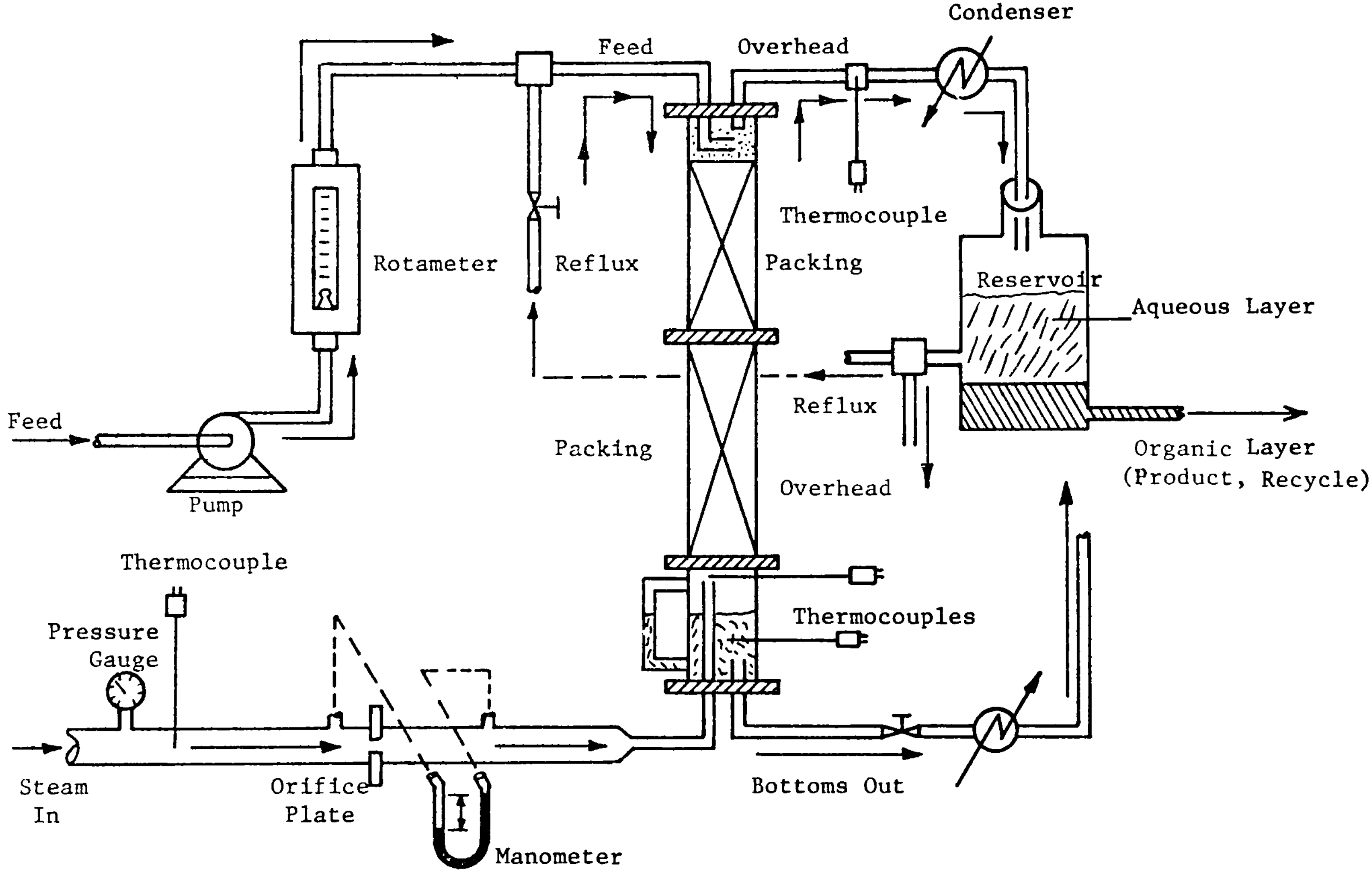
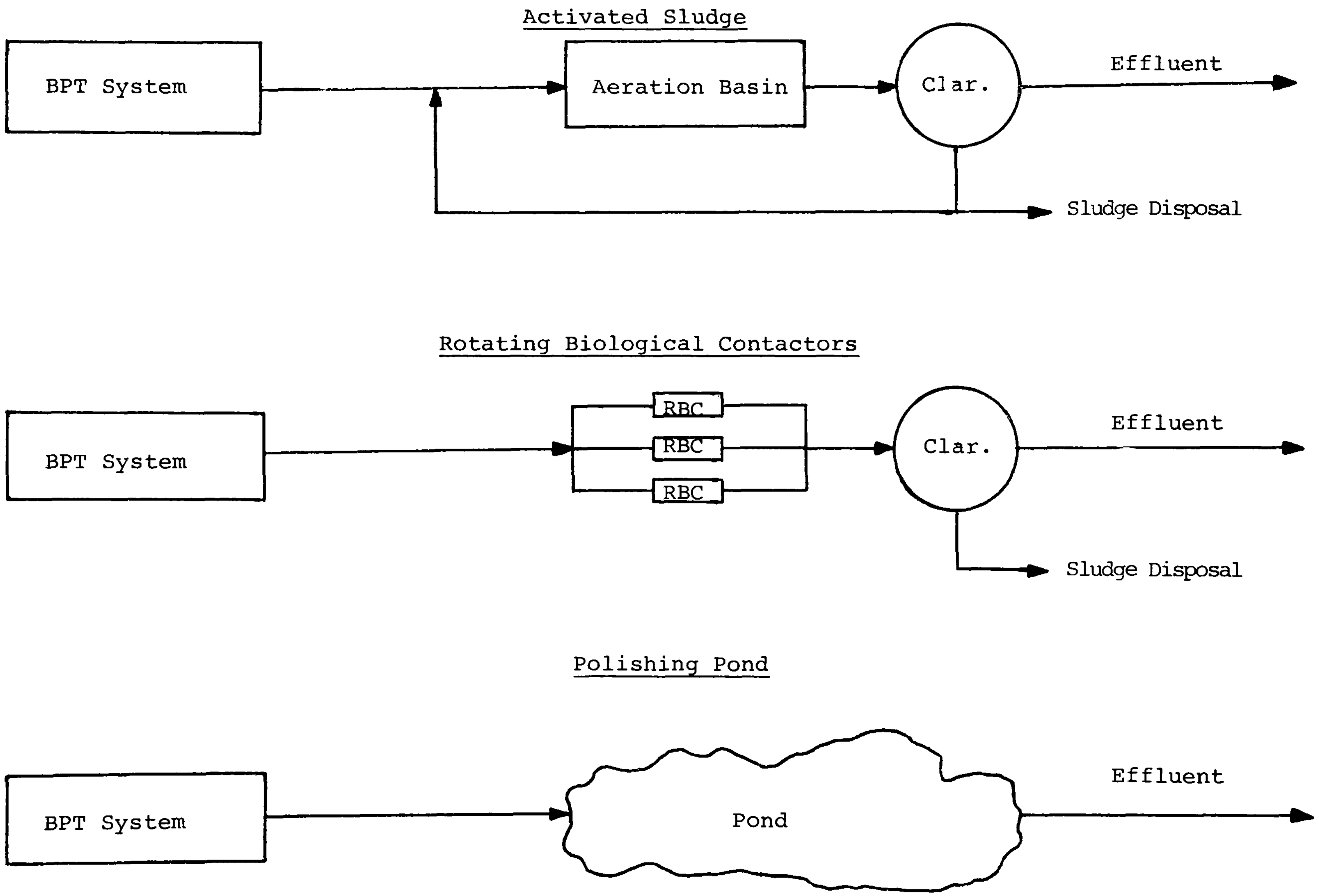


FIGURE VI-6

STEAM STRIPPING UNIT

FIGURE VI-7

EXAMPLES OF BIOLOGICAL ENHANCEMENT SYSTEMS



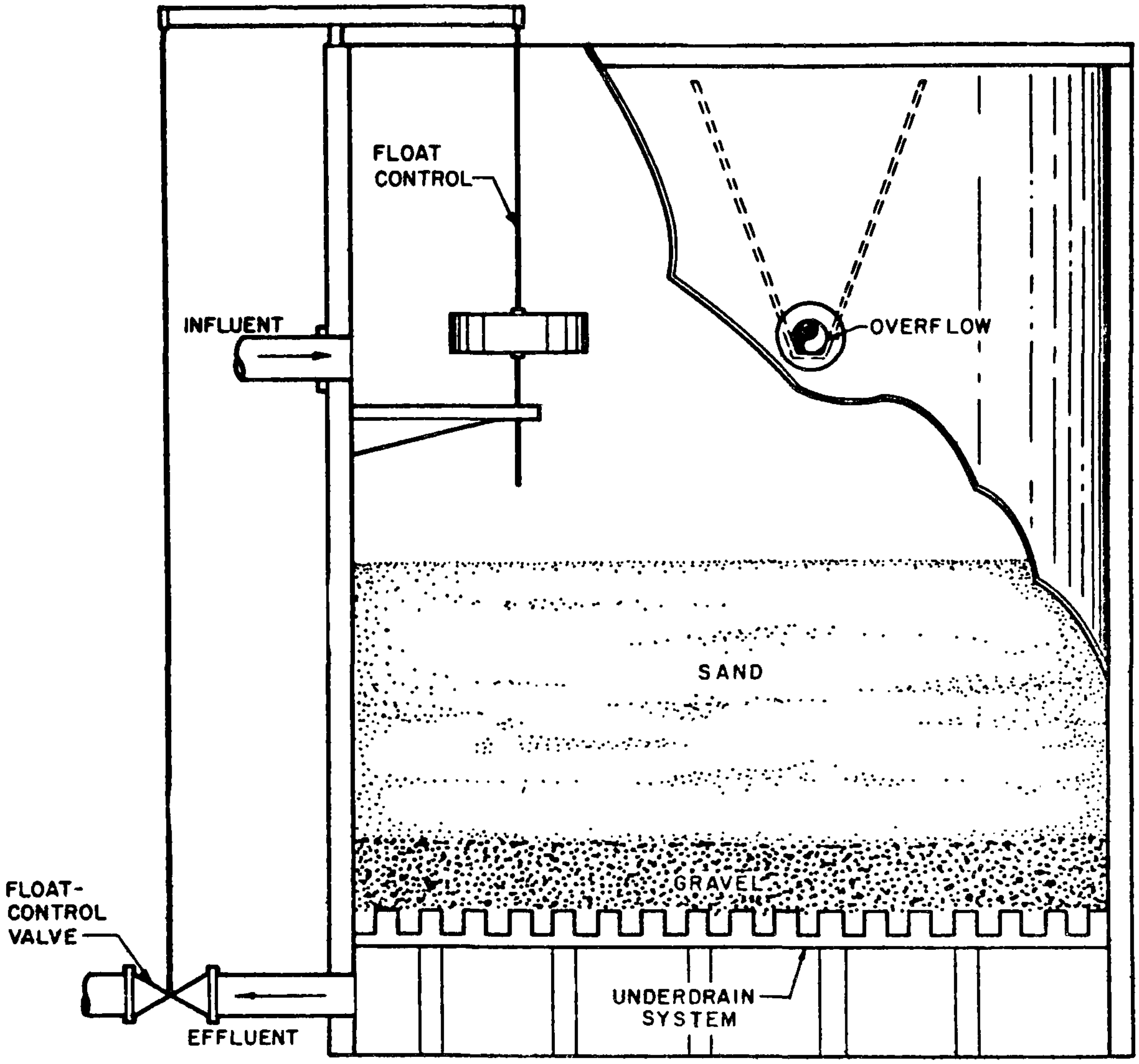


FIGURE VI-8

FILTRATION UNIT

TABLE VI-1

PHARMACEUTICAL INDUSTRY

SUMMARY OF IN-PLANT TREATMENT PROCESSES

In-Plant Technology	Number of Plants
Cyanide Destruction	6
Chromium Reduction	1
Metals Precipitation	3
Solvent Recovery	29
Steam Stripping	7
Other Technologies	19
Evaporation	9
Neutralization	5

TABLE VI-2

PHARMACEUTICAL INDUSTRY

SUMMARY OF-END-OF-PIPE TREATMENT PROCESSES

End-of-Pipe Technology	Number of Plants
Equalization	60
Neutralization	79
Primary Treatment	61
Coarse Settleable Solids Removal	41
Primary Sedimentation	37
Primary Chemical Flocculation/Clarification	11
Dissolved Air Flotation	3
Biological Treatment	74
Activated Sludge	51
Pure Oxygen	1
Powdered Activated Carbon	2
Trickling Filter	9
Aerated Lagoon	23
Waste Stabilization Pond	9
Rotating Biological Contactor	1
Other Biological Treatment	1
Physical/Chemical Treatment	17
Thermal Oxidation	3
Evaporation	5
Additional Treatment	40
Polishing Ponds	10
Filtration	16
Multimedia	7
Activated Carbon	2
Sand	5
Other Polishing	17
Secondary Chemical Flocculation/Clarification	5
Secondary Neutralization	4
Chlorination	10

Note: Subtotals may not add to totals because: 1) some plants employ more than one treatment process; 2) minor treatment processes were not listed separately; 3) details for some treatment processes were not available.

TABLE VI-3

PHARMACEUTICAL INDUSTRY

ANALYSIS OF MAJOR PRIORITY POLLUTANT EFFLUENT CONCENTRATIONS (ug/l) FROM SINGLE-STAGE BIOLOGICAL TREATMENT: SCREENING/VERIFICATION DATA

Priority Pollutant	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
Acid Extractables						
65 phenol	5	0	4	0	2	2.2
Volatile Organics						
4 benzene	7	0	10	5	5	5.0
23 chloroform	6	0	130	52	54	56.2
38 ethylbenzene	3	0	10	0	3	5.8
44 methylene chloride	10	0	4800	40	563	1494.0
86 toluene	6	0	28	7	9	10.6
Metals						
119 chromium	9	2	304	19	67	106.0
120 copper	9	10	106	20	30	30.0
122 lead	8	13	89	25	35	24.0
123 mercury	8	0.1	1.3	0.4	0.5	0.4
124 nickel	6	6	190	44	63	65.8
128 zinc	9	78	1060	163	310	322.0
Others						
121 cyanide	5	2	7700	119	1605	3408.0

Total Number of Plants in the Data Base with Single-Stage Biological Treatment: 10

Notes:

The following criteria were used to select data points for this analysis:

1. If a specific effluent value was reported, the data was used as the biological effluent.
2. If a specific influent value was reported, then:
   a. For "less than" effluent values, the detection limit was used as the biological effluent.
   b. For "not detected" effluent values, the biological effluent was assumed to be zero (0).
3. If both influent and effluent values were "less than" and/or "not detected," the data were not used.

TABLE VI-4

PHARMACEUTICAL INDUSTRY

ANALYSIS OF MAJOR PRIORITY POLLUTANT EFFLUENT CONCENTRATIONS (ug/1) FROM MULTI-STAGE BIOLOGICAL TREATMENT: SCREENING/VERIFICATION DATA

Priority Pollutant	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
Acid Extractables						
65 phenol	7	0	20	10	11	7.2
Volatile Organics						
4 benzene	7	0	120	0	23	44.3
23 chloroform	8	0	110	10	21	36.3
38 ethylbenzene	7	0	22	0	7	9.4
44 methylene chloride	9	2	260	70	92	97.1
86 toluene	7	0	315	0	72	126
Metals						
119 chromium	10	0	166	13	35	51.9
120 copper	10	0	59	26	28	21.1
122 lead	5	0	89	10	24	36.8
123 mercury	9	0	1.3	0.5	0.6	0.4
124 nickel	5	0	310	45	82	130
128 zinc	9	16	254	100	104	69
Others						
121 cyanide	6	30	400	58	153	166

Total Number of Plants in the Data Base with Multistage Biological Treatment: 10

Notes:

The following criteria were used to select data points for this analysis:

1. If a specific effluent value was reported, the data was used as the biological effluent.
2. If a specific influent value was reported, then:
   a. For "less than" effluent values, the detection limit was used as the biological effluent.
   b. For "not detected" effluent values, the biological effluent was assumed to be zero (0).
3. If both influent and effluent values were "less than" and/or "not detected," the data were not used.

TABLE VI-5

PHARMACEUTICAL INDUSTRY

ANALYSIS OF MAJOR PRIORITY POLLUTANT EFFLUENT CONCENTRATIONS (ug/1) FROM BIOLOGICAL TREATMENT ACHIEVING GREATER THAN 95 PERCENT BOD REMOVAL:
SCREENING/VERIFICATION DATA

Priority Pollutant	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
Acid Extractables						
65 phenol	7	0	20	4	6	7.5
Volatile Organics						
4 benzene	6	0	120	8	28	46.7
23 chloroform	5	0	110	10	27	46.8
38 ethylbenzene	4	0	22	5	8	10.5
44 methylene chloride	9	0	349	21	88	128.0
86 toluene	6	0	180	10	38	70.3
Metals						
119 chromium	9	2	304	19	74	105.0
120 copper	9	0	59	20	27	21.4
122 lead	6	10	89	42	49	33.0
123 mercury	8	0.1	1.0	0.5	0.5	0.3
124 nickel	7	0	30	50	94	114.0
128 zinc	9	16	403	83	118	114.0
Others						
121 cyanide	5	3	7700	58	1624	3399.0

Total Number of Plants in the Data Base with Biological Treatment Achieving Greater Than 95 Percent BOD Removal: 9

Notes:

The following criteria were used to select data points for this analysis:

1. If a specific effluent value was reported, the data was used as the biological effluent.
2. If a specific influent value was reported, then:
   a. For "less than" effluent values, the detection limit was used as the biological effluent.
   b. For "not detected" effluent values, the biological effluent was assumed to be zero (0).
3. If both influent and effluent values were "less than" and/or "not detected," the data were not used.

TABLE VI-6

PHARMACEUTICAL INDUSTRY

ANALYSIS OF MAJOR PRIORITY POLLUTANT EFFLUENT CONCENTRATIONS (ug/1) FROM ALL BIOLOGICAL TREATMENT: SCREENING/VERIFICATION DATA

Priority Pollutant	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
Acid Extractables						
65 phenol	12	0	20	5	7	7.5
Volatile Organics						
4 benzene	14	0	120	0	14	31.8
23 chloroform	14	0	130	10	35	47.0
38 ethylbenzene	10	0	22	0	6	8.3
44 methylene chloride	19	0	4800	70	335	1085.0
86 toluene	13	0	315	3	43	95.1
Metals						
119 chromium	19	0	304	16	50	81.5
120 copper	19	0	106	20	29	26.0
122 lead	13	0	89	17	28	28.8
123 mercury	17	0	1.3	0.5	0.6	0.39
124 nickel	11	0	310	45	72	94.9
128 zinc	18	16	1060	10	207	249.0
Others						
121 cyanide	11	2	7700	63	813	2288.0

Total Number of Plants in the Data Base with Biological Treatment: 20

Notes:

The following criteria were used to select data points for this analysis:

1. If a specific effluent value was reported, the data was used as the biological effluent.
2. If a specific influent value was reported, then:
   a. For "less than" effluent values, the detection limit was used as the biological effluent.
   b. For "not detected" effluent values, the biological effluent was assumed to be zero (0).
3. If both influent and effluent values were "less than" and/or "not detected," the data were not used.

TABLE VI-7

PHARMACEUTICAL INDUSTRY

ANALYSIS OF MAJOR PRIORITY POLLUTANT EFFLUENT CONCENTRATIONS (ug/1) FROM ALL BIOLOGICAL TREATMENT:
308 PORTFOLIO DATA

Priority Pollutant	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
Acid Extractables						
65 phenol	15	8	1100	65	140	271
Volatile Organics						
4 benzene	3	2	250	3	85	143
6 carbon tetrachloride	-	-	--	-	--	--
23 chloroform	5	6	3990	9	811	1777
44 methylene chloride	4	2	1650	374	600	782
86 toluene	4	1	1400	9	3505	6997
Metals						
119 chromium	11	10	100	50	52	36.6
120 copper	9	23	541	55	151	177.0
122 lead	8	2	170	80	78	50.1
123 mercury	8	0.1	10	0.5	2.2	3.4
124 nickel	7	2	2100	225	567	813.0
128 zinc	10	21	3500	250	629	1050.0
Others						
121 cyanide	12	3	2300	55	426	833.0

Total Number of Plants in the Data Base with Biological Treatment: 76

Notes:

The following criteria were used to select data points for this analysis:

1. If a specific effluent value was reported, the data was used as the biological effluent.
2. If a specific influent value was reported, then:
   a. For "less than" effluent values, the detection limit was used as the biological effluent.
   b. For "not detected" effluent values, the biological effluent was assumed to be zero (0).
3. If both influent and effluent values were "less than" and/or "not detected," the data were not used.

TABLE VI-8

COMPARISON OF MAJOR PRIORITY POLLUTANT EFFLUENT CONCENTRATIONS (ug/l)
FROM ALL BIOLOGICAL TREATMENT:
308 PORTFOLIO VERSUS SCREENING/VERIFICATION DATA

Priority Pollutant	Median Effluent Concentrations (ug/l): 308 Portfolios (X)	Screen/Verification (Y)
Acid Extractables		
65 Phenol	65	5
Volatile Organics		
4 Benzene	3	0
6 Carbon Tetrachloride		*
23 Chloroform	9	10
38 Ethylbenzene	*	0
44 Methylene Chloride	374	70
86 Toluene	9	3
Metals		
119 Chromium	50	16
120 Copper	55	20
122 Lead	80	17
123 Mercury	0.5	0.5
124 Nickel	225	45
128 Zinc	250	100
Others		
121 Cyanide	55	63

REGRESSION COEFFICIENTS (for 12 comparable priority pollutants):

Correlation: 0.795 $Y = mX+b$
Slope (m): 0.218
Intercept (B): 7.8

* Not a major priority pollutant according to the data base.

TABLE VI-9

PHARMACEUTICAL INDUSTRY

ANALYSIS OF TRADITIONAL POLLUTANT EFFLUENT CONCENTRATIONS (mg/l) FROM ALL BIOLOGICAL TREATMENT: SCREENING/VERIFICATION DATA

Traditional Pollutant by Subcategory	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
BOD:						
A	10	10	251	59	90	74.3
B	7	46	294	98	120	89.5
C	12	39	348	87	130	107
D	10	10	294	68	100	86
COD:						
A	9	232	1686	436	650	521
B	6	263	3130	632	940	1091
C	11	160	3130	637	1000	960
D	11	232	3130	626	890	939
TSS:						
A	10	10	1000	74	170	297
B	6	46	585	167	260	220
C	12	10	585	119	140	152
D	10	10	585	104	160	205

Total Number of Plants in the Data Base with Biological Treatment: 20

Notes:

1. For purposes of this analysis the data from a screening and verification plant were used in each of the single subcategory analyses for which the plant had a subcategory operation. For example: data from an A B D plant were used in the subcategory A, B, and D analyses.
2. Only reported data were used in the analysis. Assumed values for "less than, not detected, and unknown" data were not used.

TABLE VI-10

PHARMACEUTICAL INDUSTRY

ANALYSIS OF TRADITIONAL POLLUTANT EFFLUENT CONCENTRATIONS (mg/1) FROM ALL BIOLOGICAL TREATMENT:
308 PORTFOLIO DATA

Traditional Pollutant by Subcategory	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
BOD:						
A	11	7	244	105	100	76.8
B	10	6	869	133	200	262
C	24	5	3636	125	410	821
D	37	4	3636	35	270	670
COD:						
A	10	40	2370	352	660	744
B	3	29	407	113	120	198
C	18	74	9880	650	1790	2898
D	24	29	8481	290	830	1782
TSS:						
A	11	29	500	70	150	158
B	9	9	1793	150	350	567
C	26	6	2340	107	310	550
D	35	2	2340	47	210	483

Total Number of Plants in the Data Base with Biological Treatment: 53

Notes:

1. For purposes of this analysis the data from a 308 Portfolio plant were used in each of the single subcategory analyses for which the plant had a subcategory operation. For example: data from an A B D plant were used in the subcategory A, B, and D analyses.
2. Only reported data were used in the analysis. Assumed values for "less than, not detected, and unknown" data were not used.

TABLE VI-11

COMPARISON OF TRADITIONAL POLLUTANT EFFLUENT CONCENTRATIONS (mg/l)
FROM ALL BIOLOGICAL TREATMENT:
SCREENING/VERIFICATION VERSUS 308 PORTFOLIO DATA

Subcategory	Mean Effluent Concentrations (mg/l): BOD	COD	TSS
Screening/Verification (Y):			
A	90	650	170
B	120	940	260
C	130	1000	140
D	100	890	160
308 Portfolio (X):			
A	100	660	150
B	200	180	350
C	410	1790	310
D	270	830	210

Regression Coefficients:

Correlation: 0.690

Slope (m): 0.537

Intercept (b): 143.0

$Y = mX + b$

TABLE VI-12

PHARMACEUTICAL INDUSTRY

ANALYSIS OF TRADITIONAL POLLUTANT EFFLUENT CONCENTRATIONS (mg/1) FROM BIOLOGICAL TREATMENT ACHIEVING GREATER THAN 95 PERCENT BOD REMOVAL: LONG TERM DATA

Traditional Pollutant by Plant Code	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
BOD:						
12022	392	3	630		110	107.3
12026	44	20	469		108	103.1
12036	365	1	40		7	5.1
12097	225	0	228		49	53.5
12117	49	0	5		2	1.4
12161	253	6	165		22	20.2
12294	55	4	185		45	41.8
12317	52	1	31		8	8.0
12459	52	0	10		4	2.7
LONG TERM AVERAGE:+	9	2	110	22	39	43.0
COD:						
12022	-	-	-		-	-
12026	52	520	3040		1222	443.0
12036	25	17	2951		278	699.3
12097	313	4	797		44	63.7
12117	92	1	73		25	12.6
12161	359	180	3580		850	396.6
12294	55	119	587		233	105.2
12317	263	4	194		42	38.3
12459	53	0	325		111	82.1
LONG TERM AVERAGE:+	8	25	1222	172	351	444.1
TSS:						
12022	395	5	343		84	52.8
12026	-	-	-			
12036	365	1	262		17	23.0
12097	253	1	937		27	77.5
12117	51	1	51		16	13.0
12161	365	5	2080		64	216.0
12294	55	0	420		53	72.8
12317	262	0	74		10	12.2
12459	53	0	123		15	20.1
LONG TERM AVERAGE:+	8	10	84	22	36	27.6

Total number of Plants in the Data Base with Biological Treatment Achieving Greater Than 95 Percent BOD Removal: 9

+Long term average values were calculated using mean results for each individual plant.

ANALYSIS OF MAJOR PRIORITY POLLUTANT EFFLUENT CONCENTRATIONS (ug/l) FROM BIOLOGICAL TREATMENT ACHIEVING LESS THAN 50 mg/l BOD EFFLUENT: SCREENING/VERIFICATION DATA

Priority Pollutant	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
Acid Extractables						
65 phenol	3	0	10	10	7	5.8
Volatile Organics						
4 benzene	3	0	120	33	51	62.0
23 chloroform	3	10	110	10	47	57.7
38 ethylbenzene	3	0	22	10	11	11.0
44 methylene chloride	4	10	349	141	160	171.0
86 toluene	3	0	180	10	63	101.0
Metals						
119 chromium	4	10	75	20	29	31.3
120 copper	4	9	59	30	32	22.0
122 lead	1	89	89	89	89	0.0
123 mercury	4	0.4	1.0	0.6	0.7	0.3
124 nickel	3	0	310	50	120	166.0
128 zinc	4	75	403	100	170	156.0
Others						
121 cyanide	3	30	330	58	139	166.0

Total Number of Plants in the Data Base with Biological Treatment Achieving Less Than 50 mg/l BOD Effluent: 4

Notes:

The following criteria were used to select data points for this analysis:

1. If a specific effluent value was reported, the data were used as the biological effluent.
2. If a specific influent value was reported, then:
   a. For "less than" effluent values, the detection limit was used as the biological effluent.
   b. For "not detected" effluent values, the biological effluent was assumed to be zero (0).
3. If both influent and effluent values were "less than" and/or "not detected," the data were not used.

TABLE VI-14

PHARMACEUTICAL INDUSTRY

ANALYSIS OF TRADITIONAL POLLUTANT EFFLUENT CONCENTRATIONS (mg/1) FROM ENHANCED BIOLOGICAL TREATMENT ACHIEVING LESS THAN 39 mg/1* BOD EFFLUENT: LONG TERM DATA

Traditional Pollutant by Plant Code	Number of Data Points	Minimum	Maximum	Median	Mean	Standard Deviation
BOD:						
12036	365	1	40		7	5.1
12117	49	0	5		2	1.4
12161	253	6	165		22	20.2
12317	52	1	31		8	8.0
12459	52	0	10		4	2.7
LONG TERM AVERAGE:+	5	2	22	7	9	(27) 7.9
COD:						
12036	25	17	2951		278	699.3
12117	92	1	73		24	12.6
12161	359	180	3580		850	396.6
12317	263	4	194		42	38.3
12459	53	0	325		111	82.1
LONG TERM AVERAGE:+	5	24	850	111	261	(137) 344.2
TSS:						
12036	365	1	262		17	23.0
12117	51	1	51		16	13.0
12161	365	5	2080		64	216.0
12317	262	0	74		10	12.2
12459	53	0	123		15	20.1
LONG TERM AVERAGE:+	5	10	64	16	24	(32) 22.3

Total number of Plants in the Data Base with Enhanced Biological Treatment Achieving Less Than 39 mg/1 BOD Effluent: 5

*This criterion was determined from the long term average BOD value in Table VI-12.

+Long term average values were calculated using mean results for each individual plant. For comparison purposes an average of the values from the two plants in the long term data base, using filtration, are shown in parenthesis.

TABLE VI-15

PHARMACEUTICAL INDUSTRY

SUMMARY OF WASTEWATER DISCHARGES

Method of Discharge	Number of Plants in the Industry	Number of Plants by Subcategories: A	B	C	D
Direct Dischargers	54	9	8	22	34
Direct Only	45	6	4	14	30
Direct with minor Zero Discharge	9	3	4	8	4
Indirect Dischargers	271	24	61	81	219
Indirect Only	246	17	53	68	202
Indirect with minor Zero Discharge	25	7	8	14	17
Combined Direct/Indirect Dischargers	7	2	2	3	6
SUBTOTAL	322	35	71	106	259
Zero Dischargers	132	2	9	27	113
TOTAL	464	37	80	233	372

FATE OF WASTEWATERS AT ZERO DISCHARGE PLANTS (TOTAL INDUSTRY)

Discharge Method	Zero Dischargers	Direct w/Zero	Indirect w/Zero
No Process Wastewater	98	0	0
Contract Disposal	7	3	7
Deep Well Injection	0	1	2
Evaporation	7	1	3
Land Application	6	3	5
Ocean Dumping	2	1	2
Recycle/Re-use	2	0	1
Septic System	6	0	2
Subsurface Discharge	4	0	3
TOTAL	132	9	25

NOTE: Subcategory counts will not add to industry totals because of multiple subcategory plants.

SECTION VII

COST, ENERGY, AND NON-WATER QUALITY ASPECTS

INTRODUCTION

This section addresses the costs, energy requirements and non-water quality environmental impacts associated with the control and treatment technologies presented in Section VI. As such, the cost estimates contained herein represent the additional investment required over and above the capital and operating costs associated with BPT guidelines technology. These differential costs, therefore, relate to specific control and treatment alternatives that may be necessary for compliance with recommended effluent limitations.

A critical factor to be considered in the adoption of any effluent limitations guidelines is the potential economic impact of such regulations on the industry. Since it was not cost-effective to examine this impact on each individual plant in the comprehensive data base, model plants were developed which would statistically represent each pharmaceutical subcategory. Cost estimates for the various in-plant and end-of-pipe treatment technologies were prepared for four subcategory model plants and are presented in this section.

COST DEVELOPMENT

Subcategory model plants were established based upon the discussion in Section III of raw waste load characteristics of each subcategory. Representative values for wastewater flow rate and traditional pollutant loadings for each model plant are summarized in Table VII-1. As indicated in Section III, the priority pollutant loadings for the individual subcategories are best represented by the median values from all plants in the screening and verification data bases. Therefore, the four subcategory model plants were considered to have similar priority pollutant concentrations in their raw waste loads, as presented in Table VII-2.

The major capital and operating costs were determined for treatment alternatives discussed in Section VI for the four subcategory model plants. The following assumptions were used throughout the costing effort.

<u>Land</u> - The cost estimates presented do not include land costs. The cost of land is variable and site dependent and cannot be estimated on a national basis. For in-plant systems in most cases, the necessary equipment can be placed in existing structures near the source stream being treated. For end-of-pipe systems, the total area required is indicated.

Piping and Pumps - Where required, piping and pumps are assumed to be 20 percent of basic equipment costs.

Delivery and Installation - These costs were assumed to be 50 percent of total equipment costs.

Engineering and Contingency - These costs were assumed to be 30 percent of total installed costs.

Energy - Electricity costs were assumed to be $0.04 per KWh. Annual power costs for mixing and pumping were computed as follows:

(Total horsepower) x (8760 hr/yr) x (0.746 KW/hp) x ($0.04/KWh)

Labor - A rate of $10./hr, including taxes and fringe benefits, was assumed.

Maintenance - Assumed to be 3 percent of total capital costs.

Sludge Disposal - This cost, including transportation, was assumed to be $0.30 per gallon.

Capital Recovery plus Return - 10 percent at 10 years.

All cost data presented in this section are expressed in January 1978 dollars, when the Engineering News Record Construction Index was 2670 and the Chemical Engineering Plant Cost Index was 210.6. See Appendix M for tabulation of these indices. Capital costs for major equipment items such as tanks, clarifiers, filters, mixers, sludge thickeners and vacuum filters were obtained from equipment manufacturers and from a wastewater treatment cost data base developed by Catalytic, Inc. for Effluent Guidelines Division.

IN-PLANT TREATMENT COSTS

In-plant treatment is directed at removing certain pollutant parameters from specific waste streams before combining with other wastewaters. The costs of in-plant treatment alternatives allocated to any pharmaceutical plant must be based upon the flow of the process wastewater stream bearing the specific pollutant or pollutants of interest. For the purpose of preparing costs for the subcategory model plants, the flow rate of the process waste stream to be treated was assumed to be 10 percent of a plant's total wastewater flow. In addition, it was assumed that the model plant's entire mass loading of the subject pollutant, calculated from the data in Table VII-2, was contained in the process waste stream. The major priority pollutants found in pharmaceutical wastewaters were cyanide, metals, and solvents.

Therefore, cost estimates were developed for treating these three classes of pollutants. Achievable effluent concentrations for the in-plant treatment technologies discussed below were presented in Section VI.

Cyanide Destruction

Cyanide has been identified as being present in the wastewaters of a number of pharmaceutical plants. Table VII-3 contains the equipment cost bases and energy requirements for oxidation with hypochlorite in an alkaline environment. In general, batch systems are more economical for flow rates below 15 gallons per minute. Thus, batch systems have been assumed for Plants B and D, whereas continuous operations are used for Plants A and C.

Capital cost items are presented in Table VII-4 and include detention tanks, mixers, piping and pumps, and automatic chemical feed systems. The annual operating costs are shown in Table VII-5. To estimate the annual cost of chemicals, it was assumed that 1.2 lbs of hypochlorite ($ .60/lb) and 1.4 lbs of caustic ($ .12/lb) were added to each 1000 gallons of wastewater treated.

Chromium Reduction

Chromium can occur in wastewaters in the hexavalent and trivalent state. Hexavalent chromium is extremely soluble, whereas trivalent chromium is very insoluble. Therefore, the first step in the treatment of chromium is the reduction of the hexavalent ions to the trivalent state. This is usually accomplished with sulfur dioxide at low pH values; however, other reducing agents can be used.

The pH of the wastewater containing the trivalent chromium is then adjusted to the range of 8 to 10, where chromium hydroxide is precipitated and clarified. In general, the procedure described above is performed on a batch basis for systems below 15 gallons per minute, and on a continuous basis for larger systems. Table VII-6 presents the equipment cost bases and energy requirements for chromium reduction systems. Adjustment of pH and clarification are included as part of the systems being costed.

Tables VII-7 and VII-8 present the capital and operating costs for the treatment schemes outlined in Table VII-4. The chemical requirements for the systems presented include 0.45 lbs of sulfur dioxide ($ .15/lb), 0.45 lbs of sulfuric acid ($ .06/lb), and 2 lbs of caustic ($ .12/lb) for each 1000 gallons of wastewater treated.

Metal Precipitation

Metal removal generally consists of pH adjustment, usually to a pH in the range of 8 to 10, after which the metal hydroxide precipitates formed by the pH adjustment are clarified. There are a variety of chemicals that can be used to aid in the precipitation and clarification process; however, the data presented in Tables VII-9 and VII-11 are based upon lime and alum addition.

Table VII-9 presents the design bases and energy requirements for metal precipitation. The smaller systems of Plants B and D are batch operations, while Plants A and C are assumed to use continuous systems. Solids contact type clarifiers were used for costing purposes. These units include a flash mix zone, flocculation zone, and settling zone in one unit.

Metal removal by precipitation requires very little head loss, so that most systems will generally be operated by the head already available in the wastewater effluent line. The miscellaneous energy requirements shown in Table VII-9 include those for chemical addition and sludge removal.

Table VII-10 presents the capital cost items for the systems outlined, while Table VII-11 shows the associated operating costs for these treatment units. It should be noted that capital recovery plus return is by far the largest annual cost.

Steam Stripping

As dicussed in Section VI, a study (72) was conducted by EPA on the applicability of steam stripping for treating wastewaters containing organic priority pollutants. Indications are that this technology is a feasible in-plant treatment method for the pharmaceutical manufacturing industry. However, more work on this subject is needed.

In the study some preliminary cost information was presented. Since EPA is still reviewing this technology and no other specific cost data was available, the figures, reported in the study, were used in this document. Table VII-12 presents the capital and annual operating costs of steam stripping. As work continues in this area, more detailed cost information can be developed and incorporated into the analysis.

END-OF-PIPE TREATMENT COSTS

Section VI summarizes the end-of-pipe technologies that have been identified as being used by the pharmaceutical industry. The impacts of these technologies on the removal of traditional and priority pollutants from pharmaceutical wastewaters were evaluated during this study.

Biological treatment was found to be the principal end-of-pipe method by which the majority of pharmaceutical manufacturing plants are now meeting existing BPT limitations guidelines. This treatment alternative consists of a number of specific technologies, such as activated sludge systems, trickling filters, rotating biological contactors, and lagoons. In addition, variations in the application of these specific technologies can enhance biological treatment. Modifications or combinations of conventional biological treatment processes are referred to as biological enhancement.

Biological Enhancement

For the purpose of developing model costs, combinations of biological treatment processes were considered for biological enhancement. The assumption was made that a conventional biological process would be added to the BPT system already in place. The characteristics of the influent streams to the add-on systems were assumed to be the existing BPT effluent limitations for the subcategory model plants, as shown in Table VII-13.

Data analyses conducted during this study indicate that biological enhancement can achieve effluent levels of 40 mg/l BOD and 40 mg/l TSS, showing an improvement over BPT systems. However, no significant differences in priority pollutant effluent concentrations were found between conventional biological systems and biological enhancement.

Table VII-14 presents equipment cost bases and energy requirements for activated sludge systems that were designed for four subcategory model plants. Capital cost items are presented in Table VII-15 and include aeration basins, aerators, nutrient addition equipment, clarifiers, and sludge handling facilities. The total annual costs for each subcategory model plant are shown in Table VII-16.

Rotating biological contactors (RBC's) were also considered for biological enhancement. RBC systems were sized for each of the model plants and based upon the data in Table VII-17. The major capital and operating costs are presented in Table VII-18.

Enhanced treatment can also be accomplished with the use of polishing ponds. Costs were developed based on the data shown in Table VII-19. For each model plant, a pond was sized for a depth of 10 feet and a detention time as shown. Capital cost items are presented in Table VII-20 and include excavation, grading, compaction, an impervious liner, and piping. Sludge disposal costs were not included in the annual costs in Table VII-20, because cleanout should be required only once every several years.

Biological Enhancement and Filtration

Filtration can be used as a polishing step following biological treatment for increased solids removal. Analyses conducted during this study have indicated that effluent concentrations of 20 mg/l BOD and 30 mg/l TSS are achievable with biological enhancement and filtration of pharmaceutical wastewaters. However, as was the case with biological enhancement alone, data did not indicate any improvements in effluent quality over BPT in terms of priority pollutants.

Table VII-21 presents equipment cost bases and energy requirements for activated sludge systems followed by dual media filters that were designed to perform as noted above. Influent characteristics for the four subcategory model plants are shown in Table VII-13. Aeration basins were sized for longer detention times than those noted in Table VII-14. The two filters provided for each model plant are dual media, gravity flow units with bed depths of four feet and automatic backwashing. Capital and total annual costs are presented in Tables VII-21 and VII-22.

Cost estimates were also prepared for filtration units following RBC systems. The RBC units were sized for the desired effluent quality, increasing the total RBC surface area above those shown in Table VII-17. The same dual media filters as those provided above are specified in Table VII-24. Capital and total annual costs are given in Table VII-25.

COST SENSITIVITIES - RBC's

In a separate study (110) for the EPA, the sensitivities in estimating treatment costs for the pharmaceutical industry were examined by Walk, Haydel and Associates, Inc. Using the rotating biological contactor option as the example technology, this study analyzed the sensitivity of annual cost estimates to a number of different parameters. A summary of the Walk, Haydel report is presented below:

The series of curves presented in Figures VII-1, VII-2, and VII-3 indicate the sensivitity of annual costs for the rotating biological contactor (RBC) option in treatment of pharmaceutical wastewater. The RBC sizing is based on the addition of this equipment to an existing system which is achieving BPT.

The base points for the curves are the model plant costs for each subcategory. Parameters considered are wastewater flow rate, influent BOD concentration to the RBC, and target effluent BOD concentration.

It should be noted that a curve is not plotted for Case D cost sensitivity with variations in influent BOD level (Figure VII-2). There are two reasons for this. First, the 40 mg/l influent level for this case is markedly below those of the other cases, which range from 120 to 164 mg/l. Second, there is some question as to whether the sludge handling costs for Case D can be extrapolated. Although not of major importance at base conditions, sludge removal costs may be distorted at higher influent BOD levels.

The investment portion of each cost was developed with the cooperation of the Environmental Systems Division of George A. Hormel & Co. Figure VII-4 plots RBC equipment costs estimated by Hormel, as a function of disc surface. These costs are directly related to disc surface to the 0.7 power. This same exponential relationship was used to represent cost variations of other equipment, such as clarifiers and sludge dewatering.

Other key assumptions and bases include the following:

- Disc loadings (pounds of BOD per day per square foot) vary with influent and effluent BOD concentrations in accordance with pilot and commercial data utilized by Hormel in their design estimates.

- Disc area is directly proportional to wastewater flow rate, other conditions being equal.

- Base case RBC effluent BOD concentrations are approximately 20 mg/l.

- All cost factors are patterned directly after those used for Table VII-18.

- Clarifier area requirements are a direct function of wastewater flow rate.

- Sludge dewatering equipment size and/or sludge storage volume is a direct function of the amount of BOD reduction.

- Energy requirements are directly proportional to RBC disc area.

- Total annual labor costs are constant regardless of equipment size.

- Sludge disposal costs are constant per unit of sludge handled.

EFFECTIVENESS OF TECHNOLOGY OPTIONS

Section VI presented the in-plant and end-of-pipe technologies that are available for treating and controlling traditional and priority pollutants in wastewaters from the pharmaceutical manufacturing industry. The discussions addressed methods of reducing pollutants beyond BPT limitations and suggested achievable effluent concentrations. The cost estimates presented previously in this section represent investments, beyond BPT costs, for treatment alternatives that may be necessary for compliance with recommended effluent limitations. A summary of total annual costs developed for the four subcategory model plants to install these in-plant and end-of-pipe treatment methods is given in Table VII-26. Also shown are the costs associated with BPT guidelines technology for the model plants.

Based upon the information gathered during this study, Tables VII-27 through VII-30 were prepared to summarize the effectiveness of the various technology options for each subcategory. Raw waste load characteristics developed from the screening/verification data base and existing BPT guidelines for traditional pollutants are shown in both concentration and mass discharge for the entire subcategory. As noted in Table VII-2, the total priority pollutant raw waste load for an entire subcategory was calculated by multiplying the appropriate pollutant concentration by the total subcategory flow, and then adjusting by the percent of occurrence in screening/verification plants.

Technology 1 is BPT technology based on biological treatment. The discharge values shown for both the traditional and priority pollutants are representative of each subcategory and were obtained from analyses of data from screening/verification plants with biological treatment in place. Costs per pound of removal of conventional (BOD plus TSS) and priority pollutants were based on the BPT costs presented in Table VII-26.

Technologies 2 and 2A are biological enhancement and enhancement followed by filtration. These technologies can be considered as options for BCT, BAT, and NSPS regulations. Achievable effluent values for traditional pollutants were developed from long-term data gathered from the industry. Note that for Subcategories B and D, these technologies do not provide TSS reductions beyond those identified as BPT. Costs per pound of conventional pollutants removed for each process shown are based on the total annual costs given in Table VII-26. As discussed in Section VI, the screening/verification data base indicated that priority pollutant removals by biological enhancement are no better than conventional biological treatment. Thus, priority pollutant levels for these technologies are assumed to be the same as for BPT.

Technologies 3 through 5 are the in-plant methods discussed in Section VI for the control of cyanide, metals, and solvents. The effluent concentration values shown are for the in-plant process waste streams being treated. Estimated discharge values for an entire subcategory were obtained by multiplying the pollutant concentrations by the process stream flow, then by the number of plants in the subcategory, and finally adjusting by the percent occurrence noted in Table VII-2. The costs per pound of pollutants removed were determined by using the appropriate total annual costs from Table VII-26. Each of these technologies or combinations thereof can be considered as options for PSES and PSNS regulations.

BCT COST TEST

BCT requires that limitations for conventional pollutants be assessed by a "cost reasonableness" test. As specified in the Federal Register (44 FR 50732, August 29, 1979), "the BCT test compares the cost for industry to remove a pound of conventional pollutants to the cost incurred by a POTW for removing a pound of conventional pollutants. If the industry cost for a specific technology is lower than the POTW cost, the test is passed and the level of control of conventional pollutants is considered reasonable. If the industry costs of removal are higher than the POTW costs, the test is failed and BCT cannot be set at that level."

BPT is the base point for the BCT cost evaluation. All costs beyond BPT associated with the control of conventional pollutants are used in the BCT test. The costs per pound of conventionals (BOD and TSS) removed must be compared with a cost reasonableness ratio of $1.27 per pound (January 1978). This figure was based on the costs for an "average" POTW with a flow of two million gallons per day to upgrade its facility from secondary treatment (30 mg/1 BOD, 30 mg/1 TSS) to advanced secondary treatment (10 mg/1 BOD, 10 mg/1 TSS).

Table VII-31 presents the results of the BCT cost test for Technologies 2 and 2A. EPA's procedure is to use 30 day maximum effluent values for the BCT cost evaluation. BOD and TSS variability factors were applied to the achievable effluent concentrations, shown in Tables VII-27 and VII-30, to obtain monthly maximum effluent values for each technology. Variability factors for the recently acquired long term data have not yet been determined. In the interim, the monthly variability factors of 2.4 for BOD and 2.8 for TSS that were developed during the 1976 BPT study for the pharmaceutical industry were applied. The summary of total annual costs presented in Table VII-26 was then used to calculate the cost of conventional pollutant removal.

NON-WATER QUALITY ASPECTS

Solid Wastes

Sludges will be generated by the in-plant and end-of-pipe treatment technologies summarized in Tables VII-27 through VII-30. Sludge production rates for model plants, in pounds per day of dry solids, are shown for each treatment process in the cost bases tables presented in this section. The amount of sludge produced by pharmaceutical plants will vary markedly from site to site.

However, the production quantities presented in this section are conservative estimates and are expected to be equal to or higher than the actual amounts experienced by any given production site. In addition, not all pharmaceutical plants will generate each of the pollutants associated with all treatment technologies.

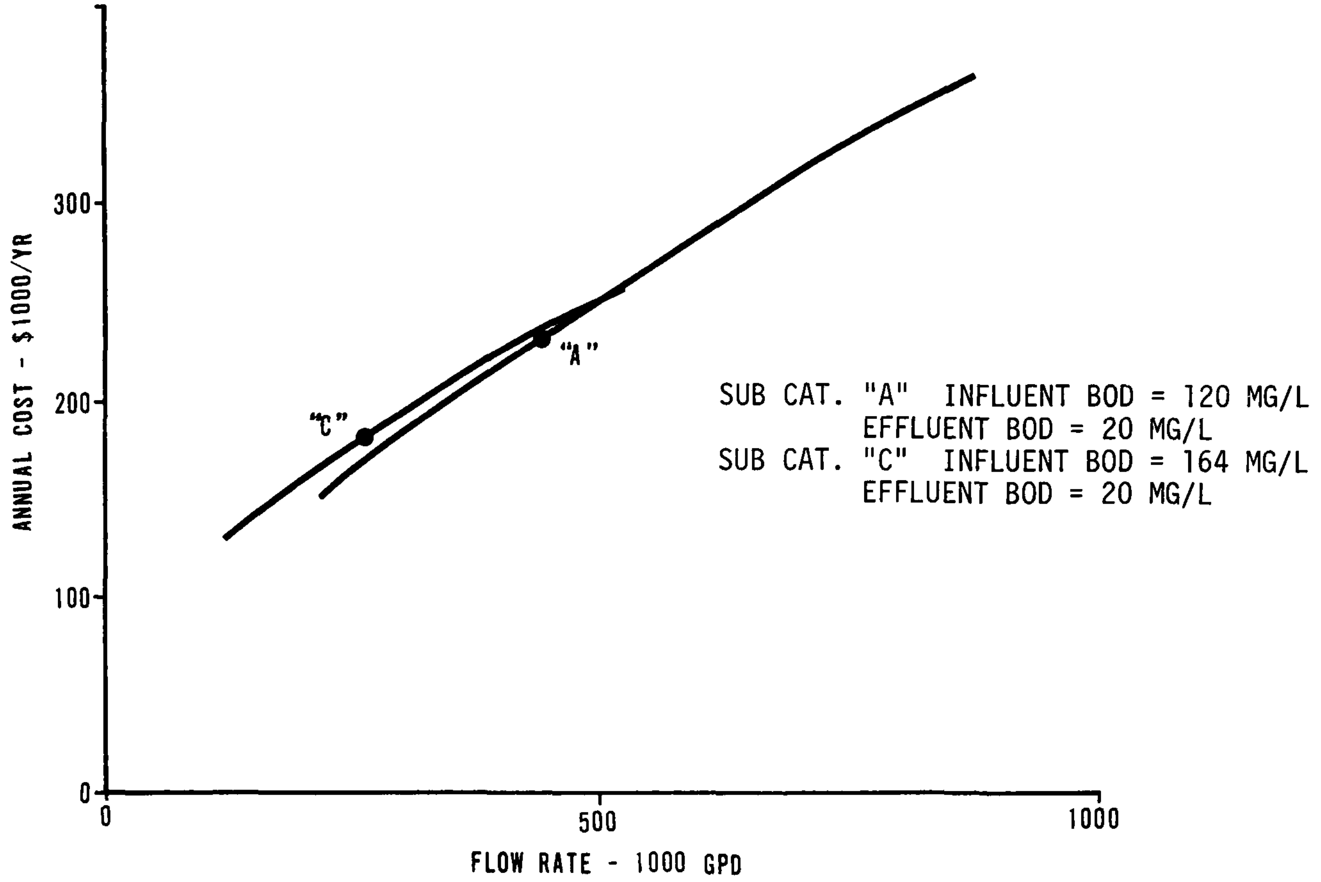
Based upon these factors, it is expected that the environmental impact of the sludge production will be minimal, especially when compared to the large quantities of sludges produced by BPT type technology.

Air Pollution

Steam stripping is one technology discussed in this report that may generate an air pollution problem. However, due to the economic value of the compounds being removed, it will often be cost effective as well as environmentally necessary to recondense and recover these compounds, rather than emit them to the atmosphere.

FIGURE VII-1

RBC SYSTEM
COST SENSITIVITY
EFFECT OF FLOW RATE



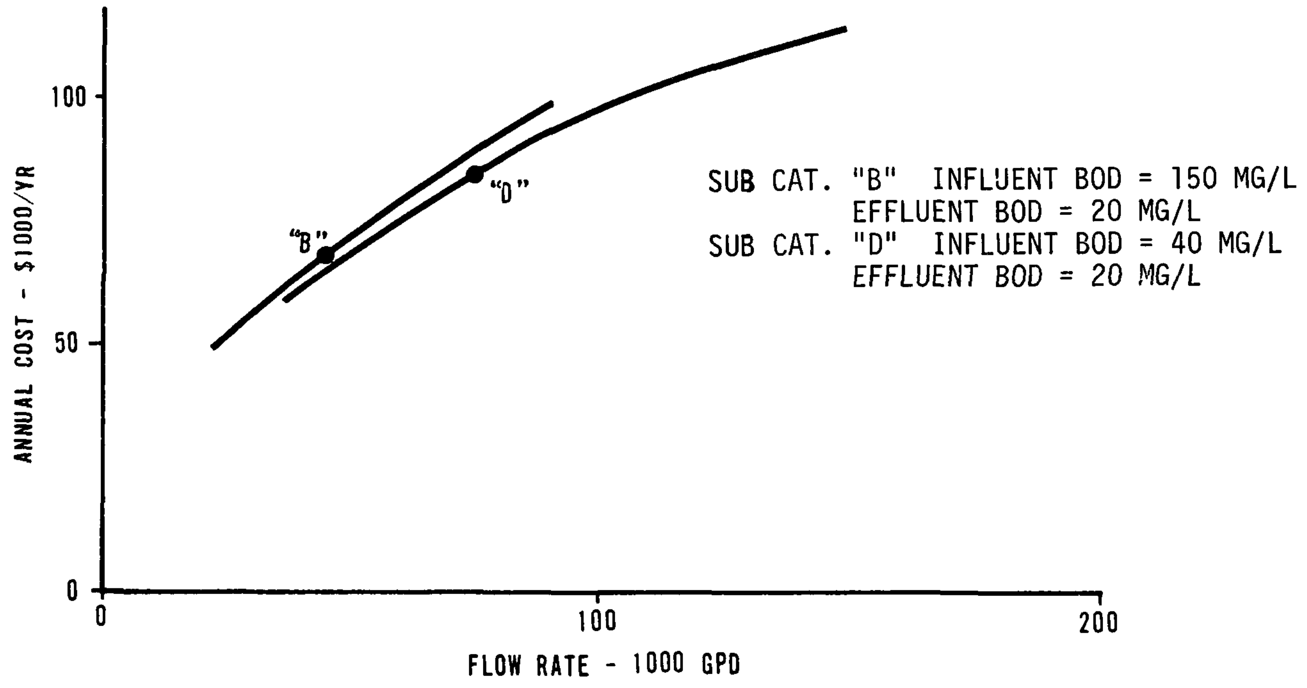


FIGURE VII-2
RBC SYSTEM
COST SENSITIVITY
EFFECT OF INFLUENT BOD LEVEL

SUB CAT. "A" FLOW = 435,000 GPD
EFFLUENT BOD = 20 MG/L
SUB CAT. "B" FLOW = 45,000 GPD
EFFLUENT BOD = 20 MG/L
SUB CAT. "C" FLOW = 260,000 GPD
EFFLUENT BOD = 20 MG/L

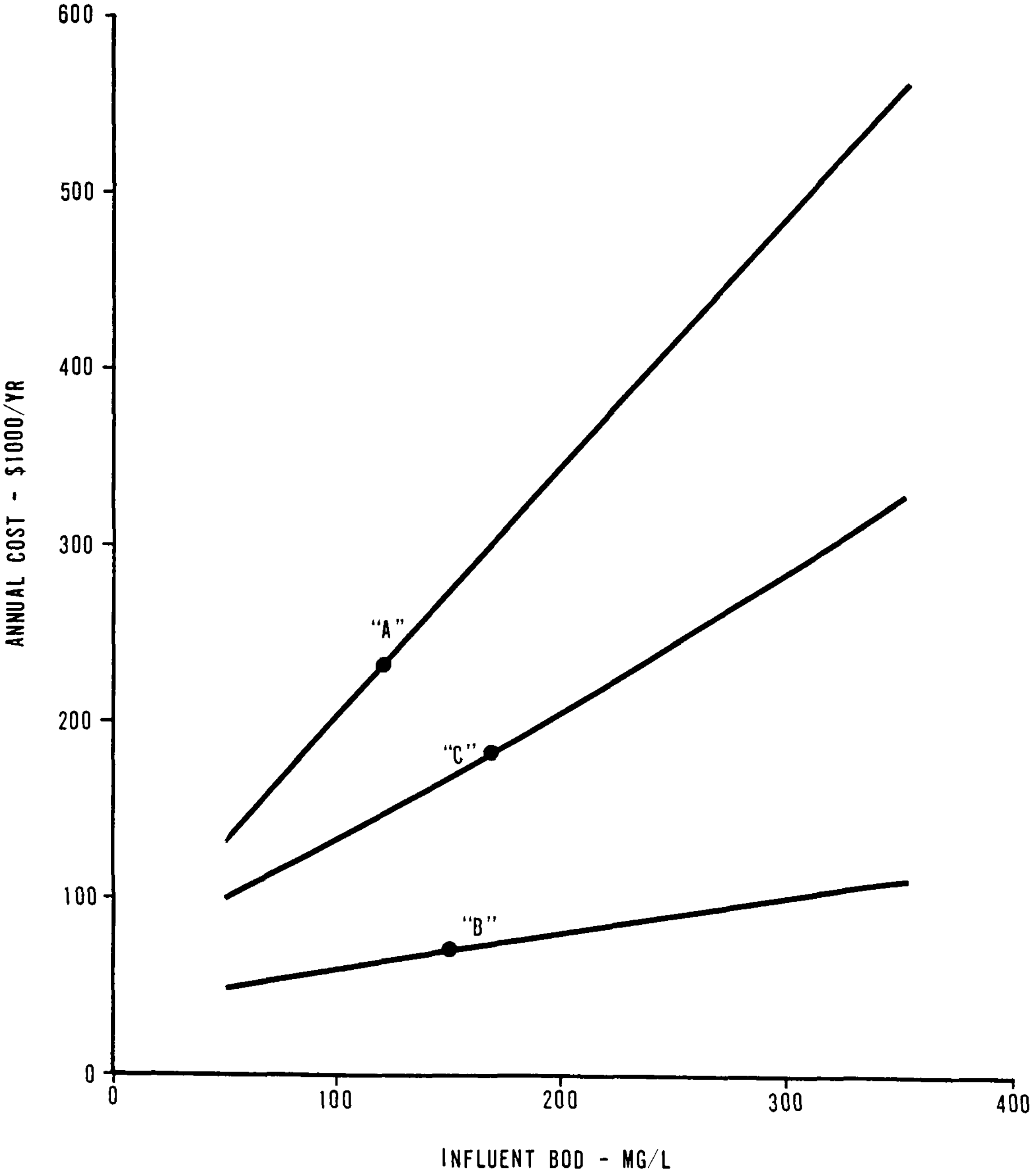


FIGURE VII-3

RBC SYSTEM

COST SENSITIVITY

EFFECT OF EFFLUENT TARGET BOD

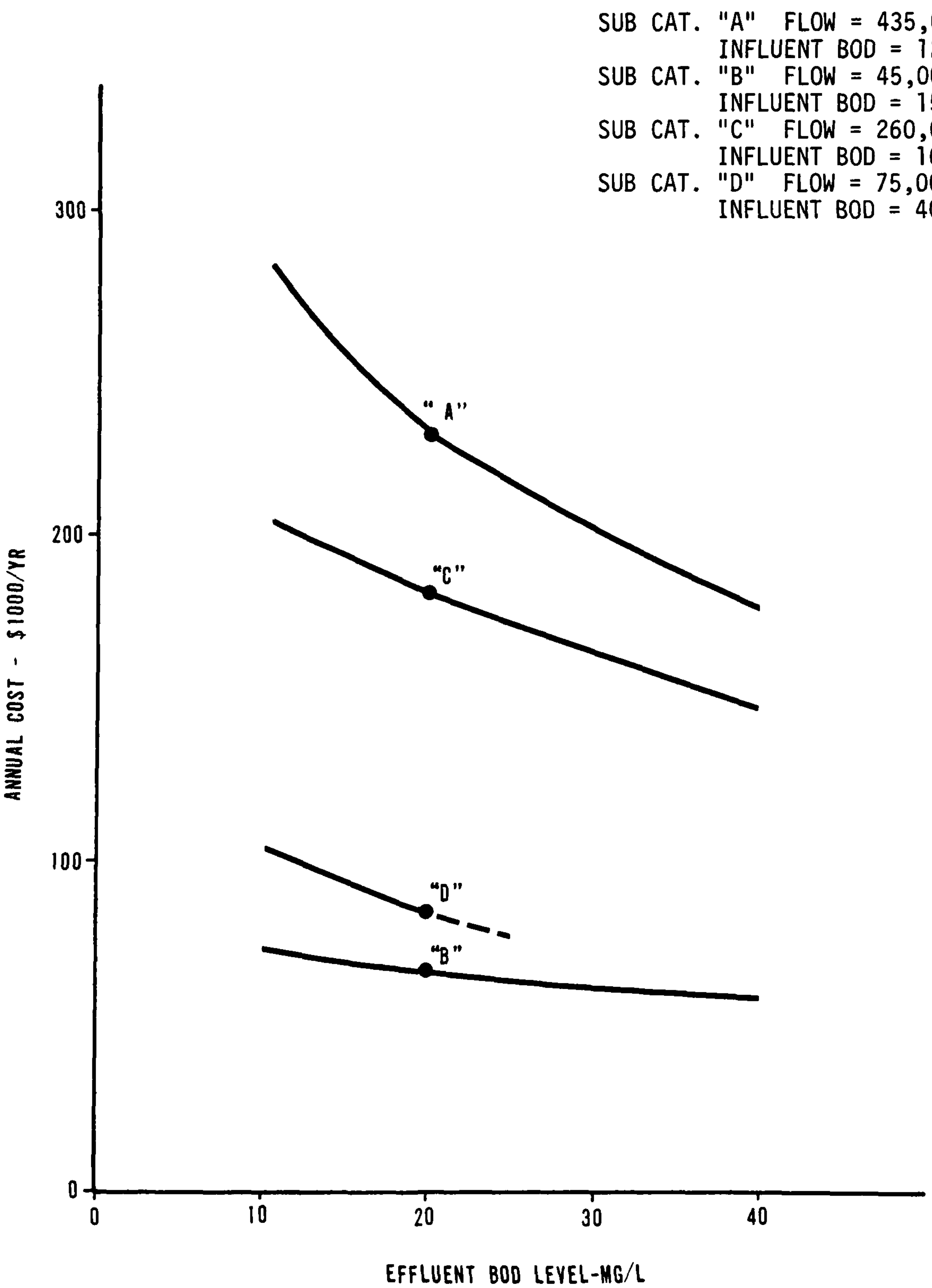


FIGURE VII-4

RBC EQUIPMENT COST

VS. DISC SURFACE AREA

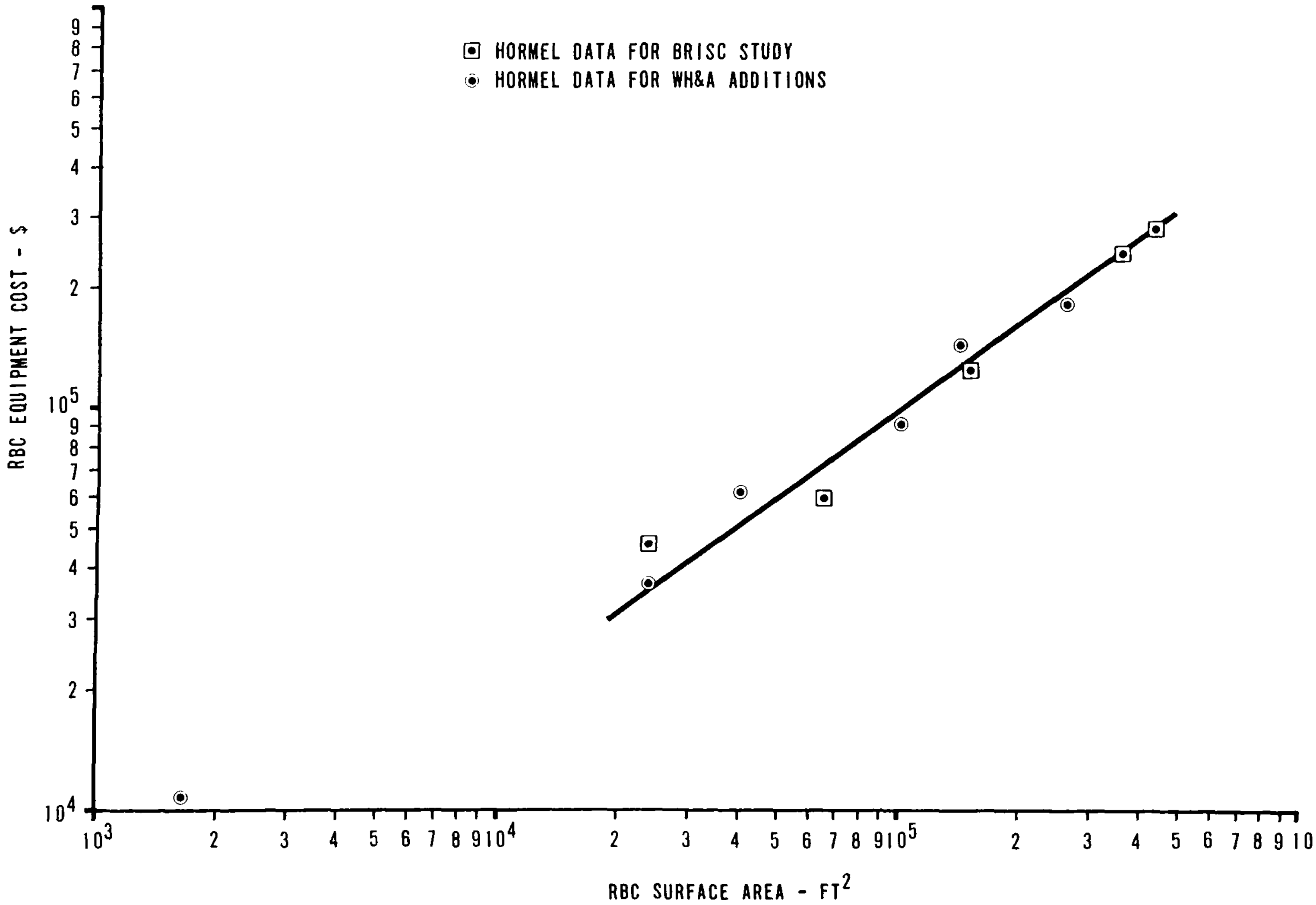


TABLE VII-1

RAW WASTE LOADS FOR SUBCATEGORY MODEL PLANTS

TRADITIONAL POLLUTANTS

Traditional Pollutant	Subcategory Model Plants A	B	C	D
BOD, mg/l	2,440	1,270	2,190	1,630
lbs/day	8,850	480	4,750	1,020
COD, mg/l	5,180	2,050	5,160	2,780
lbs/day	18,800	770	11,200	1,740
TSS, mg/l	1,030	520	740	370
lbs/day	3,740	200	1,600	230
Wastewater Flow				
Mean Plant Flow, gal/day	435,000	45,000	260,000	75,000

Notes:

1. Wastewater concentrations (mg/l) were developed using the results of the screening and verification programs. Twenty-six individual plants comprise this data base.

2. BOD, COD, and TSS concentrations are the mean of the results in the screening and verification data base for each of the three pollutants. The mean concentrations are based on the data from all plants that had that particular type of operation (Example: data from an ABC plant were used in the A, the B, and the C determinations). These concentrations were verified by the BAT 308 and BPT data bases.

TABLE VII-2

TOTAL INDUSTRY* RAW WASTE LOADS FOR THE 13 PRIORITY POLLUTANTS OF CONCERN **

Pollutant	Median Screening and Verification RWL's	
	ug/1	pounds/day +
Acid Extractables		
Phenol	180	56.8
Volatile Organics		
Benzene	100	33.7
Chloroform	150	53.0
Ethylbenzene	20	5.0
Methylene Chloride	320	147.9
Toluene	515	173.6
Metals		
Chromium	45	22.5
Copper	85	42.5
Lead	50	17.7
Mercury	8	0.4
Nickel	50	15.8
Zinc	250	125.1
Other		
Cyanide	280	76.1

(+) The total pounds discharged for each pollutant were calculated by multiplying the pollutant concentration by the total industry flow. The resultant loading was adjusted by the percent of the total screening and verification plants in which it occurs as follows:

Pollutant	Adjustment Factor
Phenol	.58
Benzene	.62
Chloroform	.65
Ethylbenzene	.46
Methylene Chloride	.85
Toluene	.62
Chromium	.92
Copper	.92
Lead	.65
Mercury	.85
Nickel	.58
Zinc	.92
Cyanide	.50

* For all subcategories (A, B, C and D)
Total industry flow - 65.2 MGD

** The 13 priority pollutants of concern are those that were found 10 or more times in the screening and verification data base.

TABLE VII-3

CYANIDE DESTRUCTION

EQUIPMENT COST BASES AND ENERGY REQUIREMENTS

Description	Subcategory Model Plants			
	A	B	C	D
Mean flow, gal/day	43,500	4,500	26,000	7,500
Type of Operation	Continuous	Batch	Continuous	Batch
Detention Tank(s), gal	One, 1,000	Two, 4,500	One, 600	Two, 7,500
Mixer(s), hp	One, 0.25	Two, 1.5	One, 0.25	Two, 2
Mixing Req., kWh/yr	1,600	9,600	1,600	12,800
Hypochlorite Feed Rate, lb/yr	19,200	2,000	11,500	3,300
Caustic Feed Rate, lb/yr	22,200	2,300	13,300	3,900
Pumping Req., kWh/yr	3,300	400	2,000	600
Manpower Req., h/yr	500	500	500	500

TABLE VII-4

CYANIDE DESTRUCTION

CAPITAL COSTS

Description	Cost, Dollars, for Subcategory Model Plants			
	A	B	C	D
Detention Tank(s)	$ 3,000	$13,000	$ 2,000	$17,000
Mixer(s)	800	5,000	800	6,000
Hypochlorite Feed System	11,000	-	9,500	-
Caustic Feed System	11,000	-	9,500	-
pH and ORP Control Systems	10,000	-	10,000	-
Piping and Pumps	7,200	3,600	6,400	4,600
Equipment Cost	43,000	21,600	38,200	27,600
Installation	21,500	10,800	19,100	13,800
Engineering	9,700	4,800	8,800	6,300
Contingency	9,800	4,800	8,900	6,300
Total Capital Cost	$84,000	$42,000	$75,000	$54,000

TABLE VII-5

CYANIDE DESTRUCTION

TOTAL ANNUAL COSTS

Description	Cost, Dollars, for Subcategory Model Plants A	B	C	D
Chemicals				
Hypochlorite	$11,600	$ 1,200	$ 6,900	$ 2,000
Caustic	2,700	300	1,600	500
Energy	200	400	200	600
Labor	5,000	5,000	5,000	5,000
Maintenance	2,500	1,300	2,300	1,600
Capital Recovery plus Return	14,000	6,800	12,000	9,300
Total Annual Cost	$36,000	$15,000	$28,000	$19,000

TABLE VII-6

CHROMIUM REDUCTION

EQUIPMENT COST BASES AND ENERGY REQUIREMENTS

Description	Subcategory Model Plants			
	A	B	C	D
Mean flow, gal/day	43,500	4,500	26,000	7,500
Type of Operation	Continuous	Batch	Continuous	Batch
Detention Tank(s), gal	One, 2,000 2 sections	Two, 4,500	One, 1,200 2 sections	Two, 7,500
Mixers, hp	One, 0.5 One, 0.25	Two, 1.5	One, 0.5 One, 0.25	Two, 2
Mixing Req., kWh/yr	4,800	9,600	4,800	12,800
Clarifier Dia., ft	10	-	8	-
SO_2 Feed Rate, lb/yr	7,200	800	4,300	1,300
Acid Feed Rate, lb/yr	7,200	800	4,300	1,300
Caustic Feed Rate, lb/yr	31,800	3,300	19,000	5,500
Pumping Req., kWh/yr	3,300	400	2,000	600
Manpower Req., h/yr	500	500	500	500
Sludge Produced, lb/yr dry solids	8,000	900	4,800	1,400

TABLE VII-7

CHROMIUM REDUCTION

CAPITAL COSTS

Description	Cost, Dollars, for Subcategory Model Plants			
	A	B	C	D
Detention Tank(s)	$ 6,000	$20,000	$ 4,500	$26,000
Mixers	2,500	5,000	2,500	6,000
Acid and SO_2 Feed Systems	22,000	-	19,000	-
pH and ORP Control Systems	10,000	-	10,000	-
Caustic Feed System	11,000	-	9,500	-
Clarifier	32,000	-	27,000	-
Piping and Pumps	16,700	5,000	13,500	6,400
Equipment Cost	100,200	30,000	86,000	38,400
Installation	50,100	15,000	43,000	19,200
Engineering	22,800	6,800	19,500	8,700
Contingency	22,900	7,200	19,500	8,700
Total Capital Cost	$196,000	$59,000	$168,000	$75,000

TABLE VII-8

CHROMIUM REDUCTION

TOTAL ANNUAL COSTS

Description	Cost, Dollars, for Subcategory Model Plants			
	A	B	C	D
Chemicals				
SO_2	$ 1,100	$ 100	$ 650	$ 200
Acid	450	50	250	100
Caustic	3,800	400	2,300	650
Energy	350	400	300	550
Labor	5,000	5,000	5,000	5,000
Maintenance	5,900	1,800	5,100	2,300
Sludge Disposal	5,800	650	3,500	1,000
Capital Recovery plus Return	31,600	9,600	27,900	12,200
Total Annual Cost	$54,000	$18,000	$45,000	$22,000

TABLE VII-9

METAL PRECIPITATION

EQUIPMENT COST BASES AND ENERGY REQUIREMENTS

Description	Subcategory Model Plants			
	A	B	C	D
Mean flow, gal/day	43,500	4,500	26,000	7,500
Type of Operation	Continuous	Batch	Continuous	Batch
Detention Tanks, gal	-	Two, 4,500	-	Two, 7,500
Mixers, hp	-	Two, 1.5	-	Two, 2
Mixing Req., kWh/yr	-	9,600	-	12,800
Clarifier Dia., ft	10	-	8	-
Filters Dia., ft	Two, 3	-	Two, 3	-
Lime Feed Rate, lb/yr	13,200	1,400	7,900	2,300
Alum Feed Rate, lb/yr	2,600	300	1,600	500
Misc. Energy Req., kWh/yr	500	50	300	100
Manpower Req., h/yr	500	500	500	500
Sludge Produced, lb/yr dry solids	15,900	1,700	9,500	2,800

TABLE VII-10

METAL PRECIPITATION

CAPITAL COSTS

Description	Cost, Dollars, for Subcategory Model Plants A	B	C	D
Detention Tanks	$ -	$20,000	$ -	$26,000
Mixers	-	5,000	-	6,000
Clarifier, Solids Contact Type	32,000	-	27,000	-
Lime and Alum Feed Systems	22,000	-	19,000	-
Filtration Units	30,000	-	30,000	-
Piping	8,400	2,500	7,600	3,200
Equipment Cost	$ 92,400	$27,500	$ 83,600	$35,200
Installation	$46,200	$13,800	$41,800	$17,600
Engineering	20,700	6,300	18,800	8,100
Contingency	20,700	6,400	18,800	8,100
Total Capital Cost	$180,000	$54,000	$163,000	$69,000

TABLE VII-11

METAL PRECIPITATION

TOTAL ANNUAL COSTS

Description	Cost, Dollars, for Subcategory Model Plants			
	A	B	C	D
Chemicals				
Lime	$ 550	$ 100	$ 350	$ 100
Alum	200	50	100	50
Energy	50	400	50	550
Labor	5,000	5,000	5,000	5,000
Maintenance	5,400	1,700	4,900	2,100
Sludge Disposal	11,500	1,250	6,800	2,000
Capital Recovery plus Return	29,300	8,500	26,800	11,200
Total Annual Cost	$52,000	$17,000	$44,000	$21,000

TABLE VII-12

STEAM STRIPPING

COST DATA

Description	Capital Cost, Dollars	
Process Equipment Steam stripper with 20 trays, 4 ft. I.D. Feed rate = 200,000 lbs/hr (400 gpm)	$ 98,000	
Physical Plant 207% of equipment cost	203,000	
Engineering and Construction 30% of the total equipment cost	90,000	
Direct Plant Cost	$ 391,000	
Fixed Capital 120% of direct plant cost		$ 469,000
Working Capital 15% of fixed capital		71,000
Total Capital Cost		$ 540,000

	Annual Cost, Dollars/1000 gal
Steam $3/1000 lbs. steam 0.1 lbs steam/lb feed	$ 2.50
Steam for Feed Heating 70°C to 100°C 0.056 lbs steam/lb feed	1.40
Electricity $0.04/kwh	0.33
Labor $10/h Operating time = 8000 h/yr	0.42
Maintenance 3% of capital cost	0.08
Capital Recovery plus Return 16.3% of capital cost	0.47
Total Annual Cost	$ 5.20/1000 gal

Source: Reference No. 72
Note: Costs have been adjusted to January 1978 dollars.

TABLE VII-13

EXISTING BPT EFFLUENT LIMITATIONS [1,2]

FOR THE SUBCATEGORY MODEL PLANTS

Pollutant	Subcategory Model Plants A	B	C	D
BOD, % Removal	90	90	90	90
mg/l	244	127	219	163
lbs/day	885	48	475	102
COD, % Removal	74	74	74	74
mg/l	1,350	533	1,340	723
lbs/day	4,900	200	2,910	452
TSS, mg/l	178	18	178	18
lbs/day	646	7	386	11

1. BOD and COD effluent levels are based on BPT percent removal regulations.

2. TSS effluent levels are from BPT data base. TSS regulation for Subcategories B and D is 52 mg/l monthly maximum. TSS regulations for Subcategories A and C were not promulgated.

TABLE VII-14

ACTIVATED SLUDGE SYSTEM

EQUIPMENT COST BASES AND ENERGY REQUIREMENTS

Description	Subcategory Model Plants			
	A	B	C	D
Mean flow, gal/day	435,000	45,000	260,000	75,000
Detention Time, days	2.2	0.2	1.2	0.3
Aerators, hp	Four, 60	Two, 5	Four, 30	Two, 5
Nutrient Addition, lbs/day				
Ammonia	32	1.4	16	1.4
Phosphorous	6	0.3	3	0.3
Lime	30	-	17	-
Ferric Chloride	8	-	4.5	-
Clarifiers, Dia., ft	Two, 30	Two, 10	Two, 24	Two, 12
Sludge Thickener Surface Area, ft^2	28	-	20	-
Vacuum Filter Area, ft^2	19	-	10	-
Energy Req., kwh/yr	1,625,000	104,000	845,000	111,000
Sludge Produced, lbs/day dry solids	130	6	85	8
Area Req., ft^2	61,000	13,000	35,000	13,000

TABLE VII-15

ACTIVATED SLUDGE SYSTEM

CAPITAL COSTS

Description	Cost, Dollars, for Subcategory Model Plants			
	A	B	C	D
Activated Sludge Unit	$ 420,000	$ 12,000	$ 290,000	$ 34,000
Aeration	218,000	40,000	154,000	40,000
Nutrient Addition	13,000	1,000	7,000	1,000
Clarification	180,000	75,000	120,000	96,000
Sludge Thickening	33,000	-	24,000	-
Vacuum Filtration	142,000	-	132,000	-
Sludge Storage	-	18,000	-	18,000
Piping (installed)	151,000	22,000	108,000	28,000
Installed Cost	1,157,000	168,000	835,000	217,000
Engineering	174,000	25,000	125,000	33,000
Contingency	174,000	25,000	125,000	33,000
Total Capital Cost	$ 1,505,000	$ 218,000	$ 1,085,000	$ 283,000

TABLE VII-16

ACTIVATED SLUDGE SYSTEM

TOTAL ANNUAL COSTS

Description	Cost, Dollars, for Subcategory Model Plants			
	A	B	C	D
Chemicals	$ 2,600	$ 200	$ 1,400	$ 200
Energy	65,000	4,200	33,800	4,400
Labor	110,000	80,000	110,000	80,000
Maintenance	45,200	6,500	32,600	8,500
Sludge Disposal	5,700	7,900	3,700	10,500
Capital Recovery plus Return	246,500	35,200	176,500	46,400
Total Annual Cost	$ 475,000	$ 134,000	$ 358,000	$ 150,000

TABLE VII-17

ROTATING BIOLOGICAL CONTACTOR (RBC) SYSTEM

EQUIPMENT COST BASES AND ENERGY REQUIREMENTS

	Subcategory Model Plants			
Description	A	B	C	D
Mean Flow, gal/day	435,000	45,000	260,000	75,000
Number of RBC Units	Four	One	Three	One
Shaft Lengths, ft	20	10	20	20
Total RBC Surface Area, ft^2	304,000	24,000	228,000	65,000
Energy Req., kwh/hr	130,000	13,000	98,000	33,000
Clarifiers, Dia., ft	Two, 30	Two, 10	Two, 24	Two, 12
Manpower Req., h/yr	2,000	2,000	2,000	2,000
Sludge Produced, lbs/day dry solids	220	20	130	40
Sludge Dewatering	Yes	No	Yes	No
Manpower Req., h/yr	1500	-	1500	-
Energy Req., kwh/yr	195,000	-	115,000	-
Area Req., ft^2	30,000	2,500	20,000	4,000

TABLE VII-18

ROTATING BIOLOGICAL CONTACTOR (RBC) SYSTEM

CAPITAL AND TOTAL ANNUAL COSTS

	Capital Costs ($)			
	Subcategory Model Plants			
Description	A	B	C	D
RBC Units, Steel Tankage, Insulated Covers	$ 205,000	$ 40,000	$ 155,000	$ 50,000
Clarifiers	120,000	50,000	80,000	64,000
Sludge Dewatering	96,000	-	84,000	-
Sludge Storage	-	8,000	-	12,000
Piping	42,000	10,000	32,000	13,000
Equipment Cost	463,000	108,000	351,000	139,000
Installation	232,000	54,000	176,000	70,000
Engineering	104,000	24,000	79,000	31,000
Contingency	104,000	24,000	79,000	31,000
Total Capital Cost	$ 903,000	$ 210,000	$ 685,000	$ 271,000
	Annual Costs ($/Yr)			
Energy	$ 13,000	$ 600	$ 8,500	$ 1,400
Labor	35,000	20,000	35,000	20,000
Maintenance	27,100	6,300	20,600	8,100
Sludge Disposal	9,600	5,300	5,700	10,500
Capital Recovery plus Return	147,300	34,800	112,200	44,000
Total Annual Cost	$ 232,000	$ 67,000	$ 182,000	$ 84,000

TABLE VII-19

POLISHING POND

COST BASES

Description	Subcategory Model Plants			
	A	B	C	D
Mean Flow, gal/day	435,000	45,000	260,000	75,000
Detention Time, days	5.5	3.3	5.0	4.0
Excavated Volume, yd^3	15,000	1,000	8,000	2,000
Lined Area, ft^2	40,000	3,300	22,000	5,700
Basin Width at Top, ft	230	80	175	100
Square basin, 1:3 slope Freeboard = 1 ft Water depth = 8 ft Sludge depth = 1 ft				
Manpower Req., h/yr	200	200	200	200
Area Req., ft^2	62,000	10,000	40,000	14,000

TABLE VII-20

POLISHING POND

CAPITAL AND TOTAL ANNUAL COSTS

Description	Capital Costs ($) Subcategory Model Plants A	B	C	D
Excavation, Grading, Compaction	$ 135,000	$ 9,000	$ 72,000	$ 18,000
Impervious Liner (installed)	26,000	2,200	14,300	3,700
Piping (installed)	24,000	1,700	12,900	3,300
Installed Cost	185,000	12,900	99,200	25,000
Engineering	28,000	2,000	14,900	4,000
Contingency	28,000	2,100	14,900	4,000
Total Capital Cost	$ 241,000	$ 17,000	$ 129,000	$ 33,000
	Annual Costs ($/yr)			
Labor	$ 2,000	$ 2,000	$ 2,000	$ 2,000
Maintenance	7,200	500	3,900	1,000
Capital Recovery plus Return	38,800	2,500	21,100	5,000
Total Annual Cost	$ 48,000	$ 5,000	$ 27,000	$ 8,000

TABLE VII-21

ACTIVATED SLUDGE SYSTEM

WITH FILTRATION

EQUIPMENT COST BASES AND ENERGY REQUIREMENTS

Description	Subcategory Model Plants			
	A	B	C	D
Mean Flow, gal/day	435,000	45,000	260,000	75,000
Detention Time, days	8	1	5.5	1
Aerators, hp	Six, 125	Two, 7.5	Four, 75	Two, 7.5
Nutrient Addition, lbs/day				
Ammonia	32	1.4	16	1.4
Phosphorous	6	0.3	3	0.3
Lime		-		-
Ferric Chloride		-		-
Clarifiers, Dia., ft	Two, 30	Two, 10	Two, 24	Two, 12
Number of Dual Media Filtration Units	Two	Two	Two	Two
Filter Diameters, ft	10	3	8	4
Sludge Thickener Surface Area, ft^2	20	-	20	-
Vacuum Filter Area, ft^2	10	-	10	-
Energy Req., kwh/yr	5,600,000	130,000	2,340,000	140,000
Sludge Produced, lbs/day dry solids	90	20	60	20
Area Req., ft^2	165,000	17,000	74,000	17,000

TABLE VII-22

ACTIVATED SLUDGE SYSTEM

WITH FILTRATION

CAPITAL COSTS

Description	Cost, Dollars, for Subcategory Model Plants			
	A	B	C	D
Activated Sludge Unit	$ 778,000	$ 63,000	$ 508,000	$ 86,000
Aeration	465,000	44,000	245,000	44,000
Nutrient Addition	13,000	1,000	7,000	1,000
Clarification	180,000	75,000	120,000	96,000
Dual Media Filtration	180,000	54,000	120,000	63,000
Sludge Thickening	24,000	-	24,000	-
Vacuum Filtration	132,000	-	132,000	-
Sludge Storage	-	44,000	-	44,000
Piping (installed)	266,000	43,000	174,000	50,000
Installed Cost	2,038,000	324,000	1,330,000	384,000
Engineering	306,000	48,000	200,000	58,000
Contingency	306,000	48,000	200,000	58,000
Total Capital Cost	$ 2,650,000	$ 420,000	$ 1,730,000	$ 500,000

TABLE VII-23

ACTIVATED SLUDGE SYSTEM

WITH FILTRATION

TOTAL ANNUAL COSTS

Description	Cost, Dollars, for Subcategory Model Plants			
	A	B	C	D
Chemicals	$ 2,500	$ 200	$ 1,200	$ 200
Energy	224,000	5,200	93,600	5,600
Labor	130,000	100,000	130,000	100,000
Maintenance	79,500	12,600	51,900	15,000
Sludge Disposal	4,000	26,300	2,600	26,300
Capital Recovery plus Return	432,000	68,700	280,700	81,900
Total Annual Cost	$ 872,000	$ 213,000	$ 560,000	$ 229,000

TABLE VII-24

ROTATING BIOLOGICAL CONTACTOR (RBC) SYSTEM
WITH FILTRATION

EQUIPMENT COST BASES AND ENERGY REQUIREMENTS

	Subcategory Model Plants			
Description	A	B	C	D
Mean Flow, gal/day	435,000	45,000	260,000	75,000
Number of RBC Units	Four	One	Four	One
Shaft Lengths, ft	25	20	20	20
Total RBC Surface Area, ft^2	442,000	65,000	364,000	65,000
Energy Req., kwh/hr	260,000	33,000	195,000	33,000
Clarifiers, Dia., ft	Two, 30	Two, 10	Two, 24	Two, 12
Number of Dual Media Filtration Units	Two	Two	Two	Two
Filter Diameters, ft	10	3	8	4
Manpower Req., h/yr	4,500	4,500	4,500	4,500
Sludge Produced, lbs/day dry solids	300	30	180	50
Sludge Dewatering	Yes	No	Yes	No
Manpower Req., h/yr	1500	-	1500	-
Energy Req., kwh/yr	265,000	-	160,000	-
Area Req., ft^2	31,000	3,000	21,000	4,500

TABLE VII-25

ROTATING BIOLOGICAL CONTACTOR (RBC) SYSTEM
WITH FILTRATION

CAPITAL AND TOTAL ANNUAL COSTS

	Capital Costs ($)			
	Subcategory Model Plants			
Description	A	B	C	D
RBC Units, Steel Tankage, Insulated Covers	$ 235,000	$ 50,000	$ 205,000	$ 50,000
Clarifiers	120,000	50,000	80,000	64,000
Filtration Units	120,000	36,000	80,000	42,000
Sludge Dewatering	108,000	-	92,000	-
Sludge Storage	-	12,000	-	18,000
Piping	58,000	15,000	46,000	17,000
Equipment Cost	641,000	163,000	503,000	191,000
Installation	321,000	82,000	251,000	96,000
Engineering	144,000	37,000	113,000	43,000
Contingency	144,000	37,000	113,000	43,000
Total Capital Cost	$ 1,250,000	$ 319,000	$ 980,000	$ 373,000
	Annual Costs ($/Yr)			
Energy	$ 21,000	$ 1,400	$ 14,200	$ 1,400
Labor	60,000	45,000	60,000	45,000
Maintenance	37,400	9,600	29,400	11,200
Sludge Disposal	13,100	7,900	7,900	13,100
Capital Recovery plus Return	203,500	52,100	159,500	61,300
Total Annual Cost	$ 335,000	$ 116,000	$ 271,000	$ 132,000

TABLE VII-26

SUMMARY OF TREATMENT TECHNOLOGY COSTS

	Total Annual Cost ($/yr) for Subcategory Model Plants			
	A	B	C	D
End-of-pipe:				
Mean Flow (gal/day)	435,000	45,000	260,000	75,000
Technology 1 - BPT	$ 2,290,000	$ 689,000	$ 939,000	$ 455,000
Technology 2 - A/S	475,000	134,000	358,000	150,000
RBC	232,000	67,000	182,000	84,000
Pond	48,000	5,000	27,000	8,000
Technology 2A - A/S + Filtration	872,000	213,000	560,000	229,000
RBC + Filtration	335,000	116,000	271,000	132,000
In-Plant:				
Process Flow (gal/day)	43,500	4,500	26,000	7,500
Technology 3 - Cr Reduction + Metals Precipitation	106,000	35,000	89,000	43,000
Technology 4 - CN Destruction	36,000	15,000	28,000	19,000
Technology 5 - Steam Stripping	83,000	9,000	49,000	14,000
Number of Plants in Subcategory	35	71	106	259

Notes: Total annual cost includes maintenance, labor, energy, chemicals, sludge disposal, and capital recovery plus return.

Costs for Technologies 2 - 5 are incremental costs over BPT cost.

Costs are in January 1978 dollars. ENR = 2670

TABLE VII-27

PHARMACEUTICAL INDUSTRY
FERMENTATION PROCESSING SUBCATEGORY (A)
TECHNOLOGY OPTIONS

Total Flow for the Subcategory - 15,000,000 GPD; Mean Plant Flow - 435,000 GPD; Dischargers - 31% Direct, 69% Indirect

Pollutant	RWL mg/l	RWL lbs/day (Total Subcat)	Existing BPT Guidelines % Removal	Existing BPT Guidelines mg/l	Existing BPT Guidelines lbs/day (Total Subcat)	Technology 1 - BPT % Removal	Technology 1 - BPT mg/l	Technology 1 - BPT lbs/day (Total Subcat)	Technology 1 - BPT Cost $/lb	Technology 2 mg/l	Technology 2 lbs/day (Total Subcat)	Technology 2 Cost $/lb
BOD	2440.	305,000.	90.0	244.	30,500.	96.3	90.	11,300.	$0.54	40.	5,000.	
COD	5180.	648,000.	74.0	1350.	169,000.	87.5	650.	81,300.		360.	45,000.	
TSS	1030.	129,000.		178.	22,300.	83.5	170.	21,300.	Incl. in above	40.	5,000.	
Phenol	.180	13.1					.005	.4				
Benzene	.100	7.8					-	-				
Chloroform	.150	12.2					.010	.81				
Ethylbenzene	.020	1.2					-	-				
Methylene Chloride	.320	34.0					.070	7.4				
Toluene	.515	40.0					.003	.2				
Chromium	.045	5.2					.016	1.8				
Copper	.085	9.8					.020	2.3				
Lead	.050	4.1					.017	1.4				
Mercury	.0008	.09					.0005	.05				
Nickel	.050	3.6					.045	3.3				
Zinc	.250	28.8					.100	11.5				
Cyanide	.280	17.5					.063	3.9				
Total P.P.		177.4						33.1	$1,500.			
Total Volatile P.P.		95.2						8.4				
Total Metals		51.6						20.4				
Treatment						Biological Treatment				Biological Enhancement (2-Stage Biological Treatment)		
# Units in:												
Single Subcategory A Plants -				2			2				2	
All Subcategory A Plants -				14			13				6	
Total Industry -				83			74				22	
Solid Wastes							120,000 lbs dry solids/day			8,000 lbs dry solids/day		

Existing BPT Guidelines — Note: BOD and COD effluent levels based on BPT percent removal regulations. TSS level from BPT data base; regulation was not promulgated.

Technology 2 — Costs based on BOD removal only:

A/S	$1.75
RBC + Clar.	$ .85
Polishing Lagoon	$ .20

Technology 2 — Costs based on BOD and TSS removals:

A/S	$1.05
RBC + Clar.	$ .50
Polishing Lagoon	$ .10

Pollutant	Technology 2A mg/l	Technology 2A lbs/day (Total Subcat)	Technology 2A Cost $/lb	Technology 3 mg/l (In-plant value)	Technology 3 lbs/day (Total Subcat)	Technology 3 Cost $/lb	Technology 4 mg/l (In-plant value)	Technology 4 lbs/day (Total Subcat)	Technology 4 Cost $/lb	Technology 5 mg/l (In-plant value)	Technology 5 lbs/day (Total Subcat)	Technology 5 Cost $/lb
BOD	20.	2,500.										
COD	270.	33,800.										
TSS	30.	3,750.										
Phenol												
Benzene										.05	.39	
Chloroform										.05	.41	
Ethylbenzene										.05	.29	
Methylene Chloride										.05	.53	
Toluene										.05	.39	
Chromium				0.3	3.5							
Copper				0.2	2.3							
Lead				0.1	.8							
Mercury												
Nickel				0.5	3.6							
Zinc				0.3	3.5							
Cyanide							0.04	0.3	$198.			
Total P.P.												
Total Volatile P.P.											2.01	$84.
Total Metals					13.7	$264.						
Treatment	Biological Enhancement (2-Stage Bio. Trt. + Filter)			Chromium Reduction Plus Metal Precipitation			Cyanide Destruction with Chlorine			Steam Stripping		
# Units in:												
Subcategory B only Plants -	0			0			0			0		
All Subcategory B Plants -	0			0			1			3		
Total Industry -	3			3			6			7		
Solid Wastes	11,000 lbs dry solids/day			1,500 lbs dry solids/day			None			None		
Notes				This technology eliminates all metals from secondary			This technology eliminates cyanide from secondary sludge.			This technology eliminates the problem of air stripping in secondary treatment system.		

Technology 2A — Costs based on BOD and TSS removals:

A/S + Filt.	$2.95
RBC + Clar. + Filt.	$1.15

Technology 2A — Costs based on BOD and TSS removals:

A/S + Filt.	$1.75
RBC + Clar. + Filt.	$ .70

TABLE VII-28

PHARMACEUTICAL INDUSTRY
BIOLOGICAL EXTRACTION SUBCATEGORY (B)
TECHNOLOGY OPTIONS

Total Flow for the Subcategory - 3,200,000 GPD; Mean Plant Flow - 45,000 GPD; Dischargers - 13% Direct, 87% Indirect

Pollutant	RWL mg/l	RWL lbs/day (Total Subcat)	Existing BPT Guidelines % Removal	Existing BPT mg/l	Existing BPT lbs/day (Total Subcat)	Technology 1 - BPT % Removal	Technology 1 mg/l	Technology 1 lbs/day (Total Subcat)	Technology 1 Cost $/lb	Technology 2 mg/l	Technology 2 lbs/day (Total Subcat)	Technology 2 Cost $/lb
BOD	1270.	33,900.	90.	127.	3,390.	90.6	120.	3,200.	$3.56	40.	1,070.	
COD	2050.	54,700.	74.	533.	14,200.	54.1	940.	25,100.	Incl. in above	360.	9,600.	
TSS	520.	13,900.		18.	480.	50.0	260.	6,940.	Incl. in above	18.	480.	
Phenol	.180	2.8					.005	.08				
Benzene	.100	1.7					-	-				
Chloroform	.150	2.6					.010	.17				
Ethylbenzene	.020	0.2					-	-				
Methylene Chloride	.320	7.3					.070	1.6				
Toluene	.515	8.5					.003	.05				
Chromium	.045	1.1					.016	.39				
Copper	.085	2.1					.020	.49				
Lead	.050	.9					.017	.30				
Mercury	.0008	.02					.0005	.01				
Nickel	.050	0.8					.045	.69				
Zinc	.250	6.1					.100	2.5				
Cyanide	.280	3.7					.063	.84				
Total P.P.		37.8						7.1	$4,370.			
Total Volatile P.P.		20.3						1.8				
Total Metals		11.0						4.4				
Treatment						Biological Treatment				Biological Enhancement (2-Stage Biological Treatment)		
# Units in:												
Single Subcategory B Plants -				2			2				1	
All Subcategory B Plants -				19			18				4	
Total Industry -				83			74				22	
Solid Wastes						11,200 lbs dry solids/day				1,500 lbs dry solids/day		

Note: BOD and COD effluent levels based on BPT percent removal regulations. TSS level from BPT data base; regulation is 52 mg/l monthly maximum.

Technology 2 — Costs based on BOD removal only:*

A/S	$11.30
RBC + Clar.	$ 5.60
Polishing Lagoon	$ .40

*No TSS reductions achieved by this technology option

Pollutant	Technology 2A mg/l	Technology 2A lbs/day (Total Subcat)	Technology 2A Cost $/lb	Technology 3 mg/l (In-plant value)	Technology 3 lbs/day (Total Subcat)	Technology 3 Cost $/lb	Technology 4 mg/l (In-plant value)	Technology 4 lbs/day (Total Subcat)	Technology 4 Cost $/lb	Technology 5 mg/l (In-plant value)	Technology 5 lbs/day (Total Subcat)	Technology 5 Cost $/lb
BOD	20.	535.										
COD	270.	7,200.										
TSS	18.	480.										
Phenol												
Benzene										.05	.08	
Chloroform										.05	.09	
Ethylbenzene										.05	.06	
Methylene Chloride										.05	.11	
Toluene										.05	.08	
Chromium				0.3	.74							
Copper				0.2	.5							
Lead				0.1	.17							
Mercury												
Nickel				0.5	.77							
Zinc				0.3	.74							
Cyanide							0.01	0.05	$802.			
Total P.P.												
Total Volatile P.P.											.42	$88.
Total Metals					2.92	$843.						
Treatment	Biological Enhancement (2-Stage Bio. Trt. + Filter)			Chromium Reduction Plus Metal Precipitation			Cyanide Destruction with Chlorine			Steam Stripping		
# Units in:												
Subcategory B only Plants -	0			0			0			1		
All Subcategory B Plants -	0			0			1			2		
Total Industry -	3			3			6			7		
Solid Wastes	2,200 lbs dry solids/day			320 lbs dry solids/day			None			None		
Notes				This technology eliminates all metals from secondary sludge.			This technology eliminates cyanide from secondary sludge.			This technology eliminates the problem of air stripping in secondary treatment system.		

Technology 2A — Costs based on BOD and TSS removals:

A/S + Filt.	$14.50
RBC + Clar. + Filt.	$ 7.90

TABLE VII-29

PHARMACEUTICAL INDUSTRY
CHEMICAL SYNTHESIS SUBCATEGORY (C)
TECHNOLOGY OPTIONS

Total Flow for the Subcategory - 27,600,000 GPD; Mean Plant Flow - 260,000 GPD; Dischargers - 23% Direct, 77% Indirect

Pollutant	RWL mg/l	RWL lbs/day (Total Subcat)	Existing BPT Guidelines % Removal	Existing BPT Guidelines mg/l	Existing BPT Guidelines lbs/day (Total Subcat)	Technology 1 - BPT % Removal	Technology 1 - BPT mg/l	Technology 1 - BPT lbs/day (Total Subcat)	Technology 1 - BPT Cost $/lb	Technology 2 mg/l	Technology 2 lbs/day (Total Subcat)	Technology 2 Cost $/lb
BOD	2190.	504,000.	90.	219.	50,400.	94.1	130.	29,900.	$0.45	40.	9,210.	
COD	5160.	1,190,000.	74.	1340.	308,000.	80.6	1000.	230,000.	Incl. in above	360.	82,900.	
TSS	740.	170,000.		178.	41,000.	81.1	140.	32,000.	Incl. in above	40.	9,210.	
Phenol	.180	24.1					.005	.74				
Benzene	.100	14.4					-	-				
Chloroform	.150	22.4					.010	1.5				
Ethylbenzene	.020	2.2					-	-				
Methylene Chloride	.320	62.6					.070	13.6				
Toluene	.515	73.6					.003	0.37				
Chromium	.045	9.6					.016	3.3				
Copper	.085	18.0					.020	4.2				
Lead	.050	7.5					.017	2.6				
Mercury	.0008	.17					.0005	.09				
Nickel	.050	6.6					.045	6.1				
Zinc	.250	53.0					.100	21.2				
Cyanide	.280	32.2					.063	7.2				
Total P.P.		326.4						60.9	$1,030.			
Total Volatile P.P.		175.2						15.5				
Total Metals		94.9						37.5				
Treatment						Biological Treatment				Biological Enhancement (2-Stage Biological Treatment)		
# Units in:												
Single Subcategory C Plants -			16			15				4		
All Subcategory C Plants -			42			38				10		
Total Industry -			83			74				22		
Solid Wastes						119,000 lbs dry solids/day				14,000 lbs dry solids/day		

Note: BOD and COD effluent levels based on BPT percent removal regulations. TSS level from BPT data base; regulation was not promulgated.

Technology 2 – Costs based on BOD removal only:

A/S	$2.50
RBC + Clar.	$1.30
Polishing Lagoon	$ .20

Technology 2 – Costs based on BOD and TSS removals:

A/S	$1.45
RBC + Clar.	$ .75
Polishing Lagoon	$ .10

Pollutant	Technology 2A mg/l	Technology 2A lbs/day (Total Subcat)	Technology 2A Cost $/lb	Technology 3 mg/l (In-plant value)	Technology 3 lbs/day (Total Subcat)	Technology 3 Cost $/lb	Technology 4 mg/l (In-plant value)	Technology 4 lbs/day (Total Subcat)	Technology 4 Cost $/lb	Technology 5 mg/l (In-plant value)	Technology 5 lbs/day (Total Subcat)	Technology 5 Cost $/lb
BOD	20.	4,600.										
COD	270.	62,100.										
TSS	30.	6,910.										
Phenol												
Benzene										.05	.72	
Chloroform										.05	.75	
Ethylbenzene										.05	.53	
Methylene Chloride										.05	.98	
Toluene										.05	.72	
Chromium				0.3	6.3							
Copper				0.2	4.2							
Lead				0.1	1.5							
Mercury												
Nickel				0.5	6.7							
Zinc				0.3	6.3							
Cyanide							0.04	.05	$257.			
Total P.P.												
Total Volatile P.P.											3.70	$83.
Total Metals					25.0	$371.						
Treatment	Biological Enhancement (2-Stage Bio. Trt. + Filter)			Chromium Reduction Plus Metal Precipitation			Cyanide Destruction with Chlorine			Steam Stripping		
# Units in:												
Subcategory C only Plants -	0			2			3			2		
All Subcategory C Plants -	0			2			6			6		
Total Industry -	3			3			6			7		
Solid Wastes	19,000 lbs dry solids/day			2,800 lbs dry solids/day			None			None		
Notes				This technology eliminates all metals from secondary sludge.			This technology eliminates cyanide from secondary sludge.			This technology eliminates the problem of air stripping in secondary treatment system.		

Technology 2A – Costs based on BOD removal only:

A/S + Filt.	$3.55
RBC + Clar. + Filt.	$1.75

Technology 2A – Costs based on BOD and TSS removals:

A/S + Filt.	$2.05
RBC + Clar. + Filt.	$1.00

TABLE VII-30

PHARMACEUTICAL INDUSTRY
FORMULATION SUBCATEGORY (D)
TECHNOLOGY OPTIONS

Total Flow for the Subcategory - 19,400,000 GPD; Mean Plant Flow - 75,000 GPD; Dischargers - 15% Direct, 85% Indirect

Pollutant	RWL mg/l	RWL lbs/day (Total Subcat)	Existing BPT % Removal	Existing BPT mg/l	Existing BPT lbs/day (Total Subcat)	Technology 1 - BPT % Removal	Technology 1 - BPT mg/l	Technology 1 - BPT lbs/day (Total Subcat)	Technology 1 - BPT Cost $/lb	Technology 2 mg/l	Technology 2 lbs/day (Total Subcat)	Technology 2 Cost $/lb
BOD	1630.	264,000.	90.	163.	26,400.	93.9	100.	16,200.	$1.53	40.	6,480.	
COD	2780.	450,000.	74.	723.	117,000.	68.0	890.	144,000.	Incl. in above	360.	58,200.	
TSS	370.	59,900.		18.	2,910.	56.8	160.	96,700.	Incl. in above	18.	2,910.	
Phenol	.180	16.9					.005	.52				
Benzene	.100	10.1					-	-				
Chloroform	.150	15.8					.010	1.0				
Ethylbenzene	.020	1.6					-	-				
Methylene Chloride	.320	44.0					.070	9.6				
Toluene	.515	51.7					.003	.3				
Chromium	.045	6.7					.016	2.3				
Copper	.085	12.7					.020	3.0				
Lead	.050	5.3					.017	1.8				
Mercury	.0008	.12					.0005	.06				
Nickel	.050	4.7					.045	4.3				
Zinc	.250	37.2					.100	14.9				
Cyanide	.280	22.6					.063	5.0				
									$1,730.			
Total P.P.		229.4						42.8				
Total Volatile P.P.		123.2						10.9				
Total Metals		66.7						26.4				
Treatment						Biological Treatment				Biological Enhancement (2-Stage Bio. Trt. + Filter)		
# Units In:												
Single Subcategory D Plants -				29			26				7	
All Subcategory D Plants -				57			49				14	
Total Industry -				83			74				22	
Solid Wastes						14,000 lbs dry solids/day				11,000 lbs dry solids/day		

Note: BOD and COD effluent levels based on BPT percent removal regulations. TSS level from BPT data base; regulation is 52 mg/l monthly maximum.

Costs based on BOD and TSS removals only:

A/S + Filt.	$ 5.35
RBC + Clar. + Filt.	$ 3.00
Polishing Lagoon	$ .30

Pollutant	Technology 2A mg/l (In-plant value)	Technology 2A lbs/day (Total Subcat)	Technology 2A Cost $/lb	Technology 3 mg/l (In-plant value)	Technology 3 lbs/day (Total Subcat)	Technology 3 Cost $/lb	Technology 4 mg/l (In-plant value)	Technology 4 lbs/day (Total Subcat)	Technology 4 Cost $/lb	Technology 5 mg/l (In-plant value)	Technology 5 lbs/day	Technology 5 Cost $/lb	Technology 6
BOD	20.	3,240											
COD	270.	43,700											
TSS	18.	2,910											
Phenol													
Benzene										.05	.50		Zero Discharge-
Chloroform										.05	.53		(Contract
Ethylbenzene										.05	.38		Handling)
Methylene Chloride										.05	.69		$.30/gal.
Toluene										.05	.50		
Chromium				0.3	4.5								
Copper				0.2	3.0								
Lead				0.1	1.0								
Mercury													
Nickel				0.5	4.7								
Zinc				0.3	4.5								
Cyanide							0.04	.3	$603.				
Total P.P.													
Total Volatile P.P.											2.60	$82.	
Total Metals					17.7	$622.							
Treatment	Biological Enhancement (2-Stage Boil. Trt. + Filter)			Chromium Reduction Plus Metal Precipitation			Cyanide Destruction with Chlorine			Steam Stripping			
# Units In:													
Subcategory D only Plants -	3			1			0			0			
All Subcategory D Plants -	3			1			2			3			
Total Industry -	3			3			6			7			
Solid Wastes	13,000 lbs dry solids/day			1,940 lbs dry solids/day			None			None			
Notes				This technology eliminates all metals from secondary sludge.			This technology eliminates cyanide from secondary sludge.			This technology eliminates the Problem of air stripping in Secondary treatment systems.			

Costs based on BOD removal only: *

A/S + Filt.	$7.00
RBC + Clar.+ Filt.	$4.05

* This technology option does not provide TSS reductions beyond BPT.

TABLE VII-31

BCT COST TEST

Technology 2	Total Annual Cost ($/lb) for Conventional Pollutant Removal at Subcategory Model Plants			
	A (BOD & TSS)	B (BOD Only)	C (BOD & TSS)	D (BOD Only)
Activated Sludge	0.42	4.68	0.55	2.23
RBC	0.20	2.34	0.28	1.25
Polishing Lagoon	0.04	0.17	0.04	0.12
Technology 2A				
Activated Sludge and Filtration	0.70	6.04	0.79	2.92
RBC and Filtration	0.27	3.30	0.38	1.68

Assumptions:

1. Cost test based on 30 day maximum removal rates for BOD & TSS or BOD only.
2. TSS for subcategories A & C not previously regulated but TSS data available from 1976 BPT study.
3. Costs are in Jan. 1978 dollars where ENR equals 2670.
4. BCT for cost comparison is indexed at $1.27/lb for 1st quarter 1978.

SECTION VIII

BAT

[NOTE: This section, discussing Best Available Technology Economically Achievable, is reserved for EPA.]

SECTION IX

BCT

[NOTE: This section, discussing Best Conventional Pollutant Control Technology, is reserved for EPA.]

SECTION X

NSPS

[NOTE: This section, discussing New Source Performance Standards, is reserved for EPA.]

SECTION XI

PRETREATMENT STANDARDS

[NOTE: This section, discussing Pretreatment Standards, is reserved for EPA.]

SECTION XII

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SECTION XIII

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SECTION XIV

GLOSSARY AND ABBREVIATIONS

Abatement. The measures taken to reduce or eliminate pollution.

Absorption. A process in which one material (the absorbent) takes up and retains another (the absorbate) with the formation of a homogeneous mixture having the attributes of a solution. Chemical reaction may accompany or follow absorption.

Acclimation. The ability of an organism to adapt to changes in its immediate environment.

Acid. A substance which dissolves in water with the formation of hydrogen ions.

Acidulate. To make somewhat acidic.

Act. Clean Water Act of 1977, PL 95-217.

Activated Carbon. Carbon which is treated by high temperature heating with steam or carbon dioxide producing an internal porous particle structure.

Activated Sludge Process. A process which removes the organic matter from sewage by saturating it with air and biologically active sludge. The recycled "activated" microoganisms are able to remove both the soluble and colloidal organic material from the wastewater.

Active Ingredient. The chemical constituent in a medicine which is responsible for its activity.

Adsorption. An advanced method of treating wastes in which a material removes organic matter not necessarily responsive to clarification or biological treatment by adherence on the surface of solid bodies.

Advanced Waste Treatment. Any treatment method or process employed following biological treatment to increase the removal of pollution load, to remove substances that may be deleterious to receiving waters or the environment or to produce a high-quality effluent suitable for reuse in any specific manner or for discharge under critical conditions. The term tertiary treatment is commonly used to denote advanced waste treatment methods.

Aeration. (1) The bringing about of intimate contact between air and a liquid by one of the following methods: spraying the liquid in the air, bubbling air through the liquid, or agitation of the liquid to promote surface absorption of air. (2) The process or state of being supplied or impregnated with air; in waste treatment, a process in which liquid from the primary clarifier is mixed with compressed air and with biologically active sludge.

Aerobic. Ability to live, grow, or take place only where free oxygen is present.

Algae. One-celled or many-celled plants which grow in sunlit waters and which are capable of photosynthesis. They are a food for fish and small aquatic animals and, like all plants, put oxygen in the water.

Algicide. Chemical agent used to destroy or control algae.

Alkali. A water-soluble metallic hydroxide that ionizes strongly.

Alkalinity. The presence of salts of alkali metals. The hydroxides, carbonates, and bicarbonates of calcium, sodium and magnesium are common impurities that cause alkalinity. A quantitative measure of the capacity of liquids or suspensions to neutralize strong acids or to resist the establishment of acidic conditions. Alkalinity results from the presence of bicarbonates, carbonates, hydroxides, alkaline salts and occasionally borates and is usually expressed in terms of the amount of calcium carbonate that would have an equivalent capacity to neutralize strong acids.

Alkaloids. Basic (alkaline) nitrogenous botanical products which produce a marked physiological action when administered to animals or humans.

Alkylation. The addition of a aliphatic group to another molecule. The media in which this reaction is accomplished can be vapor or liquid phase, as well as aqueous or non-aqueous.

Ammonia Nitrogen. A gas released by the microbiological decay of plant and animal protein. When ammonia nitrogen is found in waters, it is indicative of incomplete treatment.

Ampules. A small glass container that can be sealed and its contents sterilized. Ampules are used to hold hypodermic solutions.

Anaerobic. Ability to live, grow, or take place where there is no air or free oxygen present.

Anion. Ion with a negative charge.

Antagonistic Effect. The simultaneous action of separate agents mutually opposing each other.

Antibiotic. A substance produced by a living organism which has power to inhibit the multiplication of, or to destroy, other organisms, especially bacteria.

Aqueous Solution. One containing water or watery in nature.

Arithmetic Mean. The arithmetic mean of a number of items is obtained by adding all the items together and dividing the total by the number of items. It is frequently called the average. It is greatly affected by extreme values.

Autoclave. A heavy vessel with thick walls for conducting chemical reactions under high pressure. Also an apparatus using steam under pressure for sterilization.

Azeotrope. A liquid mixture that is characterized by a constant minimum or maximum boiling point which is lower or higher than that of any of the components and that distills without change in composition.

Bacteria. Unicellular, plant-like microorganisms, lacking chlorophyll. Any water supply contaminated by sewage is certain to contain a bacterial group called "coliform."

BADCT. Limitations for new sources which are based on the application of the Best Available Demonstrated Control Technology.

Base. A substance that in aqueous solution turns red litmus blue, furnishes hydroxyl ions and reacts with an acid to form a salt and water only.

Batch Process. A process which has an intermittent flow of raw materials into the the process and a resultant intermittent flow of product from the process.

BAT (BATEA) Effluent Limitations. Limitations for point sources, other than publicly owned treatment works, which are based on the application of the Best Available Technology Economically Achievable. These limitations must be achieved by July 1, 1983.

BCT. Best Conventional Pollutant Control Technology.

Bioassay. An assessment which is made by using living organisms as the sensors.

Biochemical Oxygen Demand (BOD). A measure of the oxygen required to oxidize the organic material in a sample of wastewater by natural biological process under standard conditions. This test is presently universally accepted as the yardstick of pollution and is utilized as a means to determine the degree of treatment in a waste treatment process. Usually given in mg/1(or ppm) units), meaning milligrams of oxygen required per liter of wastewater, it can also be expressed in pounds of total oxygen required per wastewater or sludge batch. The standard BOD test is five days at 20 degrees C.

Biota. The flora and fauna (plant and animal life) of a stream or other water body.

Biological Products. In the pharmaceutical industry, medicinal products derived from animals or humans, such as vaccines, toxoids, antisera and human blood fractions.

Biological Treatment System. A system that uses microoganisms to remove organic pollutant material from a wastewater.

Blood Fractionation. The separation of human blood into its various protein fractions.

Blowdown. (1) Water intentionally discharged from a cooling or heating system to maintain the dissolved solids concentration of the circulating water below a specific critical level. The removal of a portion of any process flow to maintain the constituents of the flow within desired levels. Process may be intermittent or continuous. (2) The water discharged from a boiler or cooling tower to dispose of accumulated salts.

BOD5. Biochemical oxygen Demand (BOD) is the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions. The BOD test has been developed on the basis of a 5-day incubation period (i.e. BOD5).

Botanicals. Drugs made from a part of a plant, such as roots, bark, or leaves.

BPT (BPCTA) Effluent Limitations. Limitations for point sources, other than publicly owned treatment works, which are based on the application of the Best Practicable Control Technology Currently Available. These Limitations must be achieved by July 1,1977.

Brine. Water saturated with a salt.

Buffer. A solution containing either a weak acid and its salt or a weak base and its salt which thereby resists changes in acidity or basicity, resists changes in pH.

Capsules. A gelatinous shell used to contain medicinal chemicals and as a dosage form for administering medicine.

Carbohydrate. A compound of carbon, hydrogen and oxygen, usually having hydrogen and oxygen in the proportion of two to one.

Carbonaceous. Containing or composed of carbon.

Catalyst. A substance which changes the rate of a chemical reaction but undergoes no permanent chemical change itself.

Cation. The ion in an electrolyte which carries the positive charge and which migrates toward the cathode under the influence of a potential difference.

Cellulose. The fibrous constituent of trees which is the principal raw material of paper and paperboard. Commonly thought of as a fibrous material of vegetable origin.

Chemical Oxygen Demand (COD). A measure of oxygen-consuming capacity of organic and inorganic matter present in water or wastewater. It is expressed as the amount of oxygen consumed from a chemical oxidant in a specific test. It does not differentiate between stable and unstable organic matter and thus does not correlate with biochemical oxygen demand.

Chemical Synthesis. The processes of chemically combining two or more constituent substances into a single substance.

Chlorination. The application of chlorine to water, sewage or industrial wastes, generally for the purpose of disinfection but frequently for accomplishing other biological or chemical results.

Coagulation. The clumping together of solids to make them settle out of the sewage faster. Coagulation of solids is brought about with the use of certain chemicals, such as lime, alum or polyelectrolytes.

Combined Sewer. One which carries both sewage and storm water run-off.

Composite Sample. A combination of individual samples of wastes taken at selected intervals, generally hourly for 24 hours, to minimize the effect of the variations in individual samples. Individual samples making up the composite may be of equal volume or be roughly apportioned to the volume of flow of liquid at the time of sampling.

Comprehensive Pharmaceutical Data Base. Combined data base formed by the first 308 survey of PMA-member companies plus the second, or Supplemental 308 survey.

Concentration. The total mass of the suspended or dissolved particles contained in a unit volume at a given temperature and pressure.

Conductivity. A reliable measurement of electrolyte concentration in a water sample. The conductivity measurement can be related to the concentration of dissolved solids and is almost directly proportional to the ionic concentration of the total electrolytes.

Contact Process Wastewaters. These are process-generated wastewaters which have come in direct or indirect contact with the reactants used in the process. These include such streams as contact cooling water, filtrates, centrates, wash waters, etc.

Continuous Process. A process which has a constant flow of raw materials into the process and resultant constant flow of product from the process.

Contract Disposal. Disposal of waste products through an outside party for a fee.

Crustaceae. These are small animals ranging in size form 0.2 to 0.3 millimeters long which move very rapidly through the water in search of food. They have recognizable head and posterior sections. They form a principal source of food for small fish and are found largely in relatively fresh natural water.

Crystallization. The formation of solid particles within a homogeneous phase. Formation of crystals separates a solute from a solution and generally leaves impurities behind in the mother liquid.

Culture. A mass of microorganisms growing in a media.

Cyanide, Total. Total cyanide as determined by the test prodecure specified in 40 CFR Part 136 (Federal Register, Vol. 38, no. 199, October 16,1973).

Cyanide A. Cyanides amenable to chlorination as described in "1972 Annual Book of ASTM Standards" 1972: Standard 2036-72, Method B, p. 553.

Derivative. A substance extracted from another body or substance.

Desorption. The opposite of adsorption. A phenomenon where an adsorbed molecule leaves the surface of the adsorbent.

Diluent. A diluting agent.

Direct Discharge. The discharge of process wastewaters to navigable waters such as rivers, streams and lakes.

Disinfectant. A chemical agent which kills bacteria.

Disinfection. The process of killing the larger portion (but not necessarily all) of the harmful and objectionable microorganisms in or on a medium.

Dissolved Oxygen (DO). The oxygen dissolved in sewage, water or other liquids, usually expressed either in milligrams per liter or percent of saturation. It is the test used in BOD determination.

Distillation. The separation, by vaporization, of a liquid miscible and volatile mixture into individual components, or, in some cases, into groups of components. The process of raising the temperature of a liquid to the boiling point and condensing the resultant vapor to liquid form by cooling. It is used to remove substances from a liquid or to obtain a pure liquid from one which contains impurities or which is a mixture of several liquids having different boiling temperatures. Used in the treatment of fermentation products, yeast, etc., and other wastes to remove recoverable products.

Effluent. A liquid which leaves a unit operation or process. Sewage, water or other liquids, partially or completely treated or in their natural states, flowing out of a reservoir basin, treatment plant or any other unit operation. An influent is the incoming stream.

Elution. (1) The process of washing out, or removing with the use of a solvent. (2) In an ion exchange process it is defined as the stripping of adsorbed ions from an ion exchange resin by passing through the resin solutions containing other ions in relatively high concentrations.

Emulsion. A suspension of fine droplets of one liquid in another.

Equalization Basin. A holding basin in which variations in flow and composition of a liquid are averaged. Such basins are used to provide a flow of reasonably uniform volume and composition to a treatment unit.

Esterification. This generally involves the combination of an alcohol and an organic acid to produce an ester and water. The reaction is carried out in the liquid phase, with aqueous sulfuric acid as a catalyst. The use of sulfuric acid has, in the past, caused this type of reaction to be called sulfation.

Ethical Products. Pharmaceuticals promoted by advertising to the medical, dental and veterinary professions.

Fatty Acids. An organic acid obtained by the hydrolysis (saponification) of natural fats and oils, e.g., stearic and palmitic acids. These acids are monobasic and may or may not contain some double bonds. They usually contain sixteen or more carbon atoms.

Fauna. The animal life adapted for living in a specified environment.

Fermentation. Oxidative decomposition of complex substances through the action of enzymes or ferments produced by microorganisms.

Fermentor Broth. A slurry of microorganisms in water containing nutrients (carbohydrates, nitrogen) necessary for the microorganisms' growth.

Filter Cakes. Wet solids generated by the filtration of solids from a liquid. This filter cake may be a pure material (product) or a waste material containing additional fine solids (i.e., diatomaceous earth) that has been added to aid in the filtration.

Fines. Crushed solids sufficiently fine to pass through a screen, etc.

Flocculants. Those water-soluble organic polyelectrolytes that are used alone or in conjunction with inorganic coagulants such as lime, alum or ferric chloride or coagulant aids to agglomerate solids suspended in aqueous systems or both; the large dense flocs resulting from this process permit more rapid and more efficient solids-liquid separations.

Flora. The plant life characteristic of a region.

Flotation. A method of raising suspended matter as scum to the surface of the liquid in a tank by aeration, vacuum, evolution of gas, chemicals, electrolysis, heat or bacterial decomposition and the subsequent removel of the scum by skimming.

Fractionation (or Fractional Distillation). The separation of constituents, or groups of constituents, of a liquid mixture of miscible and volatile mixtures by vaporization and recondensation over specific boiling point ranges.

Fungus. A vegetative cellular organism that subsists on organic material such as bacteria.

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

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

Grab Sample. (1) Instantaneous sampling. (2) A sample taken at a random place in space and time.

Grease. In sewage, grease includes fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oils and other non-fatty materials. The type of solvent to be used for its extraction should be stated.

Hardness. A measure of the capacity of water for precipitating soap. It is reported as the hardness that would be produced if a certain amount of $CaCo_3$ were dissolved in water. More than one ion contributes to water hardness. The "Glossary of Water and Wastewater Control Engineering" defines hardness as: A characteristic of water imparted by salts of calcium, magnesium and iron, such as bicarbonates, carbonates, sulfates, chlorides and nitrates, that causes curdling of soap, deposition of scale in boilers, damage in some industrial processes, and sometimes objectionable taste. Calcium and magnesium are the most significant constituents.

Hormone. Any of a number of substances formed in the body which activate specifically receptive organs when transported to them by the body fluids. A material secreted by ductless glands (endocrine glands). Most hormones as well as synthetic analogues have in common the cyclopentanophenanthrene nucleus.

Indirect Discharge. The discharge of (process) wastewaters to publicly owned treatment works (POTW).

Injectables. Medicinals prepared in a sterile (buffered) form suitable for administration by injection.

New Source. Any facility from which there is or may be a discharge of pollutants, the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance under section 306 of the Act.

Non-contact Cooling Water. Water used for cooling that does not come into direct contact with any raw material, intermediate product, waste product or finished product.

Non-contact Process Wastewaters. Wastewaters generated by a manufacturing process which have not come in direct contact with the reactants used in the process. These include such streams as non-contact cooling water, cooling tower blowdown, boiler blowdown, etc.

NSPS. New Source Performance Standards.

NPDES. National Pollution Discharge Elimination System. A federal program requiring industry to obtain permits to discharge plant effluents to the nation's water courses.

Nutrient. Any substance assimilated by an organism which promotes growth and replacement of cellular constituents.

Operation and Maintenance. Costs required to operate and maintain pollution abatement equipment including labor, material, insurance, taxes, solid waste disposal, etc.

Organic Loading. In the activated sludge process,the food to microorganisms (F/M) ratio defined as the amount of biodegradable material available to a given amount of microorganisms per unit of time.

Oxidation. A process in which an atom or group of atoms loses electrons; the combination of a substance with oxygen, accompanied with the release of energy. The oxidized atom usually becomes a positive ion while the oxidizing agent becomes a negative ion (in chlorination, for example).

Oxidation Reduction (OR). A class of chemical reactions in which one of the reacting species gives up electrons (oxidation) while another species in the reaction accepts electrons (reductions). At one time, the term oxidation was restricted to reactions involving hydrogen. Current chemical technology has broadened the scope of these terms to include all reactions where electrons are given up and taken on by reacting species; in fact, the donating and accepting of electrons must take place simultaneously.

Oxidation Reduction Potential (ORP). A measurement that indicates the activity ratio of the oxidizing and reducing species present.

Oxygen, Available. The quantity of atmospheric oxygen dissolved in the water of a stream; the quantity of dissolved oxygen available for the oxidation of organic matter in sewage.

Oxygen, Dissolved. The oxygen (usually designated as DO) dissolved in sewage, water or another liquid and usually expressed in mg/l, parts per million, or percent of saturation.

Parts Per Million (ppm). Parts by weight in sewage analysis;ppm by weight is equal to milligrams per liter divided by the specific gravity. It should be noted that in water analysis, ppm is always understood to imply a weight/weight ratio, even though in practice volume may be measured instead of a weight.

Pathogenic. Disease producing.

pH. The negative logarithm of the hydrogen ion concentration or activity in a solution. The number 7 indicates neutrality, numbers less than 7 indicate increasing acidity and numbers greater than 7 indicate increasing alkalinity.

Photosynthesis. The mechanism by which chlorophyll-bearing plants utilize light energy to produce carbohydrate and oxygen from carbon dioxide and water(the reverse of respiration.).

Physical/Chemical Treatment System. A system that utilizes physical (i.e., sedimentation, filtration, centrifugation, activated carbon, reverse osmosis, etc.) and /or chemical means (i.e. coagulation, oxidation, precipitation, etc.) to treat wastewaters.

Plasma. The liquid part of the lymph and of the blood.

PMA. Pharmaceutical Manufacturers Association.

Point Source. Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.

Potable Water. Drinking water sufficiently pure for human use.

Potash. Potassium compounds used in agriculture and industry. Potassium carbonate can be obtained from wood ashes. The mineral potash is usually a muriate. Caustic potash is its hydrated form.

Preaeration. A preparatory treatment of sewage, consisting of aeration to remove gases and add oxygen or to promote the flotation of grease and aid coagulation.

Precipitation. The phenomenon which occurs when a substance held in solution passes out of that solution into solid form. The adjustment of pH can reduce solubility and cause precipitation. Alum and lime are frequently used chemicals in such operations as water softening or alkalinity reduction.

Pretreatment. Any wastewater treatment process used to partially reduce the pollution load before the wastewater is introduced into a main sewer system or delivered to a treatment plant for substantial reduction of the pollution load.

Process Waste Water. Any water which, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, by-product, or waste product.

Process Water. Any water(solid, liquid or vapor) which, during the manufacturing process, comes into direct contact with any raw material, interdediate product, by-product, waste product, or finished product.

Proprietary Products. Pharmaceuticals promoted by advertising directly to the consumer.

PSES. Pretreatment Standards for Existing Sources.

PSNS. Pretreatment Standards for New Sources.

Raw Waste Load (RWL). The quantity (kg) of pollutant being discharged in a plant's wastewater measured in terms of some common denominator (i.e., kkg of production or m^2 of floor area).

Receiving Waters. Rivers, lakes, oceans or other courses that receive treated or untreated wastewaters.

Reduction. A process in which an atom (or group of atoms) gains electrons. Such a process always requires the input of energy.

Refractory Organics. Organic materials that are only partially nonbiodegradable in biological waste treatment processes. Refractory organics include detergents, pesticides, color- and odor-causing agents, tannins, lignins, ethers, olefins, alcohols, amines, aldehydes, ketones, etc.

Residual Chlorine. The amount of chlorine left in the treated water that is available to oxidize contaminants if they enter the stream. It is usually in the form of hypochlorous acid of hypochlorite ion or of one of the chloramines. Hypochlorite concentration alone is called "free chlorine residual" while together with the chloramine concentration their sum is called "combined chlorine residual."

Retort. A vessel, commonly a glass bulb with a long neck bent downward,used for distilling or decomposing substances by heat.

Sanitary Sewers. In a separate system, pipes in a city that carry only domestic wastewater. The storm water runoff is handled by a separate system of pipes.

Saprophytic Organism. One that lives on dead or decaying organic matter.

Secondary Treatment. The second step in most waste treatment systems in which bacteria consume the organic part of the wastes. This is accomplished by bringing the sewage and bacteria together either in trickling filters or in the activated sludge process.

Seed. To introduce microorganisms into a culture medium.

Serum. A fluid which is extracted from an animal rendered immune against a pathogenic organism and injected into a patient with the disease resulting from the same organism.

Settleable Solids. Suspended solids which will settle out of a liquid waste in a given period of time.

Sewage, Storm. The liquid flowing in sewers during or following a period of heavy rainfall and resulting therefrom.

Sewerage. A comprehensive term which includes facilities for collecting, pumping, treating and disposing of sewage; the sewerage system and the sewage treatment works.

SIC Codes. Standard Industrial Classification. Numbers used by the U.S. Department of Commerce to denote segments of industry.

Sludge, Activated. Sludge floc produced in raw or settled sewage by the growth of zoogleal bacteria and other organisms in the presence of dissolved oxygen and accumulated in sufficient concentration by returning the floc previously formed.

Sludge, Age. The ratio of the weight of volatile solids in the digester to the weight of volatile solids added per day. There is a maximum sludge age beyond which no significant reduction in the concentration of volatile solids will occur.

Sludge, Digested. Sludge digested under anaerobic conditions until the volatile content has been reduced, usually by approximately 50 percent or more.

Solution. A homogeneous mixture of two or more substances of dissimilar molecular structure. In a solution, there is a dissolving medium-solvent and a dissolved substance-solute.

Solvent Extraction. The treatment of a mixture of two or more components by a solvent that preferentially dissolves one or more of the components in the mixture. The solvent in the extract leaving the extractor is usually recovered and reused.

Steam Distillation. Fractionation in which steam is introduced as one of the vapors or in which steam is injected to provide the heat of the system.

Sterilization. The complete destruction of all living organisms in or on a medium; heat to 121°C at 5 psig for 15 minutes.

Steroid. Term applied to any one of a large group of substances chemically related to various alcohols found in plants and animals.

Still Bottom. The residue remaining after distillation of a material. Varies from a watery slurry to a thick tar which may turn hard when cool.

Stillwell. A pipe, chamber, or compartment with comparatively small inlet or inlets communicating with a main body of water. Its purpose is to dampen waves or surges while permitting the water level within the well to rise and fall with the major fluctuations of the main body of water. It is used with water-measuring devices to improve accuracy of measurement.

Stoichiometric. Characterized by being a proportion of substances exactly right for a specific chemical reaction with no excess of any reactant or product.

Stripper. A device in which relatively volatile components are removed from a mixture by distillation or by passage of steam through the mixture.

Supernatant. Floating above or on the surface.

Surge Tank. A tank for absorbing and dampening the wavelike motion of a volume of liquid; an in-process storage tank that acts as a flow buffer between process tanks.

Suspended Solids. The wastes that will not sink or settle in sewage. The quantity of material deposited on a filter when a liquid is drawn through a Gooch crucible.

Synergistic. An effect which is more than the sum of the individual contributors.

Tablet. A small, disc-like mass of medicinal powder used as a dosage form for administering medicine.

Tertiary Treatment. A process to remove practically all solids and organic matter from wastewater. Granular activated carbon filtration is a tertiary treatment process. Phosphate removal by chemical coagulation is also regarded as a step in tertiary treatment.

Thermal Oxidation. The wet combustion of organic materials through the application of heat in the presence of oxygen.

Total Organic Carbon (TOC). A measure of the amount of carbon in a sample originating from organic matter only. The test is run by burning the sample and measuring the carbon dioxide produced.

Total Solids. The total amount of solids in a wastewater both in solution and suspension.

Toxoid. Toxin treated so as to destroy its toxicity, but still capable of inducing formation of antibodies.

Vaccine. A killed or modified live virus or bacteria prepared in suspension for inoculation to prevent or treat certain infectious diseases.

Viruses. (1) An obligate intracellular parasitic microorganism smaller than bacteria. Most can pass through filters that retain bacteria. (2) The smallest (10-300 um in diameter) form capable of producing infection and diseases in man or other large species. Occurring in a variety of shapes, viruses consist of a nucleic acid core surrounded by an outer shell (capsid) which consists of numerous protein subunits (capsomeres). Some of the larger viruses contain additional chemical substances. The true viruses are insensitive to antibiotics. They multiply only in living cells where they are assembled as complex macromolecules utilizing the cells' biochemical systems. They do not multiply by division as do intracellular bacteria.

Volatile Suspended Solids (VSS). The quantity of suspended solids lost after the ignition of total suspended solids.

Water Quality Criteria. Those specific values of water quality associated with an identified beneficial use of the water under consideration.

Zero Discharge. Plants that do not discharge wastewaters to either publicly owned treatment works or to navigable waters. Plants that use evaporation ponds or deep well sites are considered zero dischargers.

APPENDIX A

308 PORTFOLIO
FOR
PHARMACEUTICAL MANUFACTURING

308 PORTFOLIO
FOR
PHARMACEUTICAL MANUFACTURING

INSTRUCTIONS AND DEFINITIONS

Instructions

1. Please complete this portfolio for each pharmaceutical manufacturing site in your company which manufactures Fermentation Products (Subcategory A), Biological and Natural Extraction Products (Subcategory B), Chemical Synthesis Products (Subcategory C) and Formulation Products (Subcategory D). This portfolio is also to be completed for each pharmaceutical research facility (Subcategory E) in your company. If this copy has been received by or for a non-manufacturing site (i.e. main office, warehouse, sales office, etc.) or by or for a non-manufacturing site which also does not conduct pharmaceutical research, please follow the procedure below:

   A. Please check the carbon copies list attached to Mr. Schaffer's letter to see if each of your company's manufacturing locations has received a separate portfolio. If any of your manufacturing locations has not received a portfolio, please request additional copies as indicated in (C) below. Please ensure that the requested information is provided for each site where your company manufactures pharmaceutical products or conducts pharmaceutical research.

   B. Please complete Part I, questions 1 through 5 of the portfolio only, write "not a manufacturing site" and return the portfolio in the enclosed envelope. Portfolios have been sent to company headquarters as notification that each manufacturing site will receive and should complete a separate portfolio. You may reproduce this document and maintain a copy in your files for future reference.

   C. Extra copies of the portfolio may be obtained by contacting Mr. J. S. Vitalis at 202-426-2497. Since each copy of this portfolio is coded, it is necessary to obtain additional copies from Mr. Vitalis.

2. Please read all definitions which follow these instructions carefully before completing this portfolio. It is preferred that the individuals who respond to this portfolio be familiar with the manufacturing processes and the wastewater treatment systems and operations at this site.

3. Please check the appropriate box or boxes in each question where they appear throughout this portfolio. (More than one box may be checked for some questions, where appropriate.) Please complete all questions which require written responses by printing or typing in the spaces provided. If separate sheets or attachments are used to clarify or answer a question, please make certain that the code number for this portfolio, which appears at the top right hand corner of each page, is also placed at the top right hand corner of each page of the attachments.

4. Please indicate which information in your responses is confidential so that it may be treated properly.

5. Please answer all items. Also, please provide a separate set of responses for each plant. The purpose of this request is to gather all available, pertinent information and is not designed to create an undue burden of sampling requirements on your plant personnel. If a question is not applicable to a particular facility, indicate by writing "N/A". If an item is not known, indicate unknown and explain why such information is not available. If an item seems ambiguous, complete as best as possible and state your assumptions in clarifying the apparent ambiguity.

6. The U.S. Environmental Protection Agency will review the information submitted and may, at a later date, request your cooperation for site visits and additional sampling in order to complete the data base. Please retain a copy of the completed portfolio in case future contact is necessary to verify your responses.

7. Use the Merck Index, Ninth Edition, 1976, to specify the Merck Index Identification Numbers (Merck Index Number) in Part II of this questionnaire. Many of the Chemical Abstract Service Registry Numbers (CAS Numbers) may be found in the Merck Index beginning on page REG-1 for use in completing Part II of this portfolio.

8. Please use the enclosed, pre-addressed envelope to return the completed portfolio and appropriate attachments. If you are sending supplemental information that will not fit into the return envelope provided, please send it under separate cover to:

   Mr. Robert B. Schaffer, Director
   Effluent Guidelines Division
   U.S. EPA (WH-552)
   401 M. Street, S.W.
   Washington, D.C. 20460

   Attention: J.S. Vitalis

9. If you have any questions, please telephone Mr. J.S. Vitalis at 202-426-2497

Definitions

Subcategory A -	Fermentation Products-Pharmaceutical products derived from fermentation processes.
Subcategory B	Biological and Natural Extraction Products-Pharmaceutical products which include blood fractions; vaccines; serums; animal bile derivatives; endocrine products; and isolation of medicinal products, such as alkaloids, from botanical drugs and herbs.
Subcategory C -	Chemical Synthesis Products-Pharmaceutical products which result from chemical synthesis.
Subcategory D -	Mixing/Compounding and Formulation Products- Pharmaceutical products from plants which blend, mix, compound, and formulate pharmaceutical ingredients and includes pharmaceutical preparations for human and veterinary use such as ampules, tablets, capsules, vials, ointments, medicinal powders, and solutions.
Subcategory E	Research - Products or services which result from pharmaceutical research, which includes micro-biological, biological and chemical operations.
POTW	Publicly Owned Treatment Works Municipal sewage treatment plant
NPDES	National Pollutant Discharge Elimination System
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solids
TOC	Total Organic Carbon

308 PORTFOLIO FOR
Pharmaceutical Manufacturing

For multiple plant companies, please complete one portfolio for each manufacturing and research site, and return within 60 days of receipt to:

Robert B. Schaffer, Director
Effluent Guidelines Division
U.S. EPA (WH-552)
401 M Street, S.W.
Washington, D.C. 20460

Attention: J. S. Vitalis

PART I

GENERAL INFORMATION

1. Name of Firm ______________________________

2. Address of Firm Headquarters:

____
Street City State Zip

3. Name of Plant ______________________________

4. Address of Plant:

____
Street City State Zip

5. Name(s) of firm personnel to be contacted for information pertaining to this data collection portfolio:

Name	Title	(Area Code) Telephone

6. Number of Manufacturing Employees in 1976: Minimum________ Maximum________ Average________

7. Year of operational startup________

8. Type of production operation within this site for each subcategory:

	Subcategory A	B	C	D
Batch	☐	☐	☐	☐
Continuous	☐	☐	☐	☐
Semicontinuous	☐	☐	☐	☐

9.a. Indicate below the type of research and development activities conducted at this site and, for each activity checked, provide the total laboratory square footage in column A, the number of employees in column B and, if applicable, the animal capacity in column C.

Activities	A Total Laboratory Square Footage	B Number of Employees	C Animal Capacity
☐ Microbiological			
☐ Biological			
☐ Chemical			
☐ Clinical			
☐ Development			
☐ Pilot Plant			

b. If animals are used in the above research activities, list their type below:

____

____

10. Does this plant have a National Pollutant Discharge Elimination System Permit (NPDES)? Yes ☐ No ☐

11. Has plant submitted NPDES permit application? Yes ☐ No ☐

12. Permit or application number________________________

13. Date of permit expiration________________________

14. Does this plant have wastewater treatment facilities on site? Yes ☐ No ☐

15. Name and address of publicly owned treatment works (POTW) receiving plant wastewater, if any:

Name____

Address____

____

16. Type of wastewater discharge to POTW: Process ☐ Sanitary ☐ Cooling ☐

17. Level of treatment provided by POTW: Primary ☐ Secondary ☐ Tertiary ☐

18. Is there a user charge for discharge to the POTW? Yes ☐ No ☐

If yes, provide the net annual charge below and indicate which parameters listed below serve as a basis for this charge.

Net Annual Charge____________________

Basis for Charge

☐ Flow

☐ BOD_5

☐ COD

☐ TSS

☐ TOC

☐ Other (Specify)____

19. Is the plant under the requirements of a municipal sewer use ordinance or other ordinance regulating sewer use?

Yes ☐ No ☐

20. Has an industrial wastewater survey report been submitted to the State and/or U.S. EPA Regional Office in compliance with a municipal NPDES Permit compliance schedule for industrial discharge to POTW?

Yes ☐ No ☐

If yes, attach copy of survey report.

PART II

PRODUCTS AND PRODUCTION PROCESSES

1. A. For products which are produced at this site, list the Fermentation Products (Subcategory A) in Table II A, the Biological and Natural Extraction Products (Subcategory B) in Table II B, and the Chemical Synthesis Products (Subcategory C) in Table II C. In each table, indicate for each product the number of production steps (chemical processes and physical operations) which result in wastewater generation in column A and the annual production as kilograms in column B. For the Chemical Synthesis Products (Subcategory C), list only the products which are produced in quantities of 100 kilograms per year or greater. For each of the Fermentation Products (in Subcategory A) that you list in Table II A provide a separate list of raw materials and solvents, along with quantities used in kilograms per day. Fermentation Products, which constitute less than 5% of the active ingredient production by weight, may be grouped together and submitted as a composite annual production number; however, each production product comprising such a grouping, should be identified and listed in Table II A. Provide the above information for the period January 1, 1975 to December 31, 1976 or for the exact period of production if less than this two year period. For each product listed, provide the Merck Index Identification Number (Merck Index Number) and the Chemical Abstracts Service Registry Number (CAS Number) in the columns provided, if these numbers exist for the product. If these numbers do not exist for the particular product, please note NA in the appropriate space. The production data should match with the wastewater data tables in Part III. Please photocopy each table prior to filling in the requested information to allow for adequate space to cover the products produced at this plant.

   B. List in Table II D Chemical Synthesis Products not in Table II C if they account for an unusually high pollution load either in terms of pounds discharged per 1,000 pounds of production (Raw Waste Load) or if they present difficult treatment problems.

2. Indicate which of the following are sources of wastewater:

- ☐ Floor, Equipment, Tanks, etc. - Washwater
- ☐ Waste Plasma, Blood and Blood Fractions
- ☐ Spent media broth from vaccine production
- ☐ Wet Scrubber spent waters
- ☐ Spent Beer
- ☐ Noncontact cooling water
- ☐ Pump seal water
- ☐ Barometric condenser water
- ☐ Process chemical synthesis liquids
- ☐ Spills, leakage from processes
- ☐ Solvents from research laboratories
- ☐ Ejector condensate
- ☐ Stormwater
- ☐ Sanitary wastewater
- ☐ Research laboratory waste other than solvents
- ☐ Bad batches of production seed and/or final product
- ☐ Inorganic Solids Diatomaceous earth Filter cake washdown
- ☐ Chemical wastes organic and inorganic, process waste solvents, cleanup waste solvents
- ☐ Other (Specify)______________________________

3. Describe any production process changes made to date for the primary purpose of pollution control. Also describe other process changes which have resulted in an increase or decrease of raw waste load indicating the change accordingly.

TABLE II A

List below Fermentation Products (Subcategory A).

For each of the Fermentation Products (in Subcategory A) that you list in Table IIA provide a separate list of raw materials and solvents, along with quantities used in kilograms per day. Fermentation Products, which constitute less than 5% of the active ingredient production by weight, may be grouped together and submitted as a composite annual production number; however, each production product comprising such a grouping, should be identified and listed in Table IIA.

Abbreviations:

Merck Index Number   Merck Index Identification Number
CAS Number - Chemical Abstracts Service Registry Number

Photocopy this table before filling out

CAS Number	Merck Index Number	Product	A No. of Production Steps which result in wastewater Generation	B Annual Production Kilograms

TABLE II B

List below Biological and Natural Extraction Products (Subcategory B).

Abbreviations:

Merck Index Number - Merck Index Identification Number
CAS Number - Chemical Abstracts Service Registry Number

<u>Photocopy this table before filling out</u>

CAS Number	Merck Index Number	Product	A No. of Production Steps which result in wastewater Generation	B Annual Production (Kilograms)

TABLE II C

List below Chemical Synthesis Products (Subcategory C).

Abbreviations:

Merck Index Number - Merck Index Identification Number
CAS Number   Chemical Abstracts Service Registry Number

<u>Photocopy this table before filling out.</u>

CAS Number	Merck Index Number	Product	A No. of Production Steps which result in wastewater Generation	B Annual Production (Kilograms)

TABLE II D

List below Chemical Synthesis Products not in Table II C if they account for an unusually high pollution load either in terms of pounds discharged per 1,000 pounds of production (Raw Waste Load) or if they present difficult treatment problems.

PART III

WATER USE, REUSE AND DISCHARGE

1. Water Use, Total Plant Needs During the Period January 1, 1975 to December 31, 1976

List below for your plant, the sources and quantities of water used and describe the disposition of waste waters. If a time period of less than January 1, 1975 to December 31, 1976 is used, state the reason that the values are representative of that period. Check appropriate boxes.

A. Water Source	Average Flow (Million gallons per day)	Time Period of Calculation
☐ Municipal		
☐ Surface		
☐ Ground		
☐ Recycle Process		
☐ Other		

Specify other____________________

B. Water Uses	Average Flow (Million gallons per day)	Time Period of Calculation
☐ Non-contact cooling		
☐ Direct process contact (as diluent, solvent carrier, reactant, by-product, cooling, etc.)		
☐ Indirect process contact (pumps, seals, etc.)		
☐ Non-contact ancillary uses (boilers, utilities, etc.)		
☐ Maintenance, equipment cleaning and work area washdown		
☐ Air pollution control		
☐ Sanitary and potable		
☐ Other		

Specify other____________________

C. Sources of Wastewater Flows	Average Flow (Million gallons per day)	Time Period of Calculation
☐ Non-contact cooling		
☐ Direct process contact		
☐ Indirect process contact		
☐ Non-contact ancillary uses		
☐ Maintenance, equipment cleaning and work area washdown		
☐ Air pollution control		
☐ Sanitary/Potable water		
☐ Storm water (collected in treatment system)		
☐ Other		

Specify other____________________

D. Method of Disposal of Process Wastewater (exclude non-contact cooling water)

	Treated		Untreated	
	Average Flow (Million gallons per day)	Time Period of Calculation	Average Flow (Million gallons per day)	Time Period of Calculation
☐ Surface Water				
☐ Subsurface				
☐ Deep Well				
☐ Publicly Owned Treatment Works				
☐ Land Application				
☐ Recycle/Reuse				
☐ Other				

Specify other_______________

E. Method of disposal of non-contact cooling water

	Average Flow (Million gallons per day)	Time Period of Calculation
☐ Surface Water		
☐ Subsurface		
☐ Deep Well		
☐ Publicly Owned Treatment Works		
☐ Land Application		
☐ Recycle/Reuse		
☐ Other		

Specify other_______________

2. Quality of Water Discharged

For the period January 1, 1975 to December 31, 1976, summarize your influent, effluent and raw waste loads in Tables III A, III B, III C, and III D. For plants discharging directly to publicly owned waste treatment plants, summarize the effluent and raw waste load. Information for combined waste streams should be furnished which represents the greatest degree of detail available. The tables are located at the end of this section.

Instructions for Completing Tables III A, III B, III C and III D

For Tables III A, III B, III C and III D, use the following definitions and notes. The period covered should correspond with that used for Part II.

A. Flow - Do not include rainfall runoff, unless it is collected in the treatment system. If collected, estimate the percent of total flow which is attributed to this source in Tables III B, III C and III D.

B. Maximum Monthly Average Quantity - The value for the highest 30 consecutive day average over the period January 1, 1975 to December 31, 1976 or over the actual period of analysis if less than this two year period. The 30 consecutive day period may be a calendar month or any other 30 consecutive day period for values which are computed on a monthly basis.

C. Maximum Daily Average Quantity The highest average of any day's samples if samples are taken daily or more frequently or the highest value if samples are taken less frequently than daily, over the period January 1, 1975 to December 31, 1976 or over the actual period of analysis if less than this two year period.

D. Annual Average Quantity - The highest twelve consecutive month average over the period January 1, 1975 to December 31, 1976 or over the actual period of analysis if less than this two year period. If the period of analysis is less than one year, provide the average for the entire period of analysis.

E. *Type of Sample - Insert a number from the following list in Tables III A, III B, III C, and III D to indicate* the type of samples collected.

Type of Sample	Number
Flow composite	1
Time composite	2
Grab	3
Continuous	4
Other	5

F. Frequency of Sample - Insert a number from the following list in Tables III A, III B, III C and III D to indicate the frequncy of samples collected.

Frequency	Number
Continuously	1
Hourly	2
Daily	3
Weekly	4
Monthly	5
Less than once per month	6
One time sample	7
Other	8

G. Use the blank lines at the end of each table to list additional pollutants not specifically listed, which are introduced into the wastewater as the result of materials used or products produced, for which you have test data. (Exclude the chemicals listed in Table V A of Part V of this portfolio.)

H. Identify all data which results from abnormal operating or other conditions.

I. If use of a different time period (a portion of the time period January 1, 1975 to December 31, 1976) results in more adequate representation of the pollution loads, you may do so if the time period is not less than six months. You should specify the time period and explain why that period is more representative in an attachment to this portfolio.

J. Tables

Table III A - Complete a separate Table III A for each plant intake water source at this site.

Table III B Complete a separate Table III B for each untreated waste discharge point from this site (to publicly owned treatment works, surface waters, deep wells, land application, etc.).

Table III C Complete a separate Table III C for the combined influent to each treatment facility on this site. Not applicable to plants that have not yet installed waste treatment facilities. This section is not restricted by type or level of treatment.

Table III D - Complete a separate Table III D for the treated effluent from each treatment facility on this site. Not applicable to plants that have not yet installed waste treatment facilities. This section is not restricted by type or level of treatment.

So that you may have sufficient tables to report the requested information, please photocopy each of Tables III A, III B, III C and III D before filling in. A separate table is required for each plant intake water source, each untreated wastewater discharge from this site, and the influent to and the effluent from each wastewater treatment facility on this site.

TABLE III A

INTAKE WATER

With the available information, complete, to the best of your ability, a separate Table III A for each plant intake water source.

Abbreviations:

mgd - million gallons per day
mg/l   milligrams per liter
lb/day   pounds per day

Photocopy this table before filling in the requested information

Parameter	Maximum Monthly Average Quantity	Maximum Daily Average Quantity	Annual Average Quantity	Time Period of Analysis	Type of Sample	Frequency of Sample
Flow (mgd)						
BOD 5 (mg/l)						
BOD 5 (lb/day)						
COD (mg/l)						
COD (lb/day)						
TSS (mg/l)						
TSS (lb/day)						
TOC (mg/l)						
TOC (lb/day)						
NH_3-N (mg/l)						
NH_3-N (lb/day)						
pH						
Sulfides (mg/l)						
Oil and Grease (mg/l)						
Chromium (mg/l)						
Alkalinity (mg/l as $CaCO_3$)						
Hardness (mg/l as $CaCO_3$)						

TABLE III B

UNTREATED WASTE DISCHARGE

With the available information, complete a separate Table III B for each untreated waste discharge point from this site (to publicly owned treatment works, surface waters, deep wells, land application, etc.)

Abbreviations:

mgd - million gallons per day
mg/l milligrams per liter
lb/day pounds per day

Photocopy this table before filling in the requested information

Percent Storm Water______________________________

Parameter	Maximum Monthly Average Quantity	Maximum Daily Average Quantity	Annual Average Quantity	Time Period of Analysis	Type of Sample	Frequency of Sample
Flow (mgd)						
BOD 5 (mg/l)						
BOD 5 (lb/day)						
COD (mg/l)						
COD (lb/day)						
TSS (mg/l)						
TSS (lb/day)						
TOC (mg/l)						
TOC (lb/day)						
NH_3N (mg/l)						
NH_3N (lb/day)						
pH						
Sulfides (mg/l)						
Oil and Grease (mg/l)						
Chromium (mg/l)						

TABLE III C

COMBINED INFLUENT

With the available information, complete a separate Table III C for the combined influent to each treatment facility on this site. Not applicable to plants that have not yet installed waste treatment facilities. This section is not restricted by type or level of treatment.

Abbreviations:

mgd - million gallons per day
mg/l - milligrams per liter
lb/day - pounds per day

Photocopy this table before filling in the requested information.

Percent Storm Water____________________________________

Parameter	Maximum Monthly Average Quantity	Maximum Daily Average Quantity	Annual Average Quantity	Time Period of Analysis	Type of Sample	Frequency of Sample
Flow (mgd)						
BOD 5 (mg/l)						
BOD 5 (lb/day)						
COD (mg/l)						
COD (lb/day)						
TSS (mg/l)						
TSS (lb/day)						
TOC (mg/l)						
TOC (lb/day)						
NH_3N (mg/l)						
NH_3N (lb/day)						
pH						
Sulfides (mg/l)						
Oil and Grease (mg/l)						
Chromium (mg/l)						

TABLE III D

TREATED EFFLUENT

With the available information, complete a separate Table III D for the treated effluent from each treatment facility on this site. Not applicable to plants that have not yet installed waste treatment facilities. This section is not restricted by type or level of treatment.

Abbreviations:

mgd million gallons per day
mg/l milligrams per liter
lb/day -pounds per day

Photocopy this table before filling in the requested information.

Percent Storm Water ______________________

Parameter	Maximum Monthly Average Quantity	Maximum Daily Average Quantity	Annual Average Quantity	Time Period of Analysis	Type of Sample	Frequency of Sample
Flow (mgd)						
BOD 5 (mg/l)						
BOD 5 (lb/day)						
COD (mg/l)						
COD (lb/day)						
TSS (mg/l)						
TSS (lb/day)						
TOC (mg/l)						
TOC (lb/day)						
NH_3-N (mg/l)						
NH_3-N (lb/day)						
pH						
Sulfides (mg/l)						
Oil and Grease (mg/l)						
Chromium (mg/l)						

3. Indicate all parameters listed in Part III, Tables III A through III D, which were not measured by EPA approved methods.

____

____

____

____

Has the seed used in the BOD 5 test been acclimated to the waste waters that have been treated?

Yes ☐ No ☐

If yes, what is the source of the seed?

- ☐ Sewage treatment plant
- ☐ Plant treatment facility
- ☐ Laboratory acclimation
- ☐ Other

Explain ____

____

____

____

____

____

PART IV

A. Do you have a treatment system(s) at this plant? Yes ☐ No ☐

If yes, attach a separate flow sheet for each distinct treatment facility indicating waste streams treated, unit sizes of treatment equipment, detention times, recycle rates, effluent concentration or design criteria and other pertinent engineering information for operation of the treatment facility. Include treatment of storm runoff, where applicable. Indicate the process lines for which any portion of the waste water flow is diverted to separate treatment, pretreatment or disposal (e.g., deep well, solvent recovery, incineration, etc.). Which portions are so diverted and which portions are combined for joint treatment?

For each treatment facility complete the following:

Name of Facility____________________

Source(s) of Waste Water____________________

____

1. Check which of the treatment processes listed below are employed at this plant:

☐ Equalization

☐ Neutralization

☐ Coarse Settleable Solids Removal

Primary Separation

☐ Primary Sedimentation

☐ Primary Chemical Flocculation/Clarification

☐ Other

Specify Other____________________

Biological Treatment

☐ Activated Sludge

☐ Trickling Filter

☐ Aerated Lagoon

☐ Waste Stabilization Ponds

☐ Bio-Discs

☐ Intermittent Sand Filtration

☐ Other

Specify Other____________________

☐ Physical/Chemical Treatment

Polishing

☐ Pond

☐ Multi-media Filtration

☐ Activated Carbon

☐ Other

Specify Other____________________

Sludge Handling

Thickening

☐ Mechanical

☐ Flotation

☐ Centrifugation

Stabilization

☐ Anaerobic Digestion

☐ Chemical

☐ Heat

☐ Composting

☐ Other

Specify Other____________________

Conditioning

- ☐ Heat
- ☐ Chemical
- ☐ Elutriation

Dewatering

- ☐ Vacuum Filtration
- ☐ Centrifugation
- ☐ Drying Beds
- ☐ Other

Specify Other ____________________

Reduction

- ☐ Incineration
- ☐ Wet Air Oxidation
- ☐ Pyrolysis

Final Disposal

- ☐ Landfill
- ☐ Cropland Use
- ☐ Ocean
- ☐ Other

Specify Other ____________________

Design Conditions for overall treatment facility

Flow (million gallons per day) ____________ TSS (milligrams per liter) ____________

BOD (milligrams per liter) ____________ TSS (pounds per day) ____________

BOD (pounds per day) ____________

		Year	Cost (1976 dollars)
2. a.	Original installation (treatment only)	____	____________
b.	Other costs (include collection system, piping, pumping, etc.)	____	____________
3.	Estimated replacement cost	____	____________
4.	Estimated total capital expenditure for this facility to date	____	____________
5.	Annual cost of operation and maintenance (exclude depreciation and debt service cost).	____	____________

6. List major modifications or additions since original installation and state the purpose of the modification or addition.

Modification-Addition	Treatment Facility	Year	Cost (1976 Dollars)	Purpose of Modification

7. List future scheduled modifications or additions and estimated date of completion and state the purpose of the modification or addition.

Modification-Addition	Treatment Facility	Year	Cost (1976 Dollars)	Purpose of Modification

8. Is nutrient addition practiced? Yes ☐ No ☐

9. How many employees (equivalent man-years/year) are primarily engaged as operators of the waste water treatment facility? (exclude maintenance)

____

How many employees (equivalent man-years/year) are engaged as support personnel for the waste water treatment facility?

____

10. Is an operator always present? Yes ☐ No ☐

11. Quantity of wastewater treatment facility solid wastes disposed of at present (dry basis).

______________ pounds per day

12. Moisture content of waste solids disposed of at present.

______________ percent moisture.

13. Present disposition of solids

____

____

____

____

14. Estimated annual cost of solids handling and disposal (1976 dollars).

______________ dollars per ton dry basis

15. Planned future disposition of solids:

____

____

____

____

16. What are the total annual energy requirements for the treatment facility?

Electrical ______________ kilowatt-hours

Other (e.g., Heat) ______________ British thermal units

B. Carbon Adsorption Technology

	Yes	No
Have you determined carbon adsorption isotherms on your waste waters?	☐	☐
Have carbon adsorption isotherms been determined for waste waters from your plant(s) by a person(s) other than company personnel?	☐	☐
Have you or anyone else evaluated carbon columns on waste waters from this plant?	☐	☐
Do you have carbon adsorption data from your plant(s) on:	☐	☐
raw wastes	☐	☐
biologically treated wastes	☐	☐
individual process lines	☐	☐
combined process lines	☐	☐
pilot plant studies	☐	☐
contractor evaluations	☐	☐
cost evaluations	☐	☐
plant scale evaluations	☐	☐
operational units	☐	☐

For each question above which was answered affirmatively, give a brief description of the data (source and types of wastes, period of time covered, plant involved, extent of data base and contact personnel suggested) in the space below.

C. Filtration

Have you done filtration studies on your wastewaters (sand, multi-media, etc.) beyond what was described in Section A, Part IV?

Yes ☐ No ☐

If yes, give a brief description of the data (source and types of wastes, period of time covered, process stream involved, extent of data base and contact personnel suggested) in the space below.

D. Biological Treatment

Have biological treatability studies been conducted on your wastewaters beyond what was described in Section A, Part IV?

Yes ☐ No ☐

If yes, give a brief description of the data and results (source and types of wastes treated, duration of the study, extent of data base, conclusions of study, and contact personnel suggested) in the space below:

E. Have other treatability studies, beyond what was described in Section A, Part IV, employing treatment processes such as sedimentation, neutralization, hydrolysis, precipitation, oxidation/reduction, ion exchange, phenol recovery, etc., been run on any of the process wastewater streams from the plant?

Yes ☐ No ☐

If yes, list below those product/process streams on which such treatability studies were conducted.

____

____

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Note: Use the Engineering News-Record (ENR) Index to project costs to December 1976 Dollars where requested in this portfolio. ENR Indices for January 1964 through December 1976 are shown on page IV-6 of this portfolio.

ENGINEERING NEWS - RECORD (ENR) INDICES *

YEAR	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	ANNUAL INDEX
1964	917.94	920.40	922.41	926.27	929.74	935.42	944.97	947.92	947.36	947.74	948.25	948.12	936.38
1965	947.56	957.43	957.70	957.43	957.92	969.34	977.08	984.16	986.29	986.18	985.83	987.74	971.22
1966	987.94	997.43	998.32	1006.06	1014.03	1028.65	1030.56	1033.37	1033.72	1032.40	1032.71	1033.71	1019.08
1967	1039.05	1040.67	1043.31	1043.54	1059.20	1067.88	1078.45	1089.14	1092.22	1096.22	1096.74	1098.39	1070.40
1968	1107.37	1113.63	1117.15	1123.73	1140.31	1152.78	1159.04	1169.68	1184.20	1189.08	1190.73	1200.82	1154.04
1969	1216.13	1229.56	1238.14	1248.85	1258.33	1284.96	1282.77	1292.20	1285.29	1299.31	1305.23	1304.76	1270.46
1970	1308.61	1310.90	1314.45	1329.21	1345.36	1368.66	1413.91	1418.44	1422.54	1433.64	1445.13	1445.08	1379.66
1971	1465.07	1466.85	1494.06	1511.49	1542.95	1575.05	1597.80	1614.78	1639.64	1642.59	1644.06	1654.75	1570.57
1972	1685.72	1690.76	1696.68	1706.89	1735.15	1760.78	1771.56	1776.80	1785.29	1793.75	1807.60	1815.86	1752.23
1973	1837.87	1849.70	1858.96	1873.62	1880.26	1896.21	1901.24	1920.79	1929.03	1933.19	1934.85	1938.84	1896.74
1974	1939.47	1939.74	1940.19	1961.25	1960.88	1993.47	2041.36	2075.49	2088.82	2094.74	2094.06	2098.26	2019.31
1975	2103.00	2127.72	2127.65	2135.03	2163.72	2205.00	2247.65	2274.30	2275.34	2293.03	2291.65	2297.15	2211.77
1976	2300.42	2309.97	2317.14	2327.33	2356.76	2409.51	2413.60	2444.94	2468.38	2478.22	2486.32	2489.66	2399.94

* CONSTRUCTION COST INDEX - BASE YEAR 1913=100

PART V

PRIORITY POLLUTANTS

A. Please provide the information requested in Table V A, concerning the chemicals which are considered as priority pollutants and which are listed in Table V A, in conformance with the following instructions:

1. In column A, place a check mark to indicate all of the listed chemicals which are used as raw or intermediate material.

2. In column B, place a check mark to indicate all of the listed chemicals which are manufactured at this plant as a final or intermediate material.

3. In column C, place a check mark to indicate all of the listed chemicals for which you have analyzed in your wastewater.

4. In column D, insert a number from the following list to indicate the frequency that the influent (I) and effluent (E) in your wastewater is analyzed for the presence of the listed chemicals.

Frequency	Number
Continuously	1
Hourly	2
Daily	3
Weekly	4
Monthly	5
Less than once per month	6
One time sample	7
Other	8

5. In column E, insert a number from the following list to indicate the type of sample used to analyze the influent (I) and effluent (E) in your wastewater for the presence of the listed chemicals.

Type of Sample	Number
Flow Composite	1
Time Composite	2
Grab	3
Continuous	4
Other	5

6. In columns F, G, and H, insert a value to indicate the average loading per day as pounds per day (lb/day), average flow as million gallons per day (mgd), and the average concentration as micrograms per liter (μg/l) respectively, for influent (I) and effluent (E) over a period January 1, 1975 to December 31, 1976, or over the actual period of analysis if shorter than this two year period, for all the listed chemicals for which you have analyzed in your wastewater.

B. If there is an indication in column C that an analysis is performed on your wastewater for a listed chemical, please describe in an attachment to this portfolio which analytical method(s) and specialized equipment are used for that substance.

C. If there is an indication in column C that an analysis is performed on your wastewater for a listed chemical, please provide the following information in an attachment to this portfolio:

1. If available, please provide plant data which correlate the removal of any of the chemicals in Table V A with the removal of BOD, TOC, COD and any other pollutants.

2. If available, please provide data from any treatability study which shows the effectiveness of carbon adsorption, filtration, biological treatment and other treatment technology for removal of any of the chemicals in Table V A.

3. If available, please provide any data which indicate how any of the chemicals in Table V A are removed by the treatment units at this site.

D. If there is an indication in column C that an analysis is performed on your wastewater for a listed chemical, and if there is an indication that a listed chemical is removed to any degree by the treatment units at this site, please attach a separate flow sheet for each of those treatment facilities, which indicates waste streams treated, unit sizes of treatment equipment, detention times, recycle rates, effluent concentration or design criteria and other pertinent engineering information for operation of the treatment facility. Please note that the above flow sheets may be identical to those provided in response to Part IV, Question A of the portfolio but the flow sheets should indicate clearly which chemicals are removed and which treatment equipment is used for the removal.

TABLE V A

TABLE V A

TABLE V A

PROCESSING OF CHEMICALS CONSIDERED AS PRIORITY POLLUTANTS

	CAS Number	Merck Index Number	Chemical	A Raw or Inter-mediate Material	B Final or Inter-mediate Material	C Analyzed in Wastewater	D Frequency Analyzed		E Type Sample		F Loading (lb/day)		G Flow Million Gallons /Day		H Concen-tration (µg/l)	
							I*	E**	I *	E**	I *	E**	I *	E**	I *	E**
1.	83-32-9	19	acenaphthene													
2.	107-02-8	123	acrolein													
3.	107-13-1	127	acrylonitrile													
4.	71-43-2	1069	benzene													
5.	92-87-5	1083	benzidine													
6.	56-23-5	1821	carbon tetrachloride (tetrachloromethane)													
7.	108-90-7	2095	chlorobenzene													
8.	120-82-1	9310	1,2,4-trichlorobenzene													
9.	118-74-1	4544	hexachlorobenzene													
10.	107-06-2	3733	1,2-dichloroethane													
11.	71-55-6	9316	1,1,1-trichloroethane													
12.	67-72-1	4545	hexachloroethane													
13.	75-34-3	3750	1,1-dichloroethane													
14.	79-00-5	9317	1,1,2,-trichloroethane													
15.	79-34-5	8906	1,1,2,2-tetrachloroethane													
16.	75-00-3	3713	chloroethane													
17.	542-88-1	3046	bis(chloromethyl) ether													
18.	111-44-4	3040	bis(2-chloroethyl) ether													
19.	110-75-8	2119	2-chloroethyl vinyl ether (mixed)													
20.	91-58-7	2127	2-chloronaphthalene													
21.	88-06-2	9323	2,4,6-trichlorophenol													
22.	59-50-7	2108	parachlorometa cresol													
23.	67-66-3	2120	chloroform (trichloromethane)													
24.	95-57-8	2134	2-chlorophenol													
25.	95-50-1	3029	1,2-dichlorobenzene													
26.	541-73-1	3028	1,3-dichlorobenzene													
27.	106-46-7	3030	1,4-dichlorobenzene													
28.	91-94-1	3032	3,3'-dichlorobenzidine													
29.	75-35-4	9647	1,1-dichloroethylene													
30.	540-59-0	85	1,2- trans-dichloroethylene													

* I = Influent
** E = Effluent

TABLE V A

PROCESSING OF CHEMICALS CONSIDERED AS PRIORITY POLLUTANTS

	CAS Number	Merck Index Number	Chemical	A: Raw or Inter-mediate Material	B: Final or Inter-mediate Material	C: Analyzed in Wastewater	D: Frequency Analyzed I*	D: Frequency Analyzed E **	E: Type Sample I *	E: Type Sample E **	F: Loading (lb/day) I *	F: Loading (lb/day) E **	G: Flow Million Gallons /Day I *	G: Flow Million Gallons /Day E **	H: Concen-tration (μg/1) I *	H: Concen-tration (μg/1) E**
31.		----	2,4-dichlorophenol													
32.	78-87-5	7643	1,2-dichloropropane													
33.	542-75-6	3051	1,3-dichloropropylene (1,3-dichloropropene)													
34.	1300-71-6	9744	2,4-dimethylphenol													
35.		----	2,4-dinitrotoluene													
36.		----	2,6-dinitrotoluene													
37.		----	1,2-diphenylhydrazine													
38.	100-41-4	3695	ethylbenzene													
39.		----	fluoranthene													
40.		----	4-chlorophenyl phenyl ether													
41.		----	4-bromophenyl phenyl ether													
42.		----	bis(2-chloroisopropyl) ether													
43.		----	bis(2-chloroethyoxy) methane													
44.	75-09-2	5932	methylene chloride (dichloromethane)													
45.	74-87-3	5916	methyl chloride (chloromethane)													
46.	74-83-9	5904	methyl bromide (bromomethane)													
47.	75-25-2	1418	bromoform (tribromomethane)													
48.		----	dichlorobromomethane													
49.	75-69-4	9320	trichlorofluoromethane													
50.	75-71-8	3038	dichlorodifluoromethane													
51.		----	chlorodibromomethane													
52.		----	hexachlorobutadiene													
53.		----	hexachlorocyclopentadiene													
54.		----	isophorone													
55.	91-20-3	6194	naphthalene													
56.	98-95-3	6409	nitrobenzene													
57.	88-75-5	6442	2-nitrophenol													
58.	100-02-7	6443	4-nitrophenol													
59.	51-28-5	3277	2,4-dinitrophenol													
60.	534-52-1	3275	4,6-dinitro-o-cresol													

* I = Influent
** E = Effluent

TABLE V A

TABLE V A

PROCESSING OF CHEMICALS CONSIDERED AS PRIORITY POLLUTANTS

	CAS Number	Merck Index Number	Chemical	A Raw or Inter-mediate Material	B Final or Inter-mediate Material	C Analyzed in Wastewater	D Frequency Analyzed		E Type Sample		F Loading (lb/day)		G Flow Million Gallons /Day		H Concen-tration (μg/l)	
							I *	E **	I *	E **	I *	E **	I *	E **	I *	E **
61.	62-75-9	6458	N-nitrosodimethylamine													
62.		----	N-nitrosodiphenylamine													
63.		----	N-nitrosodi-n-propylamine													
64.	87-86-5	6901	pentachlorophenol													
65.	108-95-2	7038	phenol													
66.	117-81-7	1270	bis(2-ethylhexyl) phthalate													
67.		----	butyl benzyl phthalate													
68.	84-74-2	1575	di-n-butyl phthalate													
69.			di-n-octyl phthalate													
70.	84-66-2	3783	diethyl phthalate													
71.	131-11-3	3244	dimethyl phthalate													
72.	56-55-3	1063	1,2-benzanthracene													
73.	50-32-8	1113	benzo (a)pyrene (3,4-benzopyrene)													
74.		----	3,4-benzofluoranthene													
75.		----	11,12-benzofluoranthene													
76.	218-01-9	2252	chrysene													
77.		----	acenaphthylene													
78.	120-12-7	718	anthracene													
79.		----	1,12-benzoperylene													
80.	86-73-7	4037	fluorene													
81.	85-01-8	6996	phenanthrene													
82.	53-70-3	2971	1,2:5,6-dibenzanthracene													
83.		----	indeno(1,2,3-C,D) pyrene													
84.	129-00-0	7746	pyrene													
85.	127-18-4	8907	tetrachloroethylene													
86.	108-88-3	9225	toluene													
87.	79-01-6	9319	trichloroethylene													
88.	75-01-4	9645	vinyl chloride (chloroethylene)													
89.	309-00-2	220	aldrin													
90.	60-57-1	3075	dieldrin													

* I = Influent
** E = Effluent

TABLE V A

PROCESSING OF CHEMICALS CONSIDERED AS PRIORITY POLLUTANTS

	CAS Number	Merck Index Number	Chemical	A	B	C	D		E		F		G		H	
				Raw or Intermediate Material	Final or Intermediate Material	Analyzed in Wastewater	Frequency Analyzed		Type Sample		Loading (lb/day)		Flow Million Gallons /Day		Concentration (μg/l)	
							I*	E**	I*	E**	I*	E**	I*	E**	I*	E**
91.	57-74-9	2051	*chlordane (technical mixture and metabolites)*													
92.	50-29-3	2822	4,4'-DDT													
93.		----	4,4'-DDE (p,p'-DDX)													
94.	6088-51-3	2821	4,4'-DDD (p,p'-TDE)													
95.	115-29-7	3519	alpha-endosulfan													
96.	115-29-7	3519	beta-endosulfan													
97.		----	endosulfan sulfate													
98.	72-20-8	3522	endrin													
99.		----	endrin aldehyde													
100.	76-44-8	4514	heptachlor													
101.		----	heptachlor epoxide													
102.	58-89-9	5341	alpha-BHC													
103.	58-89-9	5341	beta-BHC													
104.	58-89-9	5341	gamma-BHC (lindane)													
105.	58-89-9	5341	delta-BHC													
106.		----	PCB-1242 (Arochlor 1242)													
107.		----	PCB-1254 (Arochlor 1254)													
108.		----	PCB-1221 (Arochlor 1221)													
109.		----	PCB-1232 (Arochlor 1232)													
110.		----	PCB-1248 (Arochlor 1248)													
111.		----	PCB-1260 (Arochlor 1260)													
112.		----	PCB-1016 (Arochlor 1016)													
113.	8001-35-2	9252	Toxaphene													
114.	7440-36-0	729	Antimony (Total)													
115.	7440-38-2	820	Arsenic (Total)													
116.		850	Asbestos (Fibrous)													
117.	7440-41-7	1184	Beryllium (Total)													
118.	7440-43-9	1600	Cadmium (Total)													
119.	7440-47-3	2229	Chromium (Total)													
120.	7440-50-8	2496	Copper (Total)													

* I = Influent
** E = Effluent

TABLE V A

PROCESSING OF CHEMICALS CONSIDERED AS PRIORITY POLLUTANTS

	CAS Number	Merck Index Number	Chemical	A Raw or Inter-mediate Material	B Final or Inter-mediate Material	C Analyzed in Wastewater	D Frequency Analyzed I*	D Frequency Analyzed E**	E Type Sample I*	E Type Sample E**	F Loading (lb/day) I*	F Loading (lb/day) E**	G Flow Million Gallons /Day I*	G Flow Million Gallons /Day E**	H Concen-tration (µg/l) I*	H Concen-tration (µg/l) E*
121.	420-05-3	2694	Cyanide (Total)													
122.	7439-92-1	5242	Lead (Total)													
123.	7439-97-6	5742	Mercury (Total)													
124.		6312	Nickel (Total)													
125.	7782-49-2	8179	Selenium (Total)													
126.	7440-22-4	8244	Silver (Total													
127.	7440-28-0	8970	Thallium (Total)													
128.	7440-66-6	9782	Zinc (Total)													
129.		----	2,3,7,8 - tetrachlorodibenzo-p-dioxin (TCDD)													

* I = Influent
** E = Effluent

APPENDIX B

PHARMACEUTICAL MANUFACTURING PLANTS IN THE ORIGINAL 308 DATA BASE

APPENDIX B

PHARMACEUTICAL MANUFACTURING PLANTS IN THE ORIGINAL 308 DATA BASE

NAME	LOCATION	
A. H. ROBINS COMPANY	RICHMOND	VA
A. H. ROBINS MANUFACTURING COMPANY	BARCELONETA	PR
ABBOTT LABORATORIES	BARCELONETA	PR
ABBOTT LABORATORIES	NORTH CHICAGO	IL
ABBOTT LABORATORIES - N. CHICAGO	NORTH CHICAGO	IL
ABBOTT: HOSPITAL PRODUCTS DIVISION	ROCKY MOUNT	NC
ABBOTT: MURINE COMPANY	CHICAGO	IL
ABBOTT: SCIENTIFIC PRODUCTS DIVISION	LOS ANGELES	CA
AHSC: DADE DIVISION	MIAMI	FL
AHSC: HARLECO DIVISION	GIBBSTOWN	NJ
ALCON LABORATORIES (P.R.). INC.	HUMACAO	PR
ALCON LABORATORIES - OPHTHALMIC	FORT WORTH	TX
ALCON: CENTER LABORATORIES, INC.	PORT WASHINGTON	NY
ALCON: OWEN LABORATORIES, INC.	ADDISON	TX
ALZA CORPORATION	PALO ALTO	CA
ALZA CORPORATION - BUILDING A	PALO ALTO	CA
ALZA CORPORATION - BUILDING J	PALO ALTO	CA
AMERICAN CYANAMID COMPANY	HANNIBAL	MO
AMES COMPANY	SOUTH BEND	IN
AMES IMMUNOLOGY MANUFACTURING DIV.	ELKHART	IN
ARBROOK, INC.	ARLINGTON	TX
ARMOUR PHARMACEUTICAL COMPANY	KANKAKEE	IL
ARNAR-STONE LABORATORIES, INC.	MT. PROSPECT	IL
ARNAR-STONE, INC.	AGUIGALLA	PR
ASTRA PHARMACEUTICAL PRODUCTS, INC.	WORCESTER	MA
AYERST LABORATORIES, INC.	ROUSES POINT	NY
BARNES-HIND DIAGNOSTICS, INC.	CANOVANAS	PR
BARNES-HIND PHARMACEUTICALS, INC.	SUNNYVALE	CA
BARRY LABORATORIES, INC.	POMPANO BEACH	FL
BEECHAM LABORATORIES	BRISTOL	TN
BEECHAM PHARMACEUTICALS	PISCATAWAY	NJ
BIO-REAGENTS AND DIAGNOSTICS, INC.	IRVINE	CA
BLOCK DRUG COMPANY, INC.	JERSEY CITY	NJ
BLOCK DRUG COMPANY, INC.	MEMPHIS	TN
BOWMAN PHARMACEUTICALS, INC.	CANTON	OH
BRISTOL ALPHA AND BRISCHEM	BARCELONETA	PR
BRISTOL LABORATORIES CORP.	MAYAQUEZ	PR
BRISTOL-MYERS PRODUCTS	HILLSIDE	NJ
BRISTOL-MYERS PRODUCTS	ST. LOUIS	MO
BRISTOL-MYERS: IND. & BRISTOL LABS.	EAST SYRACUSE	NY
BURDICK & JACKSON LABORATORIES, INC.	MUSKEGON	MI
BURROUGHS WELLCOME COMPANY	GREENVILLE	NC
BURROUGHS WELLCOME: VACCINE DIVISION	DENVER	CO
BYK-GULDEN, INC.	HICKSVILLE	NY
BYK-GULDEN: DAY-BALDWIN DIVISION	HILLSIDE	NJ
CARTER-WALLACE, INC.	CRANBURY	NJ
CARTER-WALLACE: DENV. CHEM. (P.R.)	HUMACAO	PR
CENTRAL PHARMACAL COMPANY	SEYMOUR	IN
CERTIFIED LABORATORIES, INC.	WARRINGTON	PA
CIBA-GEIGY CORPORATION	CRANSTON	RI

PHARMACEUTICAL MANUFACTURING PLANTS IN THE ORIGINAL 308 DATA BASE

NAME	LOCATION	
CIBA-GEIGY CORPORATION	SUFFERN	NY
CIBA-GEIGY CORPORATION	SUMMIT	NJ
CONNAUGHT LABORATORIES, INC.	SWIFTWATER	PA
COOPER LABORATORIES (P.R.), INC.	SAN GERMAN	PR
COOPER LABORATORIES (P.R.): SMP DIV.	PALO ALTO	CA
COOPER LABORATORIES: WAYNE OLD DIV.	WAYNE	NJ
CUTTER LABORATORIES, INC.	BERKELEY	CA
CUTTER LABORATORIES, INC.	CHATTANOOGA	TN
CUTTER LABORATORIES, INC.	CLAYTON	NC
CUTTER LABORATORIES, INC.	OGDEN	UT
CUTTER LABORATORIES: BAYVET DIVISION	SHAWNEE	KS
DADE DIAGNOSTICS, INC.	AGUADA	PR
DAVIS AND GECK, INC.	MANATI	PR
DENTCO, INC.	HUMACAO	PR
DOME LABORATORIES DIVISION	WEST HAVEN	CT
DORSEY LABORATORIES DIVISION	LINCOLN	NE
DOW PHARMACEUTICALS	INDIANAPOLIS	IN
E. R. SQUIBB AND SONS, INC.	NEW BRUNSWICK	NJ
E. R. SQUIBB MANUFACTURING, INC.	HUMACAO	PR
EATON LABORATORIES, INC.	MANATI	PR
ELI LILLY - CLINTON LABS.	CLINTON	IN
ELI LILLY - INDUSTRIAL CIR. 1200	INDIANAPOLIS	IN
ELI LILLY - OMAHA LABS	OMAHA	NE
ELI LILLY - PARK FLETCHER	INDIANAPOLIS	IN
ELI LILLY - TIPPECANOE LABS.	LAFAYETTE	IN
ELI LILLY AND COMPANY	CAROLINA	PR
ELI LILLY AND COMPANY	GREENFIELD	IN
ELI LILLY AND COMPANY	INDIANAPOLIS	IN
ELI LILLY AND COMPANY	MAYAGUEZ	PR
ELI LILLY INDUSTRIES	CAROLINA	PR
ENDO LABORATORIES, INC.	GARDEN CITY	NY
ENDO, INC.	MANATI	PR
FERNDALE LABORATORIES, INC.	FERNDALE	MI
FIRST TEXAS PHARMACEUTICALS, INC.	DALLAS	TX
HILTON DAVIS CHEMICAL COMPANY	CINCINNATI	OH
HOECHST-ROUSSEL PHARMACEUTICALS, INC.	SOMERVILLE	NJ
HOFFMANN-LA ROCHE - AG. DIVISION	FORT WORTH	TX
HOFFMANN-LA ROCHE, INC.	AMES	IA
HOFFMANN-LA ROCHE, INC.	BELVIDERE	NJ
HOFFMANN-LA ROCHE, INC.	FRESNO	CA
HOFFMANN-LA ROCHE, INC.	NUTLEY	NJ
HOFFMANN-LA ROCHE, INC.	SALISBURY	MD
HOFFMANN-LA ROCHE, INC.	TOTOWA	NJ
HOLLISTER-STIER LABORATORIES	SPOKANE	WA
HYNSON, WESTCOTT, & DUNNING DIVISION	BALTIMORE	MD
ICI AMERICAS, INC.	DIGHTON	MA
IMC, INC.	TERRE HAUTE	IN
INOLEX CORPORATION: PHARM. DIVISION	PARK FOREST SOUTH	IL
IVERS-LEE DIVISION	NEWARK	NJ
IVERS-LEE DIVISION	SHIPSHEWANA	IN

APPENDIX B (cont'd)

PHARMACEUTICAL MANUFACTURING PLANTS IN THE ORIGINAL 308 DATA BASE

NAME	LOCATION	
IVERS-LEE DIVISION	WEST CALDWELL	NJ
J. T. BAKER CHEMICAL COMPANY	PHILLIPSBURG	NJ
J. T. CLARK COMPANY	GENEVA	IL
JELCO LABORATORIES, INC.	RARITAN	NJ
JELCO LABORATORIES, INC.	RIVIERA BEACH	FL
JENSEN-SALSBERY LABORATORIES	KANSAS CITY	KS
JENSEN-SALSBERY LABORATORIES	KANSAS CITY	MO
JOHNSON AND JOHNSON	NORTH BRUNSWICK	NJ
JOHNSON AND JOHNSON - EAST. SURG. DR.	NORTH BRUNSWICK	NJ
JOHNSON AND JOHNSON - MIDWEST SUR. DR.	CHICAGO	IL
JOHNSON AND JOHNSON - SW. SURG. DRESS.	SHERMAN	TX
JOHNSON AND JOHNSON D.O.C., INC.	GURABO	PR
KNOLL PHARMACEUTICAL COMPANY	WHIPPANY	NJ
KREMERS-URBAN COMPANY	MEQUON	WI
LEDERLE LABORATORIES DIVISION	PEARL RIVER	NY
LEHN AND FINK PRODUCTS COMPANY	LINCOLN	IL
MALLINCKRODT, INC.	DECATUR	IL
MALLINCKRODT, INC.	ST. LOUIS	MO
MALLINCKRODT, INC. - BULK LYSATE	BEAUFORT	NC
MALLINCKRODT, INC. - NUCLEAR	MARYLAND HEIGHTS	MO
MALLINCKRODT, INC. - RALEIGH CHEMICAL	RALEIGH	NC
MALLINCKRODT, INC. - RALEIGH PARENT.	RALEIGH	NC
MALLINCKRODT, INC. - RALEIGH PLASTICS	RALEIGH	NC
MARION HEALTH AND SAFETY, INC.	ROCKFORD	IL
MARION LABORATORIES, INC.	KANSAS CITY	MO
MCGRAW LABORATORIES	IRVINE	CA
MCGRAW LABORATORIES	IRVINE	CA
MCGRAW LABORATORIES	MILLEDGEVILLE	GA
MCGRAW LABORATORIES	SABANA GRANDE	PR
MCNEIL LABORATORIES, INC.	DORADO	PR
MCNEIL LABORATORIES, INC.	FORT WASHINGTON	PA
MEAD JOHNSON AND COMPANY	EVANSVILLE	IN
MEDIPHYSICS, INC.	EMERYVILLE	CA
MEDIPHYSICS, INC.	GLENDALE	CA
MEDIPHYSICS, INC.	MIAMI LAKES	FL
MEDIPHYSICS, INC.	ROSEMONT	IL
MEDIPHYSICS, INC.	SOUTH PLAINFIELD	NJ
MERCK AND CO., INC.	RAHWAY	NJ
MERCK AND CO., INC. - CHEROKEE	DANVILLE	PA
MERCK AND CO., INC. - FLINT RIVER	ALBANY	GA
MERCK AND CO., INC. - STONEWALL	ELKTON	VA
MERCK SHARP AND DOHME, INC.	WEST POINT	PA
MERCK SHARP AND DOHME (P.R.), INC.	BARCELONETA	PR
MERRELL-NATIONAL LABORATORIES, INC.	CAYEY	PR
MERRELL-NATIONAL LABORATORIES, INC.	CINCINNATI	OH
MILES LABORATORIES, INC.	ELKHART	IN
NORWICH-EATON PHARM. DIV. - NORWICH	NORWICH	NY
NORWICH-EATON PHARM. DIV. - W'DS CORNER	NORWICH	NY
NORWICH-EATON PHARM. DIVISION	GREENVILLE	SC
ORGANON, INC.	WEST ORANGE	NJ

PHARMACEUTICAL MANUFACTURING PLANTS IN THE ORIGINAL 308 DATA BASE

NAME	LOCATION	
ORTHO DIAGNOSTICS, INC.	ARLINGTON	TX
ORTHO DIAGNOSITCS, INC.	RARITAN	NJ
ORTHO PHARMACEUTICALS, INC.	DORADO	PR
PARKE-DAVIS AND COMPANY	DETROIT	MI
PARKE-DAVIS AND COMPANY	GREENWOOD	SC
PARKE-DAVIS AND COMPANY	HOLLAND	MI
PARKE-DAVIS AND COMPANY	ROCHESTER	MI
PARKE-DAVIS LABORATORIES	FAJARDO	PR
PENNWALT CORPORATION	ROCHESTER	NY
PFIZER PHARMACEUTICALS, INC.	BARCELONETA	PR
PFIZER, INC.	BROOKLYN	NY
PFIZER, INC.	GROTON	CT
PFIZER, INC. - MAYW'D CANCER RES'RCH	MAYWOOD	NJ
PFIZER, INC. - VIGO	TERRE HAUTE	IN
PHARMASEAL LABORATORIES	IRWINDALE	CA
PHILIPS ROXANE LABORATORIES, INC.	COLUMBUS	OH
PLOUGH, INC.	MEMPHIS	TN
PURDUE FREDERICK LABORATORIES, INC.	TOTOWA	NJ
R. P. SCHERER (MIDWEST) CORP.	DETROIT	MI
R. P. SCHERER (SOUTHEAST) CORP.	MONROE	NC
REEDCO, INC.	HUMACAO	PR
REHEIS CHEMICAL COMPANY	BERKELEY HEIGHTS	NJ
RIKER LABORATORIES, INC.	NORTHRIDGE	CA
ROSS LABORATORIES	ALTAVISTA	VA
ROSS LABORATORIES	COLUMBUS	OH
S. B. PENICK AND COMPANY	LYNDHURST	NJ
S. B. PENICK AND COMPANY	MONTVILLE	NJ
S. B. PENICK AND COMPANY	NEWARK	NJ
S. B. PENICK AND COMPANY	VANCOUVER	WA
S. B. PENICK AND COMPANY	WALLINGFORD	CT
SANDOZ, INC.	EAST HANOVER	NJ
SCHERING (P.R.) CORPORATION	MANATI	PR
SCHERING CORPORATION	UNION	NJ
SCHERING-PLOUGH CORPORATION	KENILWORTH	NJ
SCHERING: AMERICAN SCIENTIFIC LABS.	MADISON	WI
SEARLE AND COMPANY	CAGUAS	PR
SEARLE LABORATORIES	SKOKIE	IL
SMITHKLINE AND FRENCH COMPANY	CAROLINA	PR
SMITHKLINE AND FRENCH LABORATORIES	PHILADELPHIA	PA
SMITHKLINE AND FRENCH LABORATORIES	SWEDELAND	PA
SMITHKLINE CORPORATION	LOWELL	AR
SMITHKLINE: NORDEN LABORATORIES	LINCOLN	NE
SMITHKLINE: SEA AND SKI CORP.	RENO	NV
STERLING DRUG, INC.	GULFPORT	MS
STERLING DRUG, INC.	MONTICELLO	IL
STERLING DRUG, INC.	MYERSTOWN	PA
STERLING DRUG, INC.	MYERSTOWN	PA
STERLING DRUG, INC.	RENSSELAER	NY
STERLING DRUG, INC.	TRENTON	NJ
STERLING DRUG, INC. - EAST GREENBUSH	RENSSELAER	NY

PHARMACEUTICAL MANUFACTURING PLANTS IN THE ORIGINAL 308 DATA BASE

NAME	LOCATION	
STERLING DRUG, INC.	MCPHERSON	KS
STERWIN LABORATORIES, INC.	MILLSBORO	DE
STERWIN LABORATORIES, INC.	OPELIKA	AL
STUART PHARMACEUTICALS DIVISION	NEWARK	DE
STUART PHARMACEUTICALS DIVISION	PASADENA	CA
SYNTEX (F.P.), INC.	HUMACAO	PR
SYNTEX AGRIBUSINESS, INC.	DES MOINES	IA
SYNTEX LABORATORIES, INC.	PALO ALTO	CA
TENNECO CHEMICALS, INC.	GARFIELD	NJ
TRAVENOL LABORATORIES, INC.	CAROLINA	PR
TRAVENOL LABORATORIES, INC.	CLEVELAND	MS
TRAVENOL LABORATORIES, INC.	COSTA MESA	CA
TRAVENOL LABORATORIES, INC.	JAYUYA	PR
TRAVENOL LABORATORIES, INC.	MARICAO	PR
TRAVENOL LABORATORIES, INC.	MARION	NC
TRAVENOL LABORATORIES, INC.	MORTON GROVE	IL
TRAVENOL LABORATORIES, INC.	MOUNTAIN HOME	AR
TRAVENOL: CLINICAL ASSAYS	CAMBRIDGE	MA
TRAVENOL: DAYTON FLEXIBLE PROD. DIV.	KINGSTREE	SC
TRAVENOL: HYLAND DIVISION	GLENDALE	CA
TRAVENOL: HYLAND DIVISION	LOS ANGELES	CA
TRAVENOL: HYLAND DIVISION	ROUND LAKE	IL
UPJOHN COMPANY	ARECIBO	PR
UPJOHN COMPANY	KALAMAZOO	MI
UPJOHN COMPANY	KALAMAZOO	MI
USV LABORATORIES	MANATI	PR
USV PHARMACEUTICAL CORP.	TUCKAHOE	NY
VICKS HEALTH CARE DIVISION	GREENSBORO	NC
VICKS HEALTH CARE DIVISION	HATBORO	PA
VICKS RESEARCH AND DEVELOPMENT DIV.	MT. VERNON	NY
WARNER-CHILCOTT DIVISION	MORRIS PLAINS	NJ
WARNER-CHILCOTT LABORATORIES	CAROLINA	PR
WARNER-CHILCOTT PHARMACEUTICAL CO.	VEGA BAJA	PR
WARREN-TEED LABORATORIES, INC.	COLUMBUS	OH
WARREN-TEED, INC.	HUMACAO	PR
WESTWOOD PHARMACEUTICALS, INC.	BUFFALO	NY
WILLIAM H. RORER, INC.	FORT WASHINGTON	PA
WILLIAM H. RORER, INC.	SAN LEANDRO	CA
WILLIAM P. POYTHRESS AND CO., INC.	RICHMOND	VA
WINTHROP LABORATORIES, INC.	BARCELONETA	PR
WYETH LABORATORIES, INC.	MARIETTA	PA
WYETH LABORATORIES, INC.	SKOKIE	IL
WYETH LABORATORIES, INC.	WEST CHESTER	PA
WYETH LABORATORIES, INC. - GR. VALLEY	MALVERN	PA

TOTAL NUMBER OF MFG. PLANTS IN THE ORIGINAL 308 DATA BASE: 244

APPENDIX C

SUPPLEMENTAL 308 PORTFOLIO
FOR THE
PHARMACEUTICAL MANUFACTURING INDUSTRY

SUPPLEMENTAL 308 PORTFOLIO
FOR THE
PHARMACEUTICAL MANUFACTURING INDUSTRY

Instructions

1. Please complete the following portfolio and return within 30 days of receipt to:

   Mr. Robert B. Schaffer, Director
   Effluent Guidelines Division
   U.S. EPA (WH-552)
   401 M. Street, S.W.
   Washington, D.C. 20460

   Attention: J. S. Vitalis

2. Please read all instructions and questions carefully before completing this portfolio. It is preferred that the individual(s) who responds to this portfolio be familiar with manufacturing processes and wastewater treatment operations at the plant.

3. Please check the appropriate box or boxes in each question where they appear throughout this portfolio. (More than one box may be checked for some questions, where appropriate.) Please complete all questions which require written responses by printing or typing in the spaces provided.

4. Please indicate which information in your responses is confidential so that it may be treated properly.

5. The U.S. Environmental Protection Agency will review the information submitted and may, at a later date, request your cooperation for site visits and additional sampling in order to complete the data base. Please retain a copy of the completed portfolio in case future contact is necessary to verify your responses.

6. If you have any questions, please telephone Mr. J. S. Vitalis at 202-426-2497.

FORM APPROVED
OMB No. 158-R0160

PLANT CODE NO.________
(For EPA Use Only)

PART I

GENERAL INFORMATION

1. Name of Plant________________________________

2. Address of Plant:

____
Street City State Zip

3. Name of Parent Firm________________________________

4. Address of Parent Firm Headquarters:

____
Street City State Zip

5. Name(s) of plant personnel to be contacted for information pertaining to this data collection portfolio:

Name	Title	(Area Code) Telephone

PART II

PLANT DATA

1. a. Does this plant manufacture or formulate pharmaceutical active ingredients? Yes ☐ No ☐
(Research and development activities should not be considered.)

b. If the answer to (a) is no, please describe the operations at this facility, but do not complete the remainder of this portfolio.

____
____
____
____
____
____
____
____

c. If the answer to (a) is yes, please complete the remainder of this portfolio.

2. Type of production operation(s) at this facility (check all items that are appropriate):

	Batch	Continuous	Semicontinuous
a. Fermentation	☐	☐	☐
b. Biological and Natural Extraction	☐	☐	☐
c. Chemical Synthesis	☐	☐	☐
d. Mixing/Compounding and Formulation	☐	☐	☐

3. Number of manufacturing or formulating employees in 1978: Average_____ Minimum_____ Maximum_____

4. Please list in Table 1 all products manufactured at this plant site by the following production subcategories during 1978: (A) Fermentation, (B) Biological and Natural Extraction, and/or (C) Chemical Synthesis. Place an A, B, or C in the appropriate column to indicate the type of production subcategory used. Use the Merck Index, Ninth Edition, 1976, to specify the Merck Index Identification Numbers (Merck Index Number). Many of the Chemical Abstract Service Registry Numbers (CAS Numbers) may be found in the Merck Index beginning on page REG-1.

Note: Make as many photocopies of this sheet as necessary before filling in the requested information.

TABLE 1

CAS NUMBER	MERCK INDEX NO.	PRODUCT NAME	PRODUCTION SUBCATEGORY	ANNUAL PRODUCTION (kg/yr)
Examples:				
87081	6890	Penicillin V	A	10,000
-	-	Allergenic extracts	B	300
103902	36	Acetaminophen	C	5,000

PLANT CODE NO.________

PART III

WASTEWATER DATA

1. a. Does this plant site generate process wastewaters? Yes ☐ No ☐

Note: Process wastewater is any water which, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, by-product, or waste product. This does not include sanitary wastewaters, non-contact cooling waters, nor stormwater.

b. Average daily quantity of process wastewaters generated during 1978, in gallons per day

____

2. a. Does this plant have a National Pollutant Discharge Elimination System permit (NPDES) for the discharge of process wastewaters? Yes ☐ No ☐

b. Permit or application number ______________________________

c. Average daily flow rate of permitted discharge during 1978, in gallons per day ______________

3. a. Does this plant discharge process wastewaters to a municipal sewage treatment plant? Yes ☐ No ☐

b. Average daily flow rate of discharge to municipal sewage treatment plant during 1978, in gallons per day

____

4. List other methods used for process wastewater disposal (e.g., incineration, evaporation, deep well disposal, etc.)

Method	Average daily flow rate during 1978, gallons per day

Note: Flow rates presented in Questions 2.c., 3.b. and 4. should total the flow rate given in Question 1.b.

5. Are there wastewater treatment facilities on site? Yes ☐ Complete Question III.6.

No ☐ Go to Part IV.

6. Check which of the treatment processes listed below are employed at this plant:

a. In-plant

☐ Cyanide Destruction

☐ Metal Precipitation

☐ Chromium Reduction

☐ Steam Stripping

☐ Solvent Recovery

☐ Other, Specify______________________________

b. End-of-Pipe

☐ Equalization

☐ Neutralization

☐ Coarse Settleable Solids Removal

Primary Separation

☐ Primary Sedimentation

☐ Primary Chemical Flocculation/Clarification

☐ Other, Specify______________________________

Biological Treatment

☐ Activated Sludge

☐ Trickling Filter

☐ Aerated Lagoon

☐ Waste Stabilization Ponds

☐ Rotating Biological Contactor

☐ Powdered Activated Carbon

☐ Other, Specify________________________________

☐ Physical/Chemical Treatment

Polishing

☐ Pond

☐ Multi-media Filtration

☐ Activated Carbon

☐ Other, Specify________________________________

c. *Sludge Disposal*

☐ Landfill

☐ Cropland Use

☐ Ocean

☐ Other, Specify________________________________

7. If this plant operates an end-of-pipe treatment system and one or more boxes in Question 6.b were checked, then please provide available data on the performance of that system by completing Table 2. Data used to compute long term average flow rates and concentrations should be for the time period from July 1, 1977 to December 31, 1978. If data is not available for the entire 1-1/2 year period, then please provide data that is available and indicate the actual time period used to compute long term average values. Do not include data obtained before July 1, 1977. In addition, please indicate the frequency of sampling that occurred for the subject parameter during the indicated time period. In Table 2, please insert a number from the following list that corresponds to that frequency.

Frequency	Number
One time sample	1
Less than one sample per month	2
One sample per month to less than one sample per week	3
One sample per week to one sample per day	4
More than one sample per day	5

Note: gal/d = gallons per day
mg/l = milligrams per liter

TABLE 2

Parameter	Long Term Average Value: Influent to End-of-Pipe System	Long Term Average Value: Effluent from End-of-Pipe System	Time Period over which average conc. occurred	Frequency of sampling during the indicated time period
Flow (gal/d)				
BOD_5 (mg/l)				
COD (mg/l)				
TSS (mg/l)				
Cyanide (mg/l)				
Phenol (mg/l)				

PART IV

PRIORITY POLLUTANTS

Please provide the information requested in Table 3 concerning the chemicals which are considered as priority pollutants and which are listed in Table 3 in conformance with the following instructions:

1. In column A, place a check mark to indicate all of the listed chemicals which were used as raw or intermediate material during 1978.

2. In column B, place a check mark to indicate all of the listed chemicals which were manufactured at this plant as a final or intermediate material during 1978.

3. In column C, place a check mark to indicate all of the listed chemicals for which you have analyzed in your raw (untreated) process wastewater (R) and/or treated effluent (E), and for which analytical data are available.

4. If one or more check marks have been placed in column C, then please attach a copy of the analytical results. However, if the results are voluminous, the data may be summarized on a separate sheet of paper by computing an average concentration and flow rate and stating minimum and maximum concentrations and flow rates for each pollutant. In addition, please indicate the time period over which this data was collected and the frequency of sampling that occurred during that time period.

TABLE 3

PLANT CODE NO.__________

PRIORITY POLLUTANTS

	CAS Number	Merck Index Number	Chemical	A Raw or Inter-mediate Material	B Final or Inter-mediate Material	C Analyzed in Wastewater R	E
1.	83-32-9	19	acenaphthene				
2.	107-02-8	123	acrolein				
3.	107-13-1	127	acrylonitrile				
4.	71-43-2	1069	benzene				
5.	92-87-5	1083	benzidine				
6.	56-23-5	1821	carbon tetrachloride (tetrachloromethane)				
7.	108-90-7	2095	chlorobenzene				
8.	120-82-1	9310	1,2,4-trichlorobenzene				
9.	118-74-1	4544	hexachlorobenzene				
10.	107-06-2	3733	1,2-dichloroethane				
11.	71-55-6	9316	1,1,1-trichloroethane				
12.	67-72-1	4545	hexachloroethane				
13.	75-34-3	3750	1,1-dichloroethane				
14.	79-00-5	9317	1,1,2,-trichloroethane				
15.	79-34-5	8906	1,1,2,2-tetrachloroethane				
16.	75-00-3	3713	chloroethane				
17.	542-88-1	3046	bis(chloromethyl) ether				
18.	111-44-4	3040	bis(2-chloroethyl) ether				
19.	110-75-8	2119	2-chloroethyl vinyl ether (mixed)				
20.	91-58-7	2127	2-chloronaphthalene				
21.	88-06-2	9323	2,4,6-trichlorophenol				
22.	59-50-7	2108	parachlorometa cresol				
23.	67-66-3	2120	chloroform (trichloromethane)				
24.	95-57-8	2134	2-chlorophenol				
25.	95-50-1	3029	1,2-dichlorobenzene				
26.	541-73-1	3028	1,3-dichlorobenzene				
27.	106-46-7	3030	1,4-dichlorobenzene				
28.	91-94-1	3032	3,3'-dichlorobenzidine				
29.	75-35-4	9647	1,1-dichloroethylene				
30.	540-59-0	85	1,2- trans-dichloroethylene				
31.		----	2,4-dichlorophenol				
32.	78-87-5	7643	1,2-dichloropropane				
33.	542-75-6	3051	1,3-dichloropropylene (1,3-dichloropropene)				
34.	1300-71-6	9744	2,4-dimethylphenol				
35.		----	2,4-dinitrotoluene				
36.		----	2,6-dinitrotoluene				
37.		----	1,2-diphenylhydrazine				
38.	100-41-4	3695	ethylbenzene				
39.		----	fluoranthene				
40.		----	4-chlorophenyl phenyl ether				
41.		----	4-bromophenyl phenyl ether				
42.		----	bis(2-chloroisopropyl) ether				
43.		----	bis(2-chloroethyoxy) methane				

TABLE 3

PLANT CODE NO.__________

PRIORITY POLLUTANTS

	CAS Number	Merck Index Number	Chemical	A Raw or Inter-mediate Material	B Final or Inter-mediate Material	C Analyzed [illegible] P	 E
44.	75-09-2	5932	methylene chloride (dichloromethane)				
45.	74-87-3	5916	methyl chloride (chloromethane)				
46.	74-83-9	5904	methyl bromide (bromomethane)				
47.	75-25-2	1418	bromoform (tribromomethane)				
48.		----	dichlorobromomethane				
49.	75-69-4	9320	trichlorofluoromethane				
50.	75-71-8	3038	dichlorodifluoromethane				
51.		----	chlorodibromomethane				
52.		----	hexachlorobutadiene				
53.		----	hexachlorocyclopentadiene				
54.		----	isophorone				
55.	91-20-3	6194	naphthalene				
56.	98-95-3	6409	nitrobenzene				
57.	88-75-5	6442	2-nitrophenol				
58.	100-02-7	6443	4-nitrophenol				
59.	51-28-5	3277	2,4-dinitrophenol				
60.	534-52-1	3275	4,6-dinitro-o-cresol				
61.	62-75-9	6458	N-nitrosodimethylamine				
62.		----	N-nitrosodiphenylamine				
63.		----	N-nitrosodi-n-propylamine				
64.	87-86-5	6901	pentachlorophenol				
65.	108-95-2	7038	phenol				
66.	117-81-7	1270	bis(2-ethylhexyl) phthalate				
67.		----	butyl benzyl phthalate				
68.	84-74-2	1575	di-n-butyl phthalate				
69.			di-n-octyl phthalate				
70.	84-66-2	3783	diethyl phthalate				
71.	131-11-3	3244	dimethyl phthalate				
72.	56-55-3	1063	1,2-benzanthracene				
73.	50-32-8	1113	benzo (a)pyrene (3,4-benzopyrene)				
74.		----	3,4-benzofluoranthene				
75.		----	11,12-benzofluoranthene				
76.	218-01-9	2252	chrysene				
77.		----	acenaphthylene				
78.	120-12-7	718	anthracene				
79.		----	1,12-benzoperylene				
80.	86-73-7	4037	fluorene				
81.	85-01-8	6996	phenanthrene				
82.	53-70-3	2971	1,2:5,6-dibenzanthracene				
83.		----	indeno(1,2,3-C,D) pyrene				
84.	129-00-0	7746	pyrene				
85.	127-18-4	8907	tetrachloroethylene				
86.	108-88-3	9225	toluene				

PLANT CODE NO.__________

TABLE 3

PRIORITY POLLUTANTS

	CAS Number	Merck Index Number	Chemical	A Raw or Inter-mediate Material	B Final or Inter-mediate Material	C Analyzed in Wastewater R	E
87.	79-01-6	9319	trichloroethylene				
88.	75-01-4	9645	vinyl chloride (chloroethylene)				
89.	309-00-2	220	aldrin				
90.	60-57-1	3075	dieldrin				
91.	57-74-9	2051	chlordane (technical mixture and metabolites)				
92.	50-29-3	2822	4,4'-DDT				
93.		----	4,4'-DDE (p,p'-DDX)				
94.	6088-51-3	2821	4,4'-DDD (p,p'-TDE)				
95.	115-29-7	3519	alpha-endosulfan				
96.	115-29-7	3519	beta-endosulfan				
97.		----	endosulfan sulfate				
98.	72-20-8	3522	endrin				
99.		----	endrin aldehyde				
100.	76-44-8	4514	heptachlor				
101.		----	heptachlor epoxide				
102.	58-89-9	5341	alpha-BHC				
103.	58-89-9	5341	beta-BHC				
104.	58-89-9	5341	gamma-BHC (lindane)				
105.	58-89-9	5341	delta-BHC				
106.		----	PCB-1242 (Arochlor 1242)				
107.		----	PCB-1254 (Arochlor 1254)				
108.		----	PCB-1221 (Arochlor 1221)				
109.		----	PCB-1232 (Arochlor 1232)				
110.		----	PCB-1248 (Arochlor 1248)				
111.		----	PCB-1260 (Arochlor 1260)				
112.		----	PCB-1016 (Arochlor 1016)				
113.	8001-35-2	9252	Toxaphene				
114.	7440-36-0	729	Antimony (Total)				
115.	7440-38-2	820	Arsenic (Total)				
116.		850	Asbestos (Fibrous)				
117.	7440-41-7	1184	Beryllium (Total)				
118.	7440-43-9	1600	Cadmium (Total)				
119.	7440-47-3	2229	Chromium (Total)				
120.	7440-50-8	2496	Copper (Total)				
121.	420-05-3	2694	Cyanide (Total)				
122.	7439-92-1	5242	Lead (Total)				
123.	7439-97-6	5742	Mercury (Total)				
124.		6312	Nickel (Total)				
125.	7782-49-2	8179	Selenium (Total)				
126.	7440-22-4	8244	Silver (Total				
127.	7440-28-0	8970	Thallium (Total)				
128.	7440-66-6	9782	Zinc (Total)				
129.		----	2,3,7,8 tetracl' [illegible] 'benzo-p-dioxin (TCDD)				

APPENDIX D

PHARMACEUTICAL MANUFACTURING PLANTS IN THE SUPPLEMENTAL 308 DATA BASE

PHARMACEUTICAL MANUFACTURING PLANTS IN THE SUPPLEMENTAL 308 DATA BASE

NAME	LOCATION	
A. E. STALEY MANUFACTURING COMPANY	DECATUR	IL
AJAY CHEMICALS, INC.	POWDER SPRINGS	GA
ALLIED CHEMICAL COMPANY	CHICAGO	IL
AMERCHOL, INC.	EDISON	NJ
AMERICAN AGAR AND CHEMICAL COMPANY	SAN DIEGO	CA
AMERICAN APOTHECARIES COMPANY	LONG ISLAND CITY	NY
AMERICAN CYANAMID CO. - FINE CHEM.	BOUND BROOK	NJ
AMERICAN CYANAMID CO. - FINE CHEM.	WILLOW ISLAND	WV
AMERICAN LABORATORIES, INC.	OMAHA	NE
ANABOLIC, INC.	IRVINE	CA
ANDERSON DEVELOPMENT COMPANY	ARDIAN	MI
ARAPAHOE CHEMICALS, INC.	BOULDER	CO
ARAPAHOE CHEMICALS, INC.	NEWPORT	TN
ARENOL CHEMICAL CORPORATION	LONG ISLAND CITY	NY
ASH STEVENS, INC. (PILOT PLT.)	DETROIT	MI
ATLAS POWDER COMPANY	TAMAQUA	PA
BANNER GELATIN PRODUCTS CORPORATION	CHATSWORTH	CA
BARR LABORATORIES	NORTHVALE	NJ
BAYLOR LABORATORIES, INC.	HURST	TX
BEIERSDORF, INC.	SOUTH NORWALK	CT
BELPORT COMPANY, INC.	CAMARILLO	CA
BEN VENUE LABORATORIES, INC.	BEDFORD	OH
BIOCRAFT LABORATORIES, INC.	ELMWOOD PARK	NJ
BIOCRAFT LABORATORIES, INC.	ELMWOOD PARK	NJ
BIOCRAFT LABORATORIES, INC.	WALDWICK	NJ
BLISTEX, INC.	OAK BROOK	IL
BOLAR PHARMACEUTICAL COMPANY, INC.	COPTAGUE	NY
BOOTS PHARMACEUTICALS, INC.	SHREVEPORT	LA
BRIOSCHI, INC.	FAIR LAWN	NJ
C AND M PHARMACAL, INC.	HAZEL PARK	MI
C. M. BUNDY COMPANY	ERLANGER	KY
CAMPANA CORPORATION	BATAVIA	IL
CARSON CHEMCIALS, INC.	NEW CASTLE	IN
CARTER-GLOGAU LABORATORIES	GLENDALE	AZ
CARTER-GLOGAU LABORATORIES	MELROSE PARK	IL
CENTURY PHARMACEUTICALS, INC.	INDIANAPOLIS	IN
CHAP STICK COMPANY	LYNCHBURG	VA
CHASE CHEMICAL COMPANY	NEWARK	NJ
CHATTEM CHEMICALS DIVISION	CHATTANOOGA	TN
CHATTEM LABORATORIES DIVISION	CHATTANOOGA	TN
CHROMALLOY LABORATORIES	LOS ANGELES	CA
COHELFRED LABORATORIES, INC.	CHICAGO	IL
CORD LABORATORIES, INC.	BROOMFIELD	CO
CORWOOD LABORATORIES, INC.	HAUPPAUGE	NY
CREOMULSTON COMPANY	ATLANTA	GA
CUMBERLAND MANUFACTURING COMPANY	NASHVILLE	TN
D. M. GRAHAM LABORATORIES, INC.	HOBART	NY
DANBURY PHARMACAL, INC.	DANBURY	CT
DEL LABORATORIES, INC.	FARMINGDALE	NY
DEL-RAY LABORATORY, INC.	BIRMINGHAM	AL

PHARMACEUTICAL MANUFACTURING PLANTS IN THE SUPPLEMENTAL 308 DATA BASE

NAME	LOCATION	
DELL LABORATORIES, INC.	TEANECK	NJ
DEPREE COMPANY	HOLLAND	MI
DEVLIN PHARMACEUTICALS, INC.	EL SEGUNDO	CA
DEWEY PRODUCTS COMPANY	GRAND RAPIDS	MI
DIAMOND SHAMROCK CORPORATION	LOUISVILLE	KY
DON HALL LABORATORIES	PORTLAND	OR
DORASOL LABORATORIES	HATO REY	PR
DR. G. H. TICHENOR ANTISEPTIC CO.	NEW ORLEANS	LA
DR. MADIS LABORATORIES, INC.	SOUTH HACKENSACK	NJ
DR. ROSE, INC.	MADISON	CT
DRUGS, INC.	ELIZABETH	NJ
E. E. DICKINSON COMPANY, INC.	ESSEX	CT
E-Z-EM COMPANY	WESTBURY	NY
EASTMAN KODAK CO. - KODAK PARK	ROCHESTER	NY
ELKINS-SINN, INC.	CHERRY HILL	NJ
EMERSON LABORATORIES	DALLAS	TX
ENZYME PROCESS COMPANY, INC.	NORTHRIDGE	CA
EX-LAX, INC.	HUMACAO	PR
FERMCO BIOCHEMICS, INC.	ELK GROVE VILLAGE	IL
FLEMING AND COMPANY	FENTON	MO
FOREST/INWOOD LABORATORIES, INC.	INWOOD, L.I.	NY
FORT DODGE LABORATORIES	FORT DODGE	IA
FRANKLIN LABORATORIES, INC.	AMARILLO	TX
FRESH LABORATORIES, INC.	WARREN	MI
FROMM LABORATORIES, INC.	GRAFTON	WI
G AND W LABORATORIES, INC.	SOUTH PLAINFIELD	NJ
G. E. LABORATORIES, INC.	SHAMOKIN	PA
GANES CHEMICALS, INC.	CARLSTADT	NE
GANES CHEMICALS, INC.	PENNSVILLE	NJ
GEBAUER CHEMICAL COMPANY	CLEVELAND	OH
GENERIC PHARMACEUTICAL CORPORATION	PALISADES PARK	NJ
GIBO/INVENEX DIVISION	GRAND ISLAND	NY
GOODY'S MANUFACTURING COMPANY	WINSTON-SALEM	NC
GORDON LABORATORIES	UPPER DARBY	PA
GRANDPA BRANDS COMPANY	CINCINNATI	OH
GUARDIAN CHEMICAL CORPORATION	HAUPPAUGE	NY
H. CLAY GLOVER COMPANY, INC.	TOMS RIVER	NJ
HALSEY DRUG COMPANY, INC.	BROOKLYN	NY
HEATHER DRUG COMPANY, INC.	CHERRY HILL	NJ
HENKEL CORPORATION	KANKAKEE	IL
HEUN/NORWOOD LABORATORIES	ST. LOUIS	MO
HEXAGON LABORATORIES, INC.	BRONX	NY
HEXCEL SPECIALTY CHEMICALS	LODI	NJ
HIGH CHEMICAL COMPANY	PHILADELPHIA	PA
HOBART LABORATORIES, INC.	CHICAGO	IL
HOLLAND-RANTOS COMPANY, INC.	TRENTON	NJ
HOPPE PHARMACAL CORPORTION	GRAND HAVEN	MI
HUMPHREYS PHARMACAL, INC.	RUTHERFORD	NJ
ICN PHARMACEUTICALS: COVINA DIVISION	COVINA	CA
INFRACORP, LTD.	PETERSBURG	VA

APPENDIX D (cont'd)

PHARMACEUTICAL MANUFACTURING PLANTS IN THE SUPPLEMENTAL 308 DATA BASE

NAME	LOCATION	
INTERNATIONAL HORMONES, INC.	FORT MITCHELL	KY
J. H. GUILD COMPANY, INC.	RUPERT	VT
JOHN D. COPANOS COMPANY, INC.	BALTIMORE	MD
KALLESTAD LABORATORIES, INC.	CHASKA	MN
KENDALL COMPANY	AUGUSTA	GA
KENDALL COMPANY	FRANKLIN	KY
KEY PHARMACEUTICALS, INC.	MIAMI	FL
KOPPERS COMPANY, INC.	PETROLIA	PA
L. T. YORK COMPANY	BROOKFIELD	MD
LANNETT COMPANY, INC.	PHILADELPHIA	PA
LARSON LABORATORIES, INC.	ERIE	PA
LEE PHARMACEUTICALS	SOUTH EL MONTE	CA
LEWIS/HOWE COMPANY	ST. LOUIS	MO
LIBBY LABORATORIES, INC.	BERKELEY	CA
LILY WHITE SALES COMPANY, INC.	ORISKANY FALLS	NY
LORVIC CORPORATION	ST. LOUIS	MO
LYNE LABORATORIES, INC.	NEEDHAM HEIGHTS	MA
LYPHO-MED, INC.	CHICAGO	IL
M. K. LABORATORIES, INC.	FAIRFIELD	CT
MANHATTAN DRUG COMPANY	HILLSIDE	NJ
MANN CHEMICAL CORPORATION	LOUISVILLE	KY
MARSHALL PHARMACAL CORPORATION	SOUTH HACKENSACK	NJ
MAURRY BIOLOGICAL COMPANY, INC.	LOS ANGELES	CA
MBH CHEMICAL CORPORATION	ORANGE	NJ
McCONNON AND COMPANY	WINONA	MN
MENTHOLAIUM COMPANY	BUFFALO	NY
MERICON INDUSTRIES, INC.	PEORIA	IL
MERRICK MEDICINE COMPANY	WACO	TX
MERRILL-NATIONAL LABORATORIES	MILWAUKEE	WI
MICROBIOLOGICAL ASSOCIATES	WALKERSVILLE	MD
MILEX PRODUCTS, INC.	CHICAGO	IL
MILLER-MORTON COMPANY	RICHMOND	VA
MILROY LABORATORIES	SARASOTA	FL
MONSANTO CO. - JOHN F. QUEENY PLT.	ST. LOUIS	MO
MORTON PHARMACEUTICALS, INC.	MEMPHIS	TN
MOYCO INDUSTRIES, INC.	PHILADELPHIA	PA
MYLAN PHARMACEUTICALS, INC.	MORGANTOWN	WV
N.E.N. - MEDICAL DIAGNOSTIC DIVISION	NORTH BILLERICA	MA
NAPP CHEMICALS, INC.	LODI	NJ
NATCON CHEMICAL COMPANY, INC.	PLAINVIEW	NY
NATIONAL PHARMACEUTICAL MFG. COMPANY	BALTIMORE	MD
NELCO LABORATORIES, INC.	DEER PARK	NY
NEPERA CHEMICAL COMPANY, INC.	HARRIMAN	NY
NORTH AMERICAN BIOLOGICALS, INC.	MIAMI	FL
NUTRILITE PRODUCTS, INC.	BUENA PARK	CA
O'NEAL, JONES, AND FELDMAN, INC.	ST. LOUIS	MO
O'NEAL, JONES, AND FELDMAN, INC.	CINCINNATI	OH
ORGANICS, INC.	CHICAGO	IL
ORMONT DRUG AND CHEMICAL CO., INC.	ENGLEWOOD	NJ
OTIS CLAPP AND SONS	CAMBRIDGE	MA

APPENDIX D (cont'd)

PHARMACEUTICAL MANUFACTURING PLANTS IN THE SUPPLEMENTAL 308 DATA BASE

NAME	LOCATION	
OTTAWA CHEMICAL DIVISION	TOLEDO	OH
PASCAL COMPANY, INC.	BELLEVUE	WA
PAUL B. ELDER COMPANY	BRYAN	OH
PETERSON OINTMENT COMPANY	BUFFALO	NY
PFANSTIEHL LABORATORIES, INC.	WAUKEGAN	IL
PHARMACARE, INC.	LARGO	FL
PHARMACIA, INC.	PISCATAWAY	NJ
PHILIPS ROXANNE, INC.	ST. JOSEPH	MO
PIERCE CHEMICAL COMPANY	ROCKFORD	IL
PITMAN-MOORE, INC.	WASHINGTON CROSSING	NJ
PRALEX CORPORATION	ST. CROIX	VI
PREMO PHARMACEUTICAL LABS., INC.	SOUTH HACKENSACK	NJ
PRIVATE FORMULATIONS, INC.	EDISON	NJ
RACHELLE LABORATORIES, INC.	LONG BEACH	CA
RECSEI LABORATORIES	GOLETA	CA
REED AND CARNRICK, INC.	KENILWORTH	NJ
REID-PROVIDENT LABORATORIES, INC.	ATLANTA	GA
REXALL DRUG COMPANY	ST. LOUIS	MO
REXAR PHARMACAL CORPORATION	VALLEY STREAM	NY
RHONE-POULENC, INC.	NEW BRUNSWICK	NJ
RHONE-POULENC: HESS AND CLARK DIV.	ASHLAND	OH
RIKER LABORATORIES, INC.	NORTHRIDGE	CA
ROEHR CHEMICALS COMPANY	LONG ISLAND CITY	NY
RUETGERS-NEASE CHEMICAL COMPANY	STATE COLLEGE	PA
RYSTAN COMPANY, INC.	LITTLE FALLS	NJ
SCHOLL, INC.	CHICAGO	IL
SCHUYLKILL CHEMICAL COMPANY	PHILADELPHIA	PA
SEIN/MENDEZ LABORATORIES	RIO PIEDRAS	PR
SHELL CHEMICAL COMPANY	DENVER	CO
SHERWOOD LABORATORIES, INC.	EASTLAKE	OH
SINCLAIR PHARMACAL COMPANY, INC.	FISHERS ISLAND	NY
SOUTHLAND CORPORATION	GREAT MEADOWS	NJ
STANBACK COMPANY, LTD.	SALISBURY	NC
STANLABS PHARMACEUTICAL COMPANY	PORTLAND	OR
STIEFEL LABORATORIES, INC.	OAK HILL	NY
SUPPOSITORIA LABORATORIES, INC.	FARMINGDALE	NY
SYNTEX AGRI-BUSINESS, INC.	SPRINGFIELD	MO
SYNTEX AGRI-BUSINESS, INC.	VERONA	MO
SYNTEX (F.P.), INC.	HUMACAO	PR
TABLICAPS, INC.	FRANKLINVILLE	NJ
TAYLOR PHARMACAL COMPANY	DECATUR	IL
TENNESSEE EASTMAN COMPANY	KINGSPORT	TN
THOMPSON-HAYWARD CHEMICALS	KANSAS CITY	KS
TRUETT LABORATORIES	DALLAS	TX
UPSHER SMITH LABORATORIES	MINNEAPOLIS	MN
V. K. BHAT	EVERETT	WA
VALE CHEMICAL COMPANY, INC.	ALLENTOWN	PA
VINELAND LABORATORIES, INC.	VINELAND	NJ
VINELAND/EVSCO, INC.	BUENA	NJ
VIOBIN CORPORATION	MONTICELLO	IL

PHARMACEUTICAL MANUFACTURING PLANTS IN THE SUPPLEMENTAL 308 DATA BASE

NAME	LOCATION	
VISTA LABORATORIES, INC.	ST. CROIX	VI
VITA-FORE PRODUCTS COMPANY	OZONE PARK	NY
VITAMINS, INC.	CHICAGO	IL
VITARINE COMPANY, INC.	SPRINGFIELD GARDENS	NY
W. F. YOUNG, INC.	SPRINGFIELD	MA
WALGREEN LABORATORIES, INC.	CHICAGO	IL
WATKINS,INC	WINONA	MN
WEST ARGO-CHEMICALS, INC.	EIGHTY FOUR	PA
WEST ARGO-CHEMICALS, INC.	KANSAS CITY	MO
WEST-WARD, INC.	EATONTOWN	NJ
WESTERN RESEARCH LABORATORIES	DENVER	CO
WESTWOOD PHARMACEUTICALS, INC.	BUFFALO	NY
WHITEHALL LABORATORIES	ELKHART	IN
WHITEWORTH, INC.	GARDENA	CA
WHORTON PHARMACEUTICALS, INC.	FAIRFIELD	AL
WILLIAM T. THOMPSON COMPANY	CARSON	CA
WORTHINGTON DIAGNOSTICS	FREEHOLD	NJ
XTTRIUM LABORATORIES, INC.	CHICAGO	IL
YAGER DRUG COMPANY	BALTIMORE	MD
ZENITH LABORATORIES, INC.	NORTHVALE	NJ

TOTAL NUMBER OF MFG. PLANTS IN THE SUPPLEMENTAL 308 DATA BASE: 220

APPENDIX E

GENERAL PLANT INFORMATION

APPENDIX E
PHARMACEUTICAL INDUSTRY
GENERAL PLANT INFORMATION

Plant Code No.	Subcategories	Average Employment(1)	Start-Up Year(2)
12000	D	2200	1965
12001	D	380	1959
12003	A C D	5930	1931
12004	C D	72	1972
12005	B	10	1971
12006	D	54	1963
12007	D	1710	1933
12011	A B D	224	1968
12012	B D	3540	1947
12014	B	N/A	1977
12015	D	365	1960
12016	D	132	1968
12018	A C D	210	1916
12019	D	850	1960
12021	D	39	1973
12022	A C	176	1951
12023	D	442	1967
12024	D	1240	1920
12026	C	30	1950
12030	D	200	1966
12031	D	60	1897
12035	D	208	1972
12036	A	184	1948
12037	C D	1118	1937
12038	A B C D	1053	1954
12040	B D	433	1967
12042	A B D	183	1974
12043	C	14	1973
12044	A D	873	1938
12048	C D	425	1951
12051	D	19	1963
12052	C D	503	1971
12053	D	250	1963
12054	D	350	1958
12055	D	100	1956
12056	D	200	1971
12057	C D	750	1934
12058	D	100	1955
12060	D	546	1962
12061	B	152	1967
12062	C D	300	1950
12063	N/A	313	1974
12065	D	980	1960
12066	B C D	666	1953
12068	D	17	1934
12069	D	176	1964
12073	C	6	1961
12074	D	220	1897
12076	D	50	1972
12077	C D	493	1970

APPENDIX E (cont'd)
PHARMACEUTICAL INDUSTRY
GENERAL PLANT INFORMATION

Plant Code No.	Subcategories	Average Employment(1)	Start-Up Year(2)
12078	D	N/A	1977
12080	D	1640	1948
12083	D	190	1972
12084	B C D	275	1958
12085	D	74	N/A
12087	C	90	1957
12088	D	250	1950
12089	B D	32	1914
12093	C D	560	1948
12094	D	135	1967
12095	C D	102	1947
12097	C D	160	1951
12098	D	54	1975
12099	D	75	1970
12100	C D	17	N/A
12102	C D	265	N/A
12104	D	1415	1951
12107	B D	105	1923
12108	A C D	372	1974
12110	D	10	1974
12111	B D	444	1949
12112	C	12	1959
12113	D	922	1962
12115	A B D	271	1963
12117	B D	455	1882
12118	D	280	1972
12119	A D	N/A	1977
12120	D	22	1974
12122	D	6	1937
12123	C D	277	1937
12125	D	32	1974
12128	D	24	N/A
12129	D	615	1975
12131	D	32	1970
12132	A C	383	1941
12133	D	10	1969
12135	B C D	875	1896
12141	D	112	1971
12143	D	175	1924
12144	D	20	1972
12145	D	18	1972
12147	D	231	1965
12155	C D	1668	1849
12157	D	8	1973
12159	C D	356	1942
12160	D	215	1974
12161	A C D	905	1969
12166	D	90	1974
12168	A B C D	250	1938
12171	B C D	70	1970

APPENDIX E (cont'd)
PHARMACEUTICAL INDUSTRY
GENERAL PLANT INFORMATION

Plant Code No.	Subcategories	Average Employment(1)	Start-Up Year(2)
12172	D	34	1974
12173	B	3	1940
12174	D	75	1939
12175	D	66	1975
12177	D	70	1960
12178	B D	40	1962
12183	B	270	1903
12185	B C	26	1941
12186	C D	051	1976
12187	C	0632	1949
12191	A B C	450	N/A
12194	D	20	1973
12195	C	N/A	1975
12198	B D	70	1949
12199	A C D	2061	1946
12201	D	N/A	N/A
12204	A B C D	2000	1907
12205	D	300	1968
12206	D	220	1971
12207	D	55	1962
12210	B C	190	1973
12211	C	22	1976
12212	D	212	1976
12217	D	140	1975
12219	D	544	1964
12224	D	1333	1915
12225	D	22	1972
12226	B	124	1973
12227	D	25	1963
12230	B	20	1969
12231	A D	685	1968
12233	D	341	1895
12235	C	84	1971
12236	C	250	1952
12238	D	42	1976
12239	D	46	1973
12240	C D	53	1972
12243	D	70	1973
12244	C	224	1947
12245	A B C	230	1951
12246	C D	716	1948
12247	C	6	1969
12248	D	810	1961
12249	D	115	1968
12250	D	259	1940
12251	D	53	1968
12252	A C D	1400	1939
12254	A D	444	1971
12256	A B C D	1239	1948
12257	A B C D	4600	1922

APPENDIX E (cont'd)
PHARMACEUTICAL INDUSTRY
GENERAL PLANT INFORMATION

Plant Code No.	Subcategories	Average Employment(1)	Start-Up Year(2)
12260	D	176	1943
12261	C	128	1966
12263	D	28	1973
12264	A B D	4450	1910
12265	B D	65	1965
12267	D	122	1969
12268	D	112	1974
12269	D	135	1957
12273	D	14	1975
12275	B C	1297	1925
12277	D	15	1965
12281	D	303	1957
12282	B C D	85	1900
12283	D	37	1972
12287	D	3112	1964
12289	D	31	N/A
12290	D	59	1975
12294	C D	332	1969
12295	B D	8	1925
12296	D	685	N/A
12297	D	70	1972
12298	D	88	1962
12300	B	410	1953
12302	C	144	1901
12305	D	174	1971
12306	D	4	1976
12307	D	151	1975
12308	D	1052	N/A
12309	B C	30	1967
12310	C D	170	1970
12311	A B C D	1008	1953
12312	B D	693	1873
12317	D	2387	1972
12318	D	210	1960
12322	D	98	1969
12326	D	60	1975
12330	A B C D	2438	1906
12331	D	374	1967
12332	C	N/A	N/A
12333	C D	198	1970
12338	D	150	1974
12339	A C D	555	1970
12340	D	1595	1957
12342	A C D	377	1944
12343	A C D	166	1967
12345	D	389	1963
12375	B	91	1953
12384	B	35	1970
12385	D	60	1966
12392	D	110	1959

APPENDIX E (cont'd)
PHARMACEUTICAL INDUSTRY
GENERAL PLANT INFORMATION

Plant Code No.	Subcategories	Average Employment(1)	Start-Up Year(2)
12401	A D	1324	1968
12405	C D	85	1964
12406	C	163	1948
12407	C	67	1904
12409	D	18	1920
12411	B C D	750	1970
12414	D	627	1951
12415	D	450	1968
12417	D	10	1950
12419	B D	123	1969
12420	B D	160	1973
12427	D	579	1958
12429	D	51	1886
12433	D	180	1953
12438	D	560	1964
12439	C D	115	1974
12440	D	235	1965
12441	C	1108	1923
12444	D	78	1977
12447	A B C D	4095	1948
12454	B D	710	1947
12458	C D	120	1968
12459	D	4	1977
12460	B D	70	1975
12462	A	25	1972
12463	B D	224	1926
12464	D	4	N/A
12465	D	315	1967
12466	B	18	1958
12467	B	67	1959
12468	D	628	1947
12470	A	14	1967
12471	B	328	1972
12472	B C	44	1971
12473	B C	242	1947
12474	D	64	1969
12475	C	153	1966
12476	D	55	1967
12477	B C	298	1867
12479	B	5	1977
12481	D	N/A	1918
12482	N/A	N/A	N/A
12495	D	130	1959
12499	D	1150	1961
20006	D	2	
20008	B D	20	See Footnote #2
20012	C	4	
20014	D	210	
20015	D	45	
20016	D	4	

APPENDIX E (cont'd)
PHARMACEUTICAL INDUSTRY
GENERAL PLANT INFORMATION

Plant Code No.	Subcategories	Average Employment(1)	Start-Up Year(2)
20017	D	13	See Footnote #2
20020	D	68	
20026	D	3	
20030	C D	1	
20032	B D	79	
20033	C D	38	
20034	D	14	
20035	C	25	
20037	D	1	
20038	D	81	
20040	B	12	
20041	D	20	
20045	D	12	
20048	D	10	
20049	D	31	
20050	A B	31	
20051	D	6	
20052	D	30	
20054	D	21	
20055	D	4	
20057	D	30	
20058	D	15	
20062	D	35	
20064	D	16	
20070	D	150	
20073	D	2	
20075	D	4	
20078	D	1	
20080	D	35	
20081	D	14	
20082	C D	6	
20084	D	75	
20087	D	10	
20089	D	55	
20090	D	40	
20093	D	3	
20094	D	2	
20099	D	5	
20100	D	34	
20103	D	3	
20106	D	3	
20108	D	62	
20115	D	7	
20117	D	127	
20120	D	14	
20125	D	50	
20126	D	12	
20134	C D	6	
20139	C D	40	
20141	D	6	

APPENDIX E (cont'd)
PHARMACEUTICAL INDUSTRY
GENERAL PLANT INFORMATION

Plant Code No.	Subcategories	Average Employment(1)	Start-Up Year(2)
20142	D	70	See Footnote #2
20147	D	15	
20148	D	15	
20151	B C D	6	
20153	D	10	
20155	D	20	
20159	B C	22	
20165	B C	10	
20169	D	30	
20173	C	3	
20174	D	6	
20176	D	2	
20177	C	5	
20178	D	12	
20187	D	10	
20188	D	200	
20195	D	100	
20197	D	3	
20201	D	8	
20203	C	93	
20204	C D	84	
20205	C	37	
20206	C	49	
20208	D	2	
20209	D	12	
20210	D	3	
20215	D	13	
20216	D	6	
20218	C	15	
20220	D	20	
20224	D	6	
20225	D	65	
20226	D	22	
20228	D	2	
20229	D	86	
20231	D	20	
20234	C	N/A	
20235	D	7	
20236	D	120	
20237	B	28	
20240	C	20	
20241	D	31	
20242	C D	10	
20244	C	1	
20245	A C	59	
20246	C	171	
20247	B	25	
20249	C	3	
20254	C	3	
20256	D	90	

APPENDIX E (cont'd)
PHARMACEUTICAL INDUSTRY
GENERAL PLANT INFORMATION

Plant Code No.	Subcategories	Average Employment(1)	Start-Up Year(2)
20257	C	60	See Footnote #2
20258	C D	20	
20261	D	15	
20263	D	2	
20264	D	11	
20266	D	13	
20267	D	116	
20269	D	10	
20270	D	6	
20271	D	6	
20273	D	70	
20282	D	2	
20288	D	38	
20294	B	9	
20295	D	53	
20297	C	10	
20298	C	N/A	
20300	D	40	
20303	B	1	
20305	D	19	
20307	B	29	
20308	D	3	
20310	C	15	
20311	C	15	
20312	B C D	44	
20316	D	60	
20319	D	272	
20321	D	100	
20325	D	5	
20328	D	10	
20331	C	60	
20332	C	24	
20333	D	3	
20338	D	130	
20339	D	4	
20340	C	4	
20342	C	35	
20346	B C	60	
20347	D	1	
20349	C	50	
20350	C D	20	
20353	B C	35	
20355	C	25	
20356	C D	2	
20359	B D	16	
20361	A	N/A	
20362	C D	4	
20363	A C D	N/A	
20364	B D	9	
20366	B C D	315	

APPENDIX E (cont'd)
PHARMACEUTICAL INDUSTRY
GENERAL PLANT INFORMATION

Plant Code No.	Subcategories	Average Employment(1)	Start-Up Year(2)
20370	B C	45	See Footnote #2
20371	D	3	
20373	C	N/A	
20376	D	15	
20377	C D	3	
20385	D	240	
20387	C	7	
20389	C	40	
20390	D	40	
20394	B D	4	
20396	C D	4	
20397	C D	18	
20400	D	N/A	
20402	D	65	
20405	D	21	
20413	D	3	
20416	D	25	
20421	D	2	
20423	D	85	
20424	C D	60	
20425	D	2	
20435	C D	2	
20436	D	80	
20439	D	200	
20440	D	11	
20441	D	25	
20443	B D	3	
20444	D	5	
20446	D	3	
20448	D	6	
20450	D	15	
20452	D	7	
20453	D	20	
20456	D	6	
20460	D	4	
20462	D	2	
20464	D	4	
20465	D	240	
20466	D	110	
20467	B D	3	
20470	D	1	
20473	B	150	
20476	D	50	
20483	D	2	
20485	D	30	
20486	D	5	
20490	D	250	
20492	C D	3	
20494	D	65	
20496	D	12	

APPENDIX E (cont'd)
PHARMACEUTICAL INDUSTRY
GENERAL PLANT INFORMATION

Plant Code No.	Subcategories	Average Employment(1)	Start-Up Year(2)
20498	D	2	
20500	D	31	See Footnote No. 2
20502	D	3	
20503	D	1	
20504	D	2	
20507	D	3	
20509	D	33	
20511	D	8	
20518	D	5	
20519	D	13	
20522	D	6	
20526	C D	18	
20527	D	24	
20529	D	2	

(1) Average employment for orignal 308 (12000 series) plants is for 1976; for Supplemental 308 (20000 series) plants it is 1978.

(2) Data on year of operational start-up was not requested of the Supplemental 308 (20000 series) plants.

APPENDIX F

SCREENING/VERIFICATION PRIORITY AND TRADITIONAL POLLUTANT DATA

SCREENING PROGRAM

SUMMARY OF PLANT
12015

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter	
	Influent	Effluent
Acid Extractables		
Pentachlorophenol	62	-
Phenol	8	-
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	170	30
Di-N-Butyl Phthalate	20	3
Volatile Organics		
Benzene	79	-
Chloroform	300	14
Methylene Chloride	470	12
Ethyl Benzene	11	-
Toluene	900	3
Tetrachloroethylene	36	-
1,2 - Dichloroethane	19	-
Trichloroethylene	6	-
Metals		
Cu Copper	80	20
Cr Chromium	30	10
Zn Zinc	L60	100
Cd Cadmium	L2	4
Ni Nickel	L5	L5
Ag Silver	L1	L1

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Primary Sedimentation
Activated Sludge with Powdered Activated Carbon
Secondary Chemical Flocculation/Clarification
Gravity Dewatering
Aerobic Digestion
Landfill

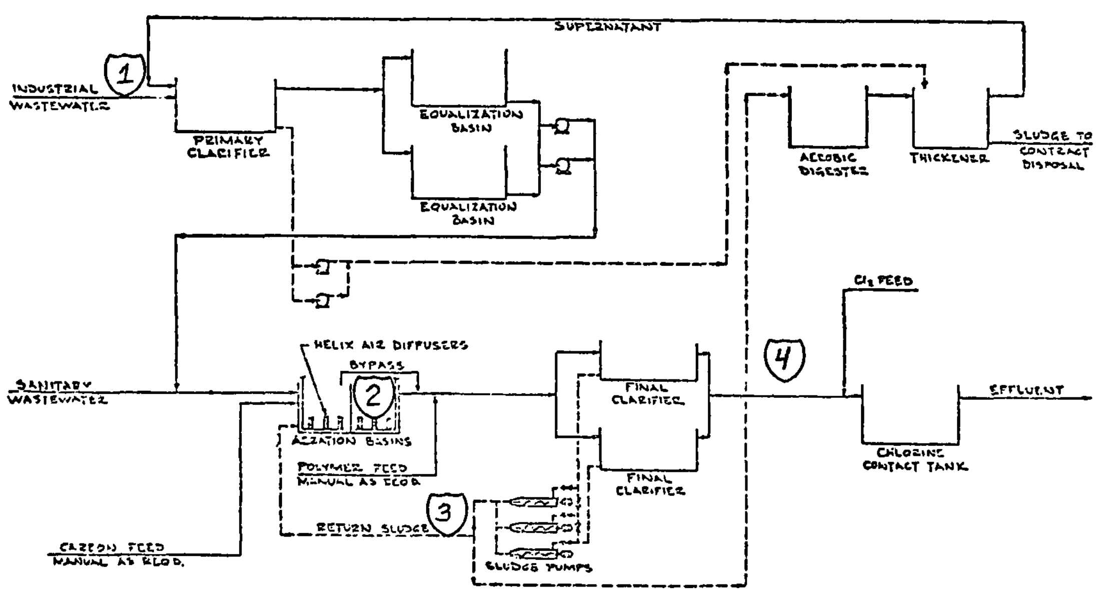
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
D	0.08	300-400

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
Unk.	Unk.	--	Unk.	Unk.	--	Unk.	0	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



NOTE:
ALL FLOW RATES ARE DESIGN AVERAGE.

SAMPLING PROGRAM

Sample Location	No. of Samples
1. Influent to primary clarifier	4
2. XAD-2 resin	4
2. Tenax column	4
3. Return sludge	4
4. Clarifier effluent	4

SCREENING PROGRAM

SUMMARY OF PLANT
12022

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
2,4,6 - Trichlorophenol	20	L10
2 - Chlorophenol	50	-
2,4 - Dichlorophenol	L10	L10
Phenol	1400	-
Base Neutral Extractables		
1,2 - Dichlorobenzene	20	-
1,4 - Dichlorobenzene	90	
Bis (2-ethylhexyl) phthalate		L10
Di-n-butyl phthalate	-	L10
Volatile Organics		
Benzene	120	-
Chloroform	80	L10
Methylene Chloride	170	L10
Ethyl Benzene	20	-
Chlorobenzene	6400	-
1,2 - Dichloroethane	11000	500
Toluene	11000	-
Trichloroethylene	L10	-
Metals		
Hg Mercury	1.40	1.00
Cu Copper	70	20
Ni Nickel	510	310
Cr Chromium	125	75
Cd Cadmium	3	1
Ag Silver	3	2
Zn Zinc	480	100
Sb Antimony	L50	L50
As Arsenic	L50	L50
Pb Lead	L20	L20
Se Selenium	L50	L50
Tl Thallium	L50	L50
Cyanide	500	330

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Coarse Settleable Solids Removal
Primary Sedimentation
Activated Sludge
Trickling Filter
Mechanical Thickening
Chemical Conditioning
Vacuum Dewatering
Incineration
Landfill

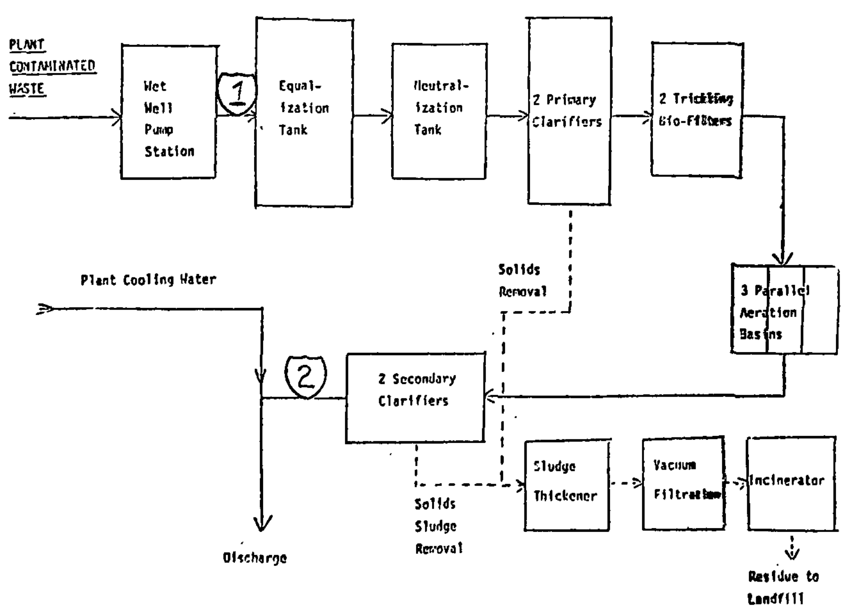
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,C	1.30	100-200

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l) Inf.	Eff.	% Rem.	COD (mg/l) Inf.	Eff.	% Rem.	TSS (mg/l) Inf.	Eff.	% Rem.
1428	39	97.3	Unk.	Unk.	--	Unk.	60	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

Sample Location	No. of Samples
1. Influent to biological treatment	2
2. Final effluent before dilution	2
Potable water	1

SCREENING PROGRAM

SUMMARY OF PLANT
12026

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
2,4,6 - Trichlorophenol	13	-
Phenol	64	6
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	11	15
Napthalene	10	-
Di-N-Butyl Phthalate	-	7
Volatile Organics		
Carbon Tetrachloride	11000	-
Chloroform	3170	8
Ethyl Benzene	130	
Toluene	470	
1,2 - Dichloroethane	17	-
Benzene	7	-
Metals		
Cu Copper	41	8
Cr Chromium	11	4
Zn Zinc	120	71
Hg Mercury	0.79	0.20
Sb Antimony	L5	L5
As Arsenic	L20	L20
Cd Cadmium	L1	L1
Pb Lead	L10	L10
Ni Nickel	L4	L4
Se Selenium	L20	L20
Ag Silver	L3	L3
Tl Thallium	L8	L8
Cyanide	1980	63

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Activated Sludge
Aerated Lagoon
Polishing Pond
Anaerobic Digestion

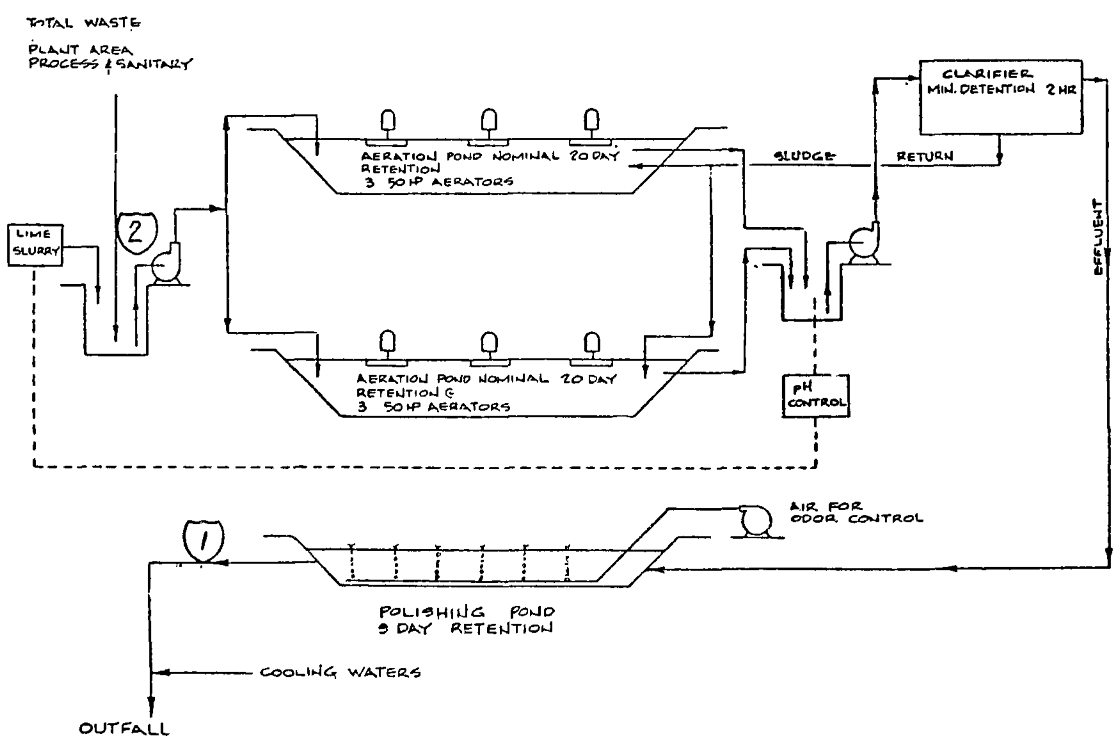
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
C	0.08	0-100

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
1418	348	75.5	2375	160	93.3	621	118	81.0

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

Sample Location	No. of Samples
1 - Discharge from Treatment Plant	5
2 Influent to Neutralization Building	5
Lab and Sanitary Waste	5
Concentrated Waste Building	3
Animal and Sanitary Waste	5
Well #1	2
Well #2	2
Well #3	2

APPENDIX F

VERIFICATION PROGRAM
ANALYTICAL RESULTS
PLANT 12026

	Concentration		Pollutant Loading	
	Influent (ug/Liter)	Effluent (ug/Liter)	Influent (kg/day)	Effluent (kg/day)
Priority Pollutants				
Volatile Organics				
Acid Extractables				
Base/Neutral Extractables				
Metals				
Pesticides				
Cyanides				
Asbestos	(Verification program did not analyze for this compound)			
Conventional				
Non-Conventional				

Note: Due to other laboratory commitments, the analytical data for this plant was not available at the time this document was published.

SCREENING PROGRAM

SUMMARY OF PLANT
12036

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
Phenol	74	L10
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	160	68
Di-N-Butyl Phthalate	56	15
Diethyl Phthalate	-	15
1,2 - Diphenylhydrazine	-	L10
Fluoranthene	-	L10
Nitrobenzene	L10	-
Diethyl Phthalate	L10	-
Volatile Organics		
Benzene	260	120
Carbon Tetrachloride	18	16
Chloroform	180	110
Methylene Chloride	6200	2600
Ethyl Benzene	18	22
Toluene	310	180
1,1,1 - Trichloroethane	22	11
1,1 - Dichloroethylene	230	180
Trichlorofluoromethane	970	420
Tetrachloroethylene	14	18
Trichloroethylene	L10	L10
Chlorobenzene	L10	-
Bromoform	L10	
Metals		
Hg Mercury	1.20	0.70
Cu Copper	73	9
Cr Chromium	16	10
Zn Zinc	251	100
Tl Thallium	18	11
As Arsenic	L50	11
SB Antimony	L20	L20
Cd Cadmium	L1	L1
Pb Lead	L5	L5
Ni Nickel	L10	L10
Se Selenium	L200	L20
Ag Silver	L1	L1
Cyanide	280	30

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Activated Sludge
Trickling Filter
Aerated Lagoon
Waste Stablization Pond
Polishing Pond
Aerobic Digestion
Cropland Use

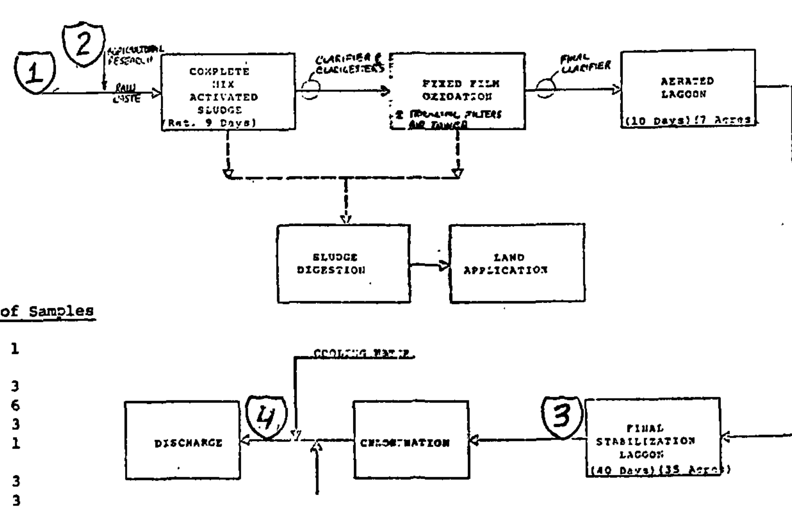
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,D	1.20	100-200

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
1900	35	98.2	4210	262	93.8	840	49	94.2

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

Sample Location	No. of Samples
1 - Influent to Wastewater Treatment System at Manhole M-5	1
2 - Agricultural Research Farm Discharge to the WTP	3
3 - Pond 4 Effluent Before Chlorination	6
4 - 001 Discharge	3
Raw Water Supply	1
Process Waste Discharge from Penicillin Packaging Operation-Manhole 12A	3
Combined Process Wastestream at Manhole M-7	3

SCREENING PROGRAM

SUMMARY OF PLANT
12038

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
Pentachlorophenol	11	-
Phenol	3100	L10
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	52	L10
1,4 - Dichlorobenzene	10	-
1,2 - Dichlorobenzene	290	-
Volatile Organics		
Benzene	380	44
Carbon Tetrachloride	50	L10
Chloroform	130	56
Methylene Chloride	4800	Very high
Ethyl Benzene	1600	160
Toluene	560	Very high
Chlorobenzene	19	-
1,1 - Dichloroethylene	190	90
Trichlorofluoromethane	620	280
Trichloroethylene	2100	L10
1,2 - Dichloroethane	3000	65
Metals		
Hg Mercury	9.60	0.40
Cu Copper	3110	63
Cr Chromium	160	26
Zn Zinc	390	63
Tl Thallium	234	-
Se Selenium	860	300

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Fermentation Waste Treatment System
Equalization
Neutralization
Coarse Settleable Solids Removal
Primary Sedimentation
Activated Sludge
Centrifugal Dewatering
Anaerobic Digestion
Landfill

Thermal Oxidation System
Equalization
Neutralization
Thermal Oxidation

Chem. Waste Treatment System
Equalization
Neutralization
Coarse Settleable Solids Removal
Primary Sedimentation
Primary Chemical Flocculation/ Clarification
Aerated Lagoon
Centrifugal Dewatering
Anaerobic Digestion
Landfill

Pretreatment System
In-Plant Treatment
Heat Conditioning

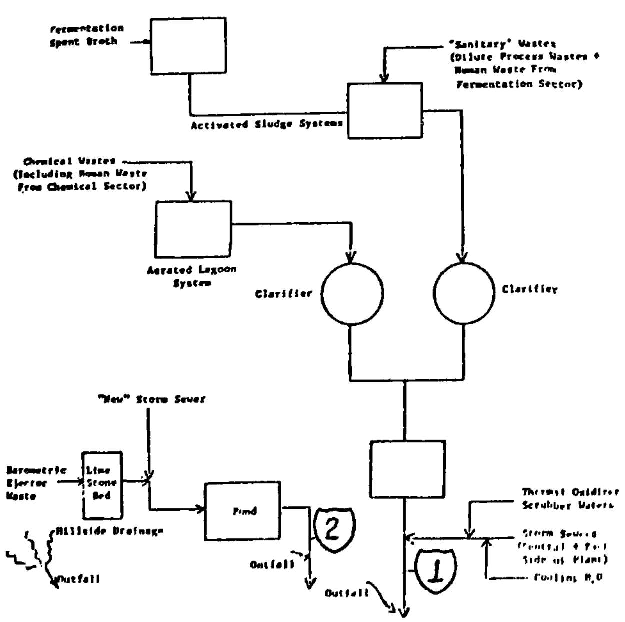
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,B,C,D	1.00	1000-1100

PERFORMANCE OF TREATMENT SYSTEM

	BOD (mg/l) Inf.	Eff.	% Rem.	COD (mg/l) Inf.	Eff.	% Rem.	TSS (mg/l) Inf.	Eff.	% Rem.
Fermentation Waste Treatment System	Unk.	180	--	Unk.	2080	--	Unk.	244	--
Chemical Waste Treatment System	Unk.	196	--	Unk.	1856	--	Unk.	69	--
Pretreatment System	Unk.	Unk.	--	Unk.	Unk.	--	Unk.	Unk.	--
Thermal Oxidation System	Unk.	Unk.	--	Unk.	Unk.	--	Unk.	Unk.	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

Sample Location	No. of Samples
1. 001 Discharge	4
2. Combined effluent from limestone bed and hillside storm sewer	3
3. Building T-17 process waste discharge	3
4. Chemical synthesis influent, T302 to T303	3
5. Influent to T307B (clarifier)	1
6. Process waste line feeding lagoon T-310 from Building T-66	1
7. Clarifier T-312 effluent	3
8. Concentrated antibiotic waste - influent to biological treatment	1
9. Dilute antibiotic waste influent to T201	3
10. Clarifier T-212 effluent	
Storm sewer	3
Combined raw water supply	1

APPENDIX F
VERIFICATION PROGRAM
ANALYTICAL RESULTS
PLANT 12038

	INFLUENT								EFFLUENT	
					From Fermentation Operations					
	From Other Operations		From Chemical Operations		Spent Beer		Dilute Wastes			
	Apparent Concentration (ug/Liter)	Pollutant Loading (kg/Day)	Apparent Concentration (ug/Liter)	Pollutant Loading (kg/Day)	Apparent Concentration (ug/Liter)	Pollutant Loading (kg/Day)	Apparent Concentration (ug/Liter)	Pollutant Loading (kg/Day)	Apparent Concentration (ug/Liter)	Pollutant Loading (kg/Day)
Priority Pollutants										
Volatile Organics										
Benzene	10	.001- .0027	100-10,300	.09-9.74					10	.275
1,2-Dichloroethane	10-30	.001- .0079	3,500-14,000	3.31-13.2					22-44	.605-1.21
Chloroform	10	.001- .0027	160-690	.151-.653					10	.275
1,1-Dichloroethylene	10	.001- .0027	10-20	.009					10	.275
1,2-Trans-Dichloroethylene	10-105	.001- .011	10	.009					10	.275
Ethylbenzene	10	.001- .0027	5,600-42,000	5.30-39.7					10	.275
Methylene Chloride	10-560	.001- .148	6,400-16,000	6.05-15.1					16-26	.44-.715
Toluene	10	.001- .0027	26,000-227,000	24.6-215					10	.275
Monochlorobenzene	10	.001- .0027	100-123,000	.09-116					10	.275
Acid Extractables										
Phenol	10-50	.0023-.0068	3,500-6,400	3.31-6.05						
2-Chlorophenol	10-50	.0023-.0056	10-25	.009-.024						
Pentachlorophenol	10	.0027								
Phenol (4 AAP)	81-279	.009-.075	21,500-48,500	20.3-45.9					20-23	.55-.63
Base/Neutral Extractables										
Pesticides										
Product X	13,000-17,000	3.03-4.49	1	.0009					1-1.9	.028-.05
Dipropylnitrosoamine	170-5,500	.04-1.5	5	.0047					1- 2	.028-.05
Metals										
Chromium	49-180	.0067-.019	37-126	.035-.119					60-81	1.65-2.23
Copper	40-115	.004-.018	5,170-6,670	4.89-6.65					57-61	1.65-1.68
Mercury	1	.0001-.0002	1-15	.0009-.0142					1	.0275
Zinc	50-202	.006-.055	313-2,690	.296-2.54					68-82	1.87-2.26
Cyanide	104,00-135,000	11.1-15			32-136	.036-.159	10-32	.011-.031	56-85	1.54-2.34
Asbestos	(Verification program did not analyze for this compound)									
Conventionals (concentrations in mg/l)										
BOD_5			3,790-9,300	3,590-8,800	9,900-10,500	11,600-11,900	674-1,210	745-946	21-46	578-1,270
TSS			892-2,140	844-2,020	1,210-1,430	1,410-1,730	548-1,100	524-1,070	28-46	770-1,270
Non-Conventionals (concentrations in mg/l)										
COD	4,390-7,130	696-1,640	9,800-21,000	9,440-19,800	17,100-20,300	20,700-22,900	1,520-2,200	1,450-1,840	216-274	5,940-7,540
NH_3-N					78-128	91.3-145	2.3-21.8	2.24-24.1	23.7-25	652-688

SCREENING PROGRAM

SUMMARY OF PLANT
12044

SUMMARY OF SCREENING DATA

No Treatment	Concentration, Micrograms/Liter	
	Influent	Effluent
Acid Extractables		
None	N/A	-
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	N/A	10
Di-N-Butyl Phthalate	-	L10
Diethyl Phthalate		L10
Volatile Organics		
Methylene Chloride	N/A	16
Ethylbenzene	N/A	21
Chlorobenzene	N/A	11
1,1,1 - Trichloroethane	N/A	22
Bromoform	N/A	12
1,1,2,2 - Tetrachloroethane		L10
Chloroform	-	L10
Tetrachloroethylene	-	L10
Toluene	-	L10
Metals		
Sb Antimony	N/A	210
Cr Chromium	N/A	102
Cu Copper	N/A	148
Pb Lead	N/A	30
Hg Mercury	N/A	0.10
Ni Nickel	N/A	23
Ag Silver	N/A	4
Zn Zinc	N/A	254
As Arsenic	-	L20
Cd Cadmium		L2
Se Selenium	-	L2
Tl Thallium	-	L100
Cyanide	N/A	7

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Neutralization

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,D	0.13	800-900

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
N/A	1425	--	N/A	3390	--	N/A	--	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM

NOT APPLICABLE

SAMPLING PROGRAM

Sample Location	No. of Samples
Citric Acid Effluent After Lime Neutralization-#81 Manhole	5
Effluent At #83 Manhole	4
Effluent At #37A Manhole	4
Effluent At #6 Manhole	4
Effluent At #74 Manhole	4

SCREENING PROGRAM

SUMMARY OF PLANT

12Q06

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
4,6 - Dinitro-O-Cresol	-	15
Phenol	45	L10
2,4 - Dichlorophenol	-	L10
Pentachlorophenol		L10
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	130	44
1,2 - Dichlorobenzene	12	
N-Nitrosodiphenylamine	12	-
1,2 - Diphenylhydrazine	L10	-
Fluoranthene	L10	-
Naphthalene	-	L10
Di-N-Butyl Phthalate		L10
Diethyl Phthalate	L10	-
Anthracene	L10	
Phenanthrene	L10	-
Volatile Organics		
Chloroform	L51	L10
Methylene Chloride	35	31
Chloromethane	51	-
Benzene	L10	L10
Carbon Tetrachloride	L10	-
Chlorobenzene	L10	L10
1,2 - Dichloroethane	L10	L10
1,1,1 - Trichloroethane	L10	L10
1,1 - Dichloroethane		L10
1,2 - Dichloropropylene	-	L10
Ethylbenzene	L10	-
Bromomethane	L10	L10
Bromoform	L10	L10
Dichlorobromomethane	L10	-
Trichlorofluoromethane	L10	L10
Chlordibromomethane	L10	-
Tetrachloroethylene	L10	L10
Toluene	L10	L10
Trichloroethylene	L10	L10
Metals		
Hg Mercury	0.90	0.50
Cu Copper	22	41
Cr Chromium	136	166
Zn Zinc	191	254
Sb Antimony	28	9
As Arsenic	20	30
Se Selenium	16	30
Cd Cadmium	7	9
Pb Lead	L20	L20
Ni Nickel	L5	L5
Ag Silver	L1	L1
Tl Thallium	L50	L50
Cyanide	L5	L5

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Neutralization
Activated Sludge
Aerated Lagoon
Mechanical Thickening
Sludge to POTW

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
B,C,D	0.26	600-700

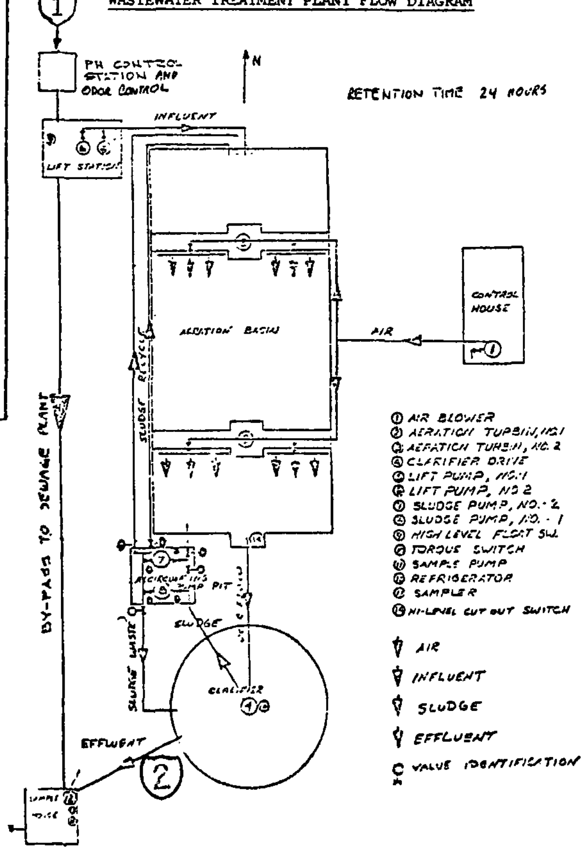
PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l) Inf.	Eff.	% Rem.	COD (mg/l) Inf.	Eff.	% Rem.	TSS (mg/l) Inf.	Eff.	% Rem.
500	98	80.4	757	687	9.2	Unk.	Unk.	--

SAMPLING PROGRAM

Sample Location	No. of Samples
1. Influent to Pretreatment Facility	5
2. Effluent from Pretreatment Facility	5

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SCREENING PROGRAM

SUMMARY OF PLANT
12097

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter (1) Influent	Effluent
Acid Extractables		
4-Nitrophenol	19	-
Base Neutral Extractables		
Acenaphthene	135	-
2,4 - Dinitrotoluene	32	-
Bis (2-Chloroisopropyl) Ether	38	-
Butylbenzl Phthalate	11	-
Diethyl Phthalate	10	-
Fluorene	11	-
Anthracene	L10	-
Phenanthrene	L10	-
Volatile Organics		
Benzene	19	-
1,1,1 - Trichloroethane	11	-
Methylene Chloride	160	-
Chlorobenzene	L10	-
Chloroform	L10	-
Ethylbenzene	L10	-
Trichlorofluoromethane	L10	-
Tetrachloroethylene	L10	-
Toluene	L10	-
Trichloroethylene	L10	-
Metals		
Cd Cadmium	6	L2
Cr Chromium	55	8
Cu Copper	154	13
Pb Lead	119	-
Hg Mercury	1.80	L0.10
Ni Nickel	31	L5
Zn Zinc	458	L60
Sb Antimony	L2000	L2
As Arsenic	L2000	L2
Se Selenium	L2000	L2
Ag Silver	L1	L1
Tl Thallium	L2000	L2
Cyanide	250	480

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Chemical Waste Treatment System
Equalization
Neutralization
Physical-Chemical Treatment
Filtration/Presses
Chemical Stabilization
Chemical Conditioning
Vacuum Dewatering
Landfill

Floor Wash Treatment System
Coarse Settleable Solids Removal
Activated Sludge with Powdered Activated Carbon
Physical-Chemical Treatment
Secondary Chemical Flocculation/Clarification
Chemical Stabilization
Chemical Conditioning
Vacuum Dewatering
Landfill

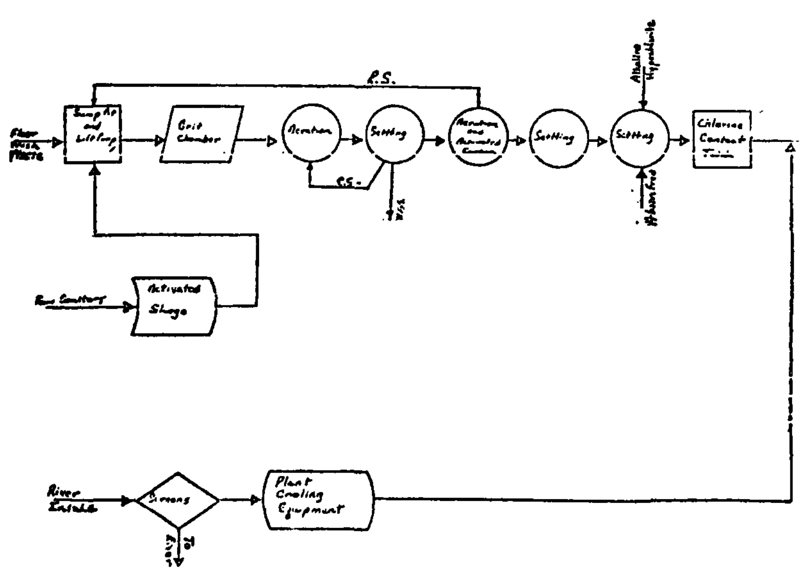
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
C,D	0.10	100-200

PERFORMANCE OF TREATMENT SYSTEM

	BOD (mg/l)			COD (mg/l)			TSS (mg/l)	
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
Floor Wash Treatment System								
1533	48	96.9	1460	240	83.6	262	5	98.1

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

Sample Location	No. of Samples
Raw Waste for Deep Well	2
Treated Waste for Deep Well	2
Raw Waste from Floor Drains	2
Treated Waste from Floor Drains	2
River Intake	2
Cooling Water Discharge	2
Well Water	1

APPENDIX F
VERIFICATION PROGRAM
ANALYTICAL RESULTS
PLANT 12097

	TAP WATER	WEAK CHEMICAL WASTE				STRONG CHEMICAL WASTE (Deep Well)			
		CONCENTRATION (ug/l)		POLLUTANT LOADING (kg/day)		CONCENTRATION (ug/l)		POLLUTANT LOADING (kg/day)	
	Concentration (ug/l)	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
Priority Pollutants									
Volatile Organics									
Benzene	4	15-180	3-6			15000-87000	1100-10000		
Toluene	3	90-6600	7-49			1400-130000	720-75000		
Acid Extractables									
Phenol	12	24-58	3-5			44-5700	140-4600		
Base/Neutral Extractables	--	--	--			--	--		
Pesticides	--	--	--			--	--		
Metals									
Antimony	1	2	1-2			1-2	1-2		
Arsenic	1	3-4	1			1-10	1-3		
Beryllium	1	1	1			1	1		
Cadimum	2	6-11	2			7-23	6-19		
Chromium	2	1-13	2			2-222	2-155		
Copper	3	244-336	3-22			431-922	562-665		
Lead	45	91-206	40-44			93-409	67-291		
Mercury	1	1	1			1-30	1-22		
Nickel	6	15-36	6			91-447	94-378		
Selenium	1	1-2	1-2			3-12	1-11		
Silver	1	1	1			1	1		
Thallium	1	1	1			1	1		
Zinc	1	134-397	1-154			254-540	308-687		
Cyanides	--	31-154	3			220-1090	69-5900		
Asbestos	(Verification program did not analyze for this compound)								
Conventionals (concentrations in mg/l)									
Oil and Grease	--	--	--			--	--		
BOD_5	--	1000-3973	186-240			16427-72320	37760-54400		
TSS	--	85-109	3.5-16			118-354	9-22		
Ph	--	7.1-7.3	7.1-7.6			5.0-6.7	4.6-6.6		
Non-Conventionals (concentrations in mg/l)									
TVSS		39-43	2-5			79-216	6-20		
TS	612	798-1234	1380-1662			19742-31148	20652-30364		
TVS	308	350-750	176-392			1596-3736	2068-3616		
TDS	609	689-1148	1377-1646			19624-30794	20634-30355		
TVDS	307	309-710	174-387			1517-3520	2582-3610		
SS		.25-7.5				.3-130	.1-.4		
COD		1762-4685	304-508			40000-92928	20200-78731		
TOC		511-665	80-150			13000-18000	14500-20200		
NH_3-N		1.18-4.31	.8-1.1			252-455	297-435		

SCREENING PROGRAM

SUMMARY OF PLANT
12108

SUMMARY OF SCREENING DATA

No Treatment	Concentration, Micrograms/Liter	
	Influent	Effluent
Acid Extractables		
Phenol	-	L10
Base Neutral Extractables		
None	N/A	-
Volatile Organics		
Benzene	N/A	390
Carbon Tetrachloride	N/A	300
Chloroform	N/A	1350
Methylene Chloride	N/A	200000
Toluene	N/A	53
1,1,1, - Trichloroethane	N/A	1300
1,1 - Dichloroethane	-	L10
Tetrachloroethylene	-	L10
Metals		
Cd Cadmium	N/A	32
Cr Chromium	N/A	107
Cu Copper	N/A	116
Pb Lead	N/A	286
Hg Mercury	N/A	50.10
Ni Nickel	N/A	137
Ag Silver	N/A	24
Zn Zinc	N/A	522
Cyanide		L2

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Neutralization

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,C,D	0.14	300-400

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
N/A	11300	--	N/A	25900	--	N/A	2640	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM

NOT APPLICABLE

SAMPLING PROGRAM

Sample Location	No. of Samples
Raw Process Wastewater	1

SCREENING PROGRAM

SUMMARY OF PLANT
12119

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
4- Nitrophenol	L42	L10
Pentachlorophenol	L10	-
Phenol	L10	-
Base Neutral Extractables		
Isophorone	11	-
Acenaphthene	2	-
Bis (2 Chloroisopropyl) Ether	448	
Butyl Benzyl Phthalate	18	
1,2 - Diphenylhydrazine	L10	-
Di-N-Butyl Phthalate	-	L10
Anthracene	L10	L10
Fluorene	L10	-
Phenanthrene	L10	L10
Volatile Organics		
Methylene Chloride	77	349
1,1,1 - Trichloroethane	L10	10
1,3 - Dichloropropene	100	-
Benzene	L10	
1,1,2 - Trichloroethane	L10	-
1,1,2,2 - Tetrachloroethane	L10	
Chloroform	L10	
Ethylbenzene	L10	-
Chloromethane	L10	
Tetrachloroethylene	L10	
Toluene	L10	-
Trichloroethylene	L10	
Metals		
Sb Antimony	40	
Cr Chromium	57	19
Cu Copper	93	39
Pb Lead	75	89
Hg Mercury	5.50	0.51
Ni Nickel	112	50
Sl Selenium	28	
Zn Zinc	1395	403
As Arsenic	L10	
Cd Cadmium	L10	L10
Ag Silver	L10	L10
Tl Thallium	-	L2
Cyanide	L2	2

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Coarse Settleable Solids Removal
Primary Sedimentation
Activated Sludge
Phys./Chem: Evaporation
Anaerobic Digestion
Drying Beds
Sludge to POTW

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,D	0.05	Unk.

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
833	10	98.8	1410	232	83.5	475	10	97.9

WASTEWATER TREATMENT PLANT FLOW DIAGRAM

Not available.

SAMPLING PROGRAM

Sample Location	No. of Samples
Raw process water	1
Process wastewater	1
Stripped wastewater	1
Influent to treatment	3
Effluent from treatment	3

SUMMARY OF PLANT
12132

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
2 - Nitrophenol	119	
Base Neutral Extractables		
None	-	-
Volatile Organics		
Benzene	4000	-
Chloroform	370	-
Methylene Chloride	11000	240
Ethyl Benzene	130	-
Toluene	50	-
1,2 - Dichloroethane	12	-
1,1,2,2 - Tetrachloroethane	20	
1,1, - Dichloroethane	5	-
1,1 - Dichloroethylene	3	-
Metals		
Cu Copper	200	-
Cr Chromium	200	-
Cd Cadmium	20	-
Pb Lead	200	-
Hg Mercury	0.70	
Ni Nickel	50	-
Ag Silver	10	-
Cyanide	1500	400

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Coarse Settleable Solids Removal
Primary Sedimentation
Primary Chemical Flocculation/Clarification
Activated Sludge
Trickling Filter
Waste Stablization Ponds
Flotation Thickening
Centrifugal Thickening
Centrifugal Dewatering
Incineration
Landfill

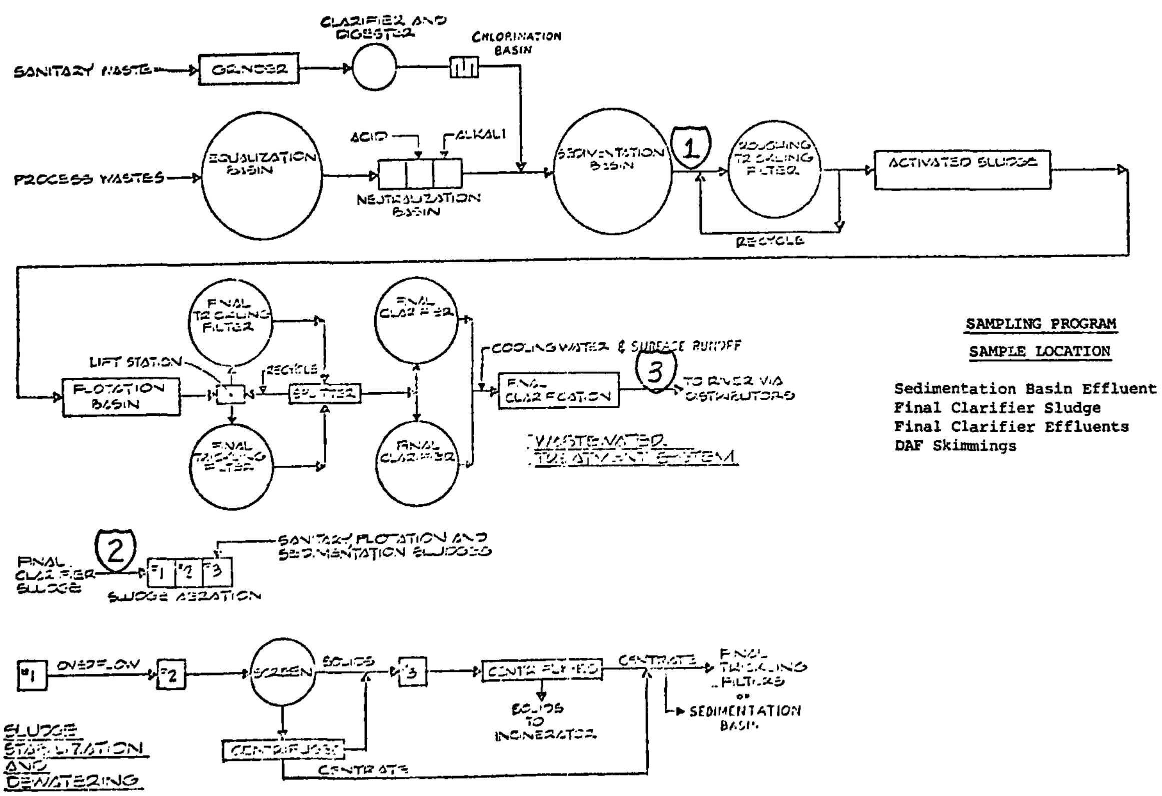
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,C	1.00	300-400

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l) Inf.	Eff.	% Rem.	COD (mg/l) Inf.	Eff.	% Rem.	TSS (mg/l) Inf.	Eff.	% Rem.
2083	251	88.0	4603	1686	63.4	620	120	80.6

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

SAMPLE LOCATION

1. Sedimentation Basin Effluent
2. Final Clarifier Sludge
3. Final Clarifier Effluents
DAF Skimmings

SCREENING PROGRAM

SUMMARY OF PLANT
12161

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
None	-	
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	39	
Volatile Organics		
Benzene	820	-
Chloroform	1050	3
Methylene Chloride	20	2
Toluene	10400	
1,1,1 - Trichloroethane	3	-
Ethylbenzene	8	
Acrolein	L100	L100
Metals		
Cu Copper	27	-
Ni Nickel	89	56
Pb Lead	46	L10
Cr Chromium	14	L2
Cd Cadmium	32	L1
Zn Zinc	250	16
Sb Antimony	24	L5
Ag Silver	4	L3
As Arsenic	L20	L20
Hg Mercury	L0.20	L0.20
Se Selenium	L20	L20
Tl Thallium	L8	L8
Cyanide	L40	L40

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Coarse Settleable Solids Removal
Primary Sedimentation
Primary Chemical Flocculation/Clarification
Activated Sludge
Polishing Ponds
Gravity Thickening
Aerobic Digestion
Composting

Landfill
Cropland Use

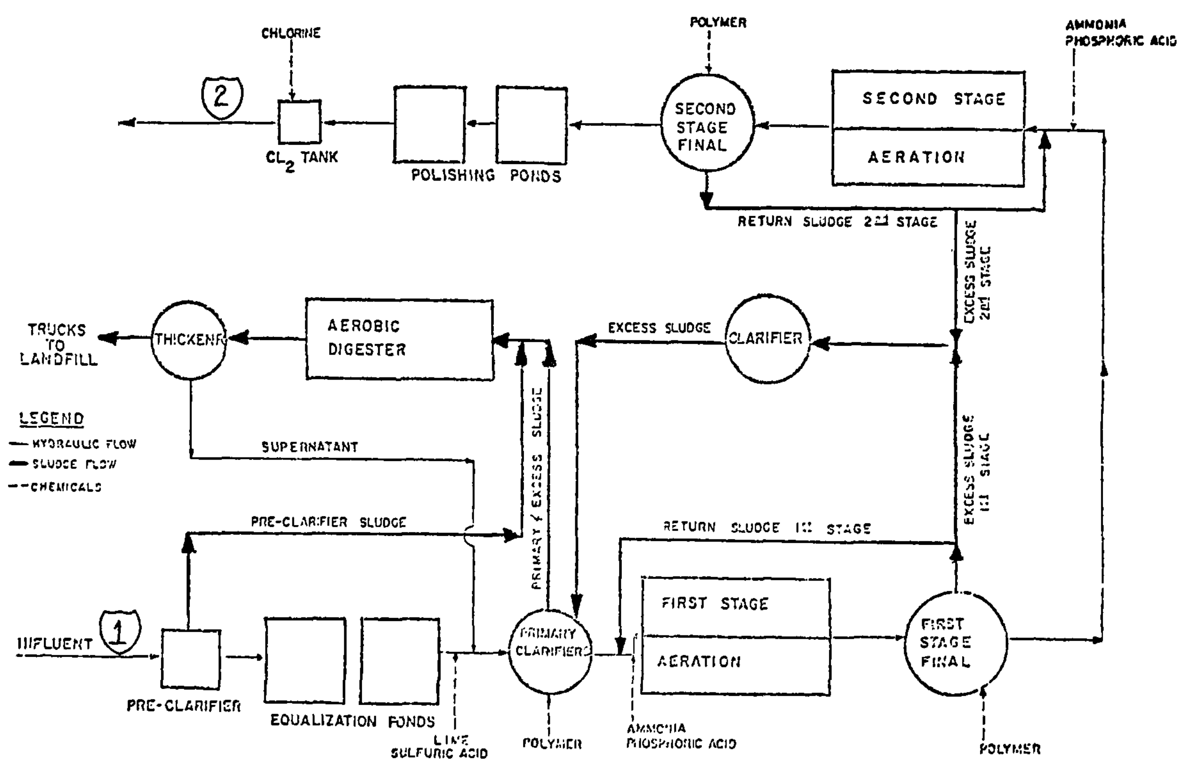
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,C,D	1.00	900-1000

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l) Inf.	Eff.	% Rem.	COD (mg/l) Inf.	Eff.	% Rem.	TSS (mg/l) Inf.	Eff.	% Rem.
1043	61	94.2	3000	780	74.0	398	88	77.9

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

Sample Location	No. of Samples
1. Raw waste (combined) to WWTP	5
2. Discharge 001 - Treated from WWTP	5
Raw waste - Plant A	4
Raw waste - Plant B	4
Raw waste - Plant C	4

SCREENING PROGRAM

SUMMARY OF PLANT
12204

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
2,4 - Dimethylphenol	62	
Phenol	38	4
Base Neutral Extractables		
Bis (2 Ethylhexyl Phthalate)		25
Volatile Organics		
Chloroform	150	90
Methylene Chloride	1400	
Ethyl Benzene	14	-
Toluene	190	-
1,1,1 - Trichloroethane	27	33
1,2 - Dichloroethane	28	
Benzene	7	-
1,1,2 - Trichloroethane	-	1
1,1 - Dichloroethylene	2	
Trichlorfluoromethane	1	-
Tetrachloroethylene	2	1
Trichloroethylene	7	1
Acrolein	L100	L100
Chlorobenzene	L2	-
Metals		
Hg Mercury	1.34	1.31
Cu Copper	88	16
Ni Nickel	28	37
Pb Lead	63	20
Zn Zinc	500	300
Sb Antimony	20	8
Cd Cadmium	4	L1
Ag Silver	6	3
As Arsenic	L20	L20
Se Selenium	L20	L20
Tl Thallium	L7	L7
Cyanide	L40	L40

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Neutralization
Coarse Settleable Solids Removal
Primary Chemical Flocculation/
Clarification
Activated Sludge with Pure Oxygen
Mechanical Thickening
Chemical Conditioning
Vacuum Dewatering
Composting

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,B,C,D	.20	2000-2100

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
1090	75	93.1	1815	263	85.5	1200	90	92.5

WASTEWATER TREATMENT PLANT FLOW DIAGRAM

Not available.

SAMPLING PROGRAM

Sample Location	No. of Samples
Municipal water	4
Well water	4
Combined influent	5
Final effluent	5
Building "A" process wastewaters	5

SCREENING PROGRAM

SUMMARY OF PLANT
12210

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
4 - Nitrophenol	L10	-
Pentachlorophenol	L10	-
Phenol	L10	-
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	160	15
Butylbenzyl Phthalate	L10	-
Di-N-Butyl Phthalate	L10	L10
Diethyl Phthalate	-	L10
Fluorene	L10	L10
Volatile Organics		
Benzene	7	10
Carbon Tetrachloride	-	61
Chloroform	L5	130
Methylene Chloride	63	130
Tetrachloroethylene	L5	L5
Toluene	L5	L5
Trichloroethylene	-	L5
Metals		
Cu Copper	60	106
Pb Lead	L10	13
Cr Chromium	L5	12
Zn Zinc	140	507
As Arsenic	L10	L10
Cd Cadmium	L10	L10
Hg Mercury	L0.89	L0.35
Ni Nickel	L10	L10
Tl Thallium	L2	L2
Cyanide	121	L2

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Aerated Lagoon

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
B,C	0.01	100-200

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l) Inf.	Eff.	% Rem.	COD (mg/l) Inf.	Eff.	% Rem.	TSS (mg/l) Inf.	Eff.	% Rem
27	106	--	Unk.	Unk.	--	30	190	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM

Not available

SAMPLING PROGRAM

Sample Location	No. of Samples
Process wastewater at waste storage tanks	2
Influent to pretreatment system for sanitary wastewater	1
Effluent from pretreatment system for sanitary wastewater	1

SCREENING PROGRAM

SUMMARY OF PLANT
12231

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
Phenol	180	20
Base Neutral Extractables		
None	-	
Volatile Organics		
Methylene Chloride	Unk.	72
Metals		
Cr Chromium	57	51
Cu Copper	150	59
Pb Lead	18	89
Hg Mercury	0.72	0.51
Ni Nickel	L10	45
Tl Thallium	-	5
Zn Zinc	208	48
Sb Antimony	L20	L20
As Arsenic	L10	L20
Cd Cadmium	L10	L10
Se Selenium	L10	L10
Ag Silver	L10	L10
Cyanide	L2	L2

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Coarse Settleable Solids Removal
Primary Sedimentation
Aerated Lagoon
Waste Stabilization Ponds
Anaerobic Digestion
Landfill

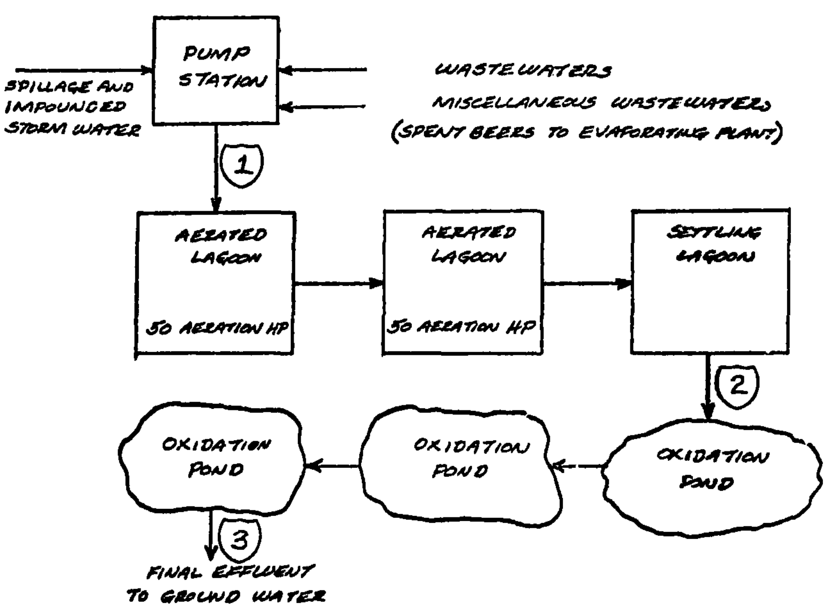
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,D	0.50	600-700

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l) Inf.	Eff.	% Rem.	COD (mg/l) Inf.	Eff.	% Rem.	TSS (mg/l) Inf.	Eff.	% Rem.
3200	147	95.4	2160	436	79.8	113	12	89.4

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

Sample Location	No. of Samples
1. Influent - raw waste to treatment	2
2. Intermediate WWTP point	2
3. Final effluent	2
Raw process water	1

SCREENING PROGRAM

SUMMARY OF PLANT
12236

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
None	-	-
Base Neutral Extractables		
1,2 - Diphenylhydrazine	20	
Bis (2 Chloroethyl) Ether	10	-
Volatile Organics		
Benzene	40	-
Chloroform	30	
Methylene Chloride	40000	200
Ethyl Benzene	12	
Toluene	33000	1350
1,1 - Dichloroethylene	190	-
Chloromethane	1300	-
Bromomethane	30	
Metals		
Cr Chromium	34	L10
Cu Copper	16	L10
Pb Lead		96
Ni Nickel	63	63
Tl Thallium	30	
Zn Zinc	191	34
Cd Cadmium	L10	L10
Hg Mercury	L0.20	L0.80
Ag Silver	L10	L10
Cyanide	560	220

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Primary Sedimentation
Activated Sludge
Flotation Thickening
Chemical Conditioning
Vacuum Dewatering
Landfill

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
C	0.90	200-300

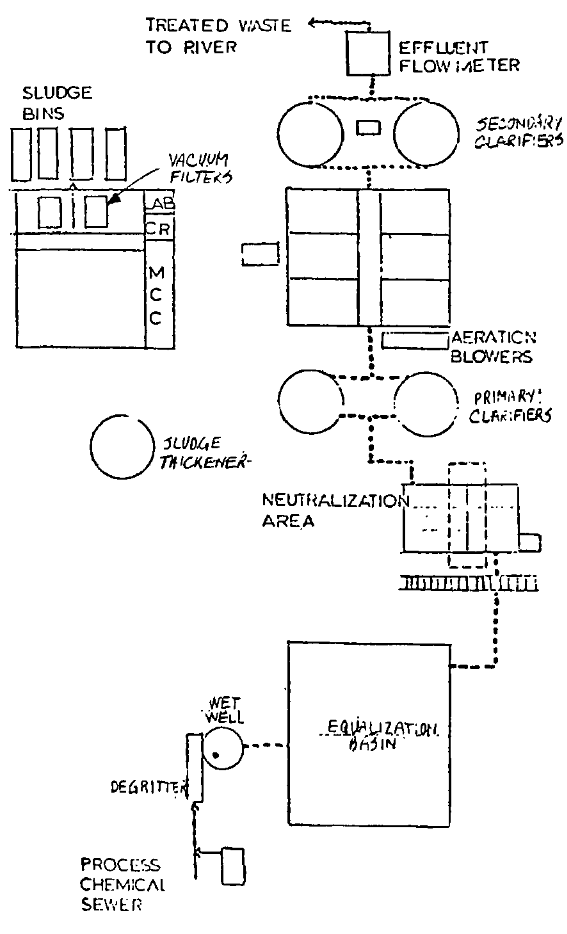
PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l) Inf.	Eff.	% Rem.	COD (mg/l) Inf.	Eff.	% Rem.	TSS (mg/l) Inf.	Eff.	% Rem.
G1200	300	75.0	3500	1370	60.6	188	94	50.0

SAMPLING PROGRAM

Sample Location	No. of Samples
1. Influent to wastewater treatment system	3
2. Effluent from wastewater treatment system	3
Non-contact cooling water discharge	3

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



APPENDIX F
VERIFICATION PROGRAM
ANALYTICAL RESULTS
PLANT 12236

	Adjusted Concentration		Pollutant Loading	
	Influent (ug/Liter)	Effluent (ug/Liter)	Influent (kg/day)	Effluent (kg/day)
Priority Pollutants				
Volatile Organics				
Toluene	56,000-71,000	10	170-210	.030
Methylene Chloride	14,000-80,000	1500-8100	42-2403	4.8-26
Chloroform	10	10	.030	.032
1,1-Dichloroethylene	10-16	10	.030-.048	.030
1,2-Dichloroethane	68-560	62-300	.2-1.7	.2-.96
Benzene	10-27	10	.030-.081	.030
Ethylbenzene	10-12	10	.030-.036	.030
Chloromethane	8,000-13,000	100-410	24-39	.32-1.3
Acid Extractables				
Base/Neutral Extractables				
Pesticides				
Metals				
Berylium	10	10	.030	.030
Cadmium	10	10	.030	.030
Chromium	42-152	10-16	.126-.456	.03-.048
Copper	14-16	10	.042-.048	.030
Lead	40	25	.12	.075
Mercury	0.62-0.69	0.2-0.56	.002	.0006-.0017
Nickel	26-39	21-30	.078-.117	.063-.09
Selenium	40	40	.12	.12
Silver	10	10	.030	.030
Zinc	69-159	13-173	.2-.477	.039-.52
Cyanides	20-270	9-228	.06-.81	.027-.684
Phenol (4AAP)	940-1900	55-455	2.82-5.7	.16-1.4
Asbestos	(Verification program did not analyze for this compound)			
Conventionals (concentrations in mg/l)				
BOD	1023-1266	130-140	3070-3800	390-420
Non-Conventionals (concentrations in mg/l)				
COD	1904-2641	633-640	5712-7923	1900-1920

SCREENING PROGRAM

SUMMARY OF PLANT
12248

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
None	-	-
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	50	10
Di-N-Butyl Phthalate	20	4
Diethyl Phthalate	-	1
Volatile Organics		
Chloroform	130	-
Methylene Chloride	800	250
1,1,1 - Trichloroethane	17	
1,2 - Dichloroethane	15	-
Toluene	2	-
Metals		
Cyanide	G250	G250

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Coarse Settleable Solids Removal
Activated Sludge
Mechanical Thickening
Aerobic Digestion
Gravity Dewatering
Landfill

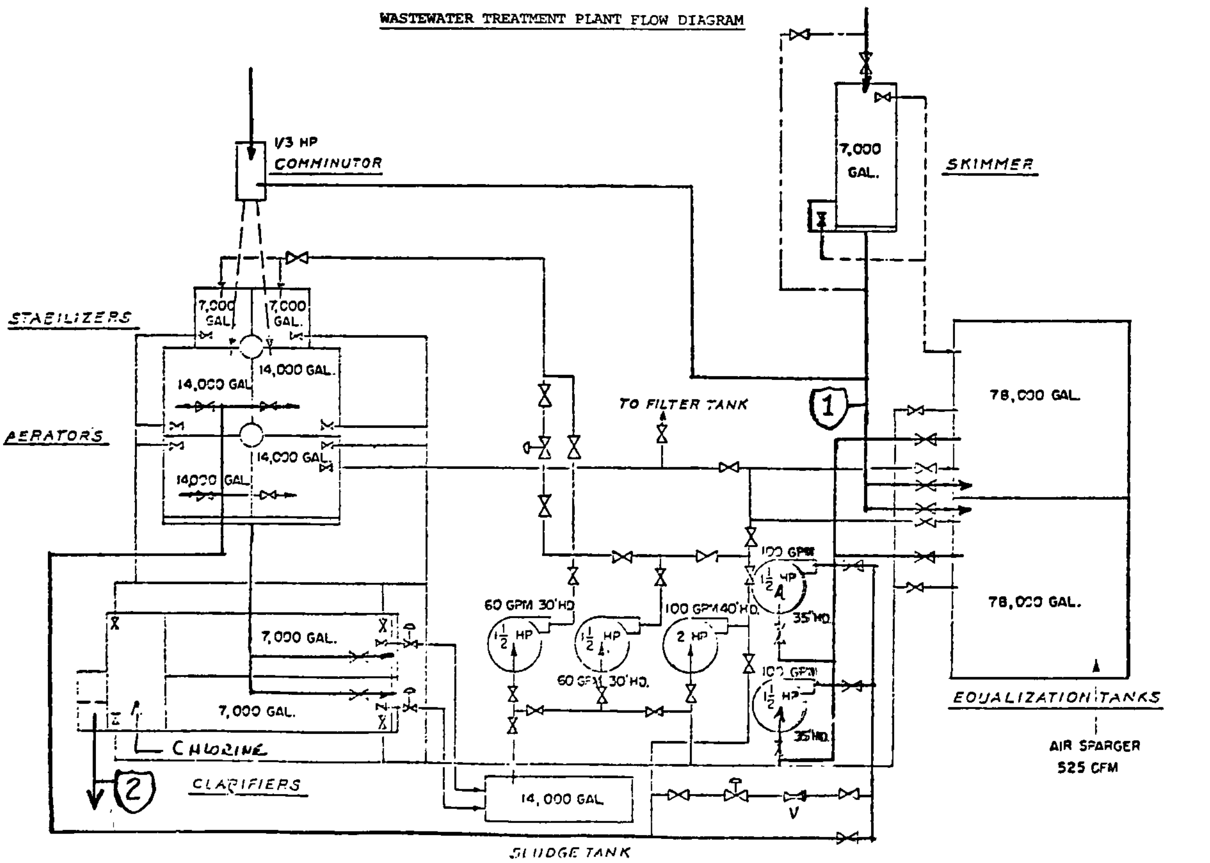
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
D	0.04	800-900

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l) Inf.	Eff.	% Rem.	COD (mg/l) Inf.	Eff.	% Rem.	TSS (mg/l) Inf.	Eff.	% Rem.
UNK	UNK	--	UNK	UNK	--	UNK	UNK	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

Sample Location

1. Influent To WWTP
2. Effluent from WWTP

SCREENING PROGRAM

SUMMARY OF PLANT
12256

SUMMARY OF SCREENING DATA

Primary	Concentration, Micrograms/Liter	
	Influent	Effluent
Acid Extractables		
None	-	-
Base Neutral Extractables		
None	-	-
Volatile Organics		
None	-	-
Metals		
Hg Mercury	1.10	0.70
Ni Nickel	300	300
Pb Lead	500	400
Cd Cadmium	40	40
Zn Zinc	310	230
Ag Silver	40	40
As Arsenic	13	14
Se Selenium	21	12
Sb Antimony	L1000	L1000
Cr Chromium	L50	L50
Cu Copper	L100	L100
Tl Thallium	L100	L100
Cyanide	-	60

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Coarse Settleable Solids Removal
Primary Sedimentation w/ Skimming

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,B,C,D	30.00	1200-1300

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
UNK.	189	--	UNK.	357	--	UNK.	38	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM

NOT AVAILABLE

SAMPLING PROGRAM

Sample Location

Well Area before Discharge Through Outfall #001
Split Manhole Discharging To Outfall #002
Manhole Prior to Discharge To Outfall #003
Skimming Basin Which Discharges To Outfall #008
Collection Basin Discharge to the Skimming Basin
Municipal Sewers Pumping Station
Raw Freshwater Supply
Saltwater Supply At Intake Structures

SCREENING PROGRAM

SUMMARY OF PLANT
12257

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
4,6 -Dinitro-O-Cresol	-	15
Phenol	L45	10
2,4 - Dichlorophenol	-	L10
Pentachlorophenol	-	L10
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	130	44
1,2 - Dichlorobenzene	12	-
N-Nitrosodiphenylamine	12	-
1,2 - Diphenylhydrazine	L10	
Fluoranthene	L10	
Naphthalene		L10
Di-N-Butyl Phthalate	-	L10
Diethyl Phthalate	L10	
Anthracene	L10	
Phenanthrene	L10	
Volatile Organics		
Chloroform	51	L10
Methylene Chloride	35	31
Chloromethane	35	31
Benzene	L10	L10
Carbon Tetrachloride	L10	
Chlororbenzene	L10	L10
1,2 - Dichloroethane	L10	L10
1,1,1 - Trichloroethane	L10	L10
1,1 -Dichloroethane		L10
1,2 -Dichlorpropylene	-	L10
Ethylbenzene	L10	
Bromomethane	L10	L10
Bromoform	L10	L10
Dichlorobromomethane	L10	-
Trichlorofluoromethane	L10	L10
Chlorodibromomethane	L10	
Tetrachloroethylene	L10	L10
Toluene	L10	L10
Trichloroethylene	L10	L10
Metals		
Hg Mercury	0.90	0.50
Cu Copper	22	41
Cr Chromium	136	166
Zn Zinc	191	254
Sb Antimony	28	9
Ar Arsenic	20	30
Se Selenium	16	30
Cd Cadmium	7	9
Pb Lead	L20	L20
Ni Nickel	L5	L5
Ag Silver	L1	L1
Tl Thallium	L50	L50
Cyanide	L5	L5

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Activated Sludge
Centrifugal Dewatering
Cropland Use

PLANT CHARACTERISTICS

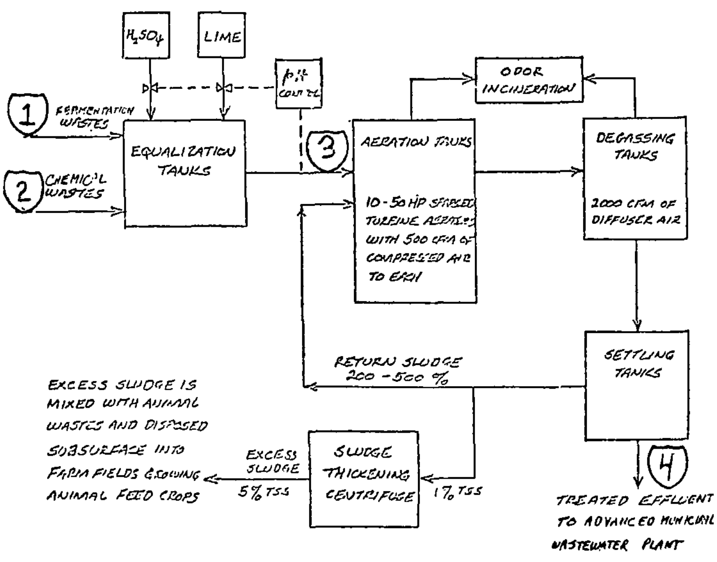
Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,B,C,D	0.50	2100-2200

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l) Inf.	Eff.	% Rem.	COD (mg/l) Inf.	Eff.	% Rem.	TSS (mg/l) Inf.	Eff.	% Rem.	
3750	56	98.5	6215	626	89.9	1136	144	87.3	(1)
3900	56	98.6	5080	626	87.7	--	--	--	(2)
--	56	--	--	626	--	--	144	--	(3)

(1) Fermentation
(2) Chemical Synthesis
(3) Biological Extraction & Formulation

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

Sample Location	No. of Samples
1. Raw fermentation process wastes	6
2. Raw chemical synthesis process wastes	5
3. Combined plant process wastes after neutralization	4
4. Treated effluent to WWTP	6
Cooling water discharge at bypass line	1
Municipal water supply	2

SCREENING PROGRAM

SUMMARY OF PLANT
12342

SUMMARY OF SCREENING DATA

No Treatment — Concentration, Micrograms/Liter

	Influent	Effluent
Acid Extractables		
Phenol	N/A	14000
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	N/A	760
Volatile Organics		
Chloroform	N/A	2
Toluene	N/A	2
1,1 - Dichloroethane	N/A	2
Ethylbenzene	N/A	1
Acrolein	-	L100
Metals		
Cu Copper	N/A	130
Ni Nickel	N/A	22
Cr Chromium	N/A	20
Zn Zinc	N/A	530
Sb Antimony	N/A	27
Hg Mercury	N/A	0.20
As Arsenic	-	L20
Cd Cadmium	-	L1
Pb Lead		L10
Se Selenium	-	L20
Ag Silver	-	L3
Tl Thallium	-	L8
Cyanide		L40

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

NO TREATMENT PROVIDED

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,C,D	1.06	300-400

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
N/A	5810	--	N/A	12840	--	N/A	3480	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM

NOT APPLICABLE

SAMPLING PROGRAM

Sample Location	No. of Samples
Discharge from Manhole No. 1	3
Discharge from Manhole No. 5	3
Discharge from Manhole No. 6	3
Discharge from Manhole No. 7	3
Potable Water Building 28	1
Potable Water Building 1	1
Potable Water - Building 5	1
Potable Water - Building 20A	1

SCREENING PROGRAM

SUMMARY OF PLANT
12411

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
Phenol	34	-
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	38	28
Di-N-Butylphthalate	-	L10
Diethyl Phthalate	-	L10
Volatile Organics		
Chloroform	860	L5
Methylene Chloride	1100	32
Toluene	290	L5
Benzene	7	-
Ethylbenzene	L5	-
Tetrachloroethylene	-	L5
Metals		
Hg Mercury	-	1.60
Cu Copper	35	26
Ni Nickel	20	40
Pb Lead	80	-
Cr Chromium	16	16
Zn Zinc	146	99
Tl Thallium	5	58
Sb Antimony	68	-
As Arsenic	32	-
Se Selenium	30	-
Cd Cadmium	L10	L10
Ad Silver	L10	L10
Cyanide	590	52

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Aerated Lagoon
Incineration

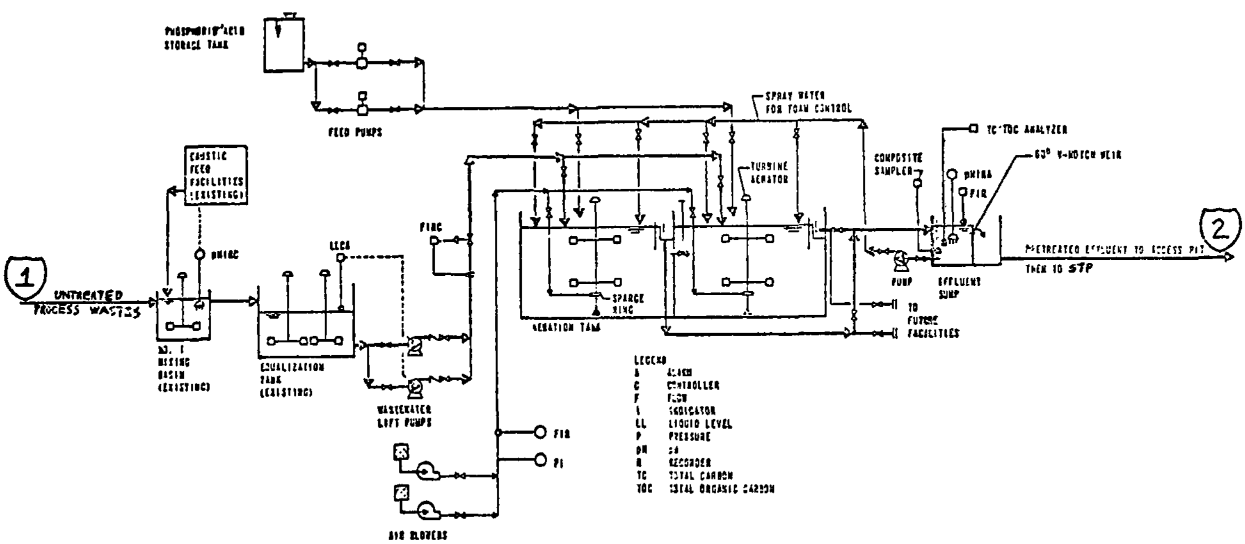
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
B,C,D	0.35	700-800

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l) Inf.	Eff.	% Rem.	COD (mg/l) Inf.	Eff.	% Rem.	TSS (mg/l) Inf.	Eff.	% Rem.
G167	G167	--	Unk.	Unk.	--	316	585	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

Sample Location	No. of Samples
1. Influent to pretreatment system	3
2. Effluent from pretreatment system	3
Combined sanitary cooling water and pretreated process wastewater at access pit	3

APPENDIX F
VERIFICATION PROGRAM
ANALYTICAL RESULTS
PLANT 12411

	Concentration		Pollutant Loading	
	Influent (ug/Liter)	Effluent (ug/Liter)	Influent (kg/day)	Effluent (kg/day)
Priority Pollutants				
Volatile Organics				
Toluene	10	10	.0086-.011	.0086-.011
Methylene Chloride	110-180	10	.095-.33	.0086-.011
Chloroform	11000-280,000	10-170	9.5-310	.0086-.19
Acid Extractables				
2-Chlorophenol	10	10	.01	.011
2-Nitrophenol	14	10	.015	.011
Phenol	10	10	.011	.011
2,4-Dimethylphenol	10	10	.011	.011
2,4-Dichlorophenol	10	10	.011	.011
2,4,6-Trichloro Phenol	10	10	.011	.011
4-Chloro-3-Methylphenol	10	10	.011	.011
2,4-Dinitro-2-Methylphenol	10	48	.011	.053
Pentachlorophenol	10	114	.011	.13
4-Nitrophenol	10	10	.011	.011
Base/Neutral Extractables				
Pesticides				
Metals				
Berylium	10	10	.009	.009
Cadmium	10	10	.009	.009
Chromium	35-89	27-40	.03-.095	.036
Copper	20-30	19-21	.018-.03	.02
Nickel	126-130	51-85	.113-.136	.055-.07
Lead	25	25	.027	.27
Selenium	40	40	.04	.04
Zinc	111-388	110-2009	.12-.39	.12-1.7
Mercury	1-310	.74-.96	0.0-.0045	0.0
Cyanides	96-268	144-254	106-260	160-246
Asbestos	(Verification program did not analyze for this compound)			
Conventionals (concentrations in mg/l)				
BOD	1470	294	1270	254
Non-Conventionals (concentrations in mg/l)				
COD	4400-5750	2900-3300	4830-5600	2770-3610

SCREENING PROGRAM

SUMMARY OF PLANT
12420

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
Base Neutral Extractables		
Bis (2 Ethylhexyl) Phthalate	30	L10
Di-N-Butyl Phthalate	L10	L10
Volatile Organics		
Benzene	580	10
Methylene Chloride	76	L10
Toluene	1050	L10
1,1,1 - Trichloroethane	L10	L10
Chloroform	L10	-
Ethylbenzene	L10	L10
Tetrachloroethylene	-	L10
Metals		
Cr Chromium	212	304
Cu Copper	106	14
Pb Lead	27	42
Hg Mercury	0.40	0.10
Zn Zinc	151	83
Cd Cadmium	L2	L2
Ni Nickel	L5	L5
Cyanide	L5	L5

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Activated Sludge
Chemical Conditioning
Centrifugal Dewatering
Landfill

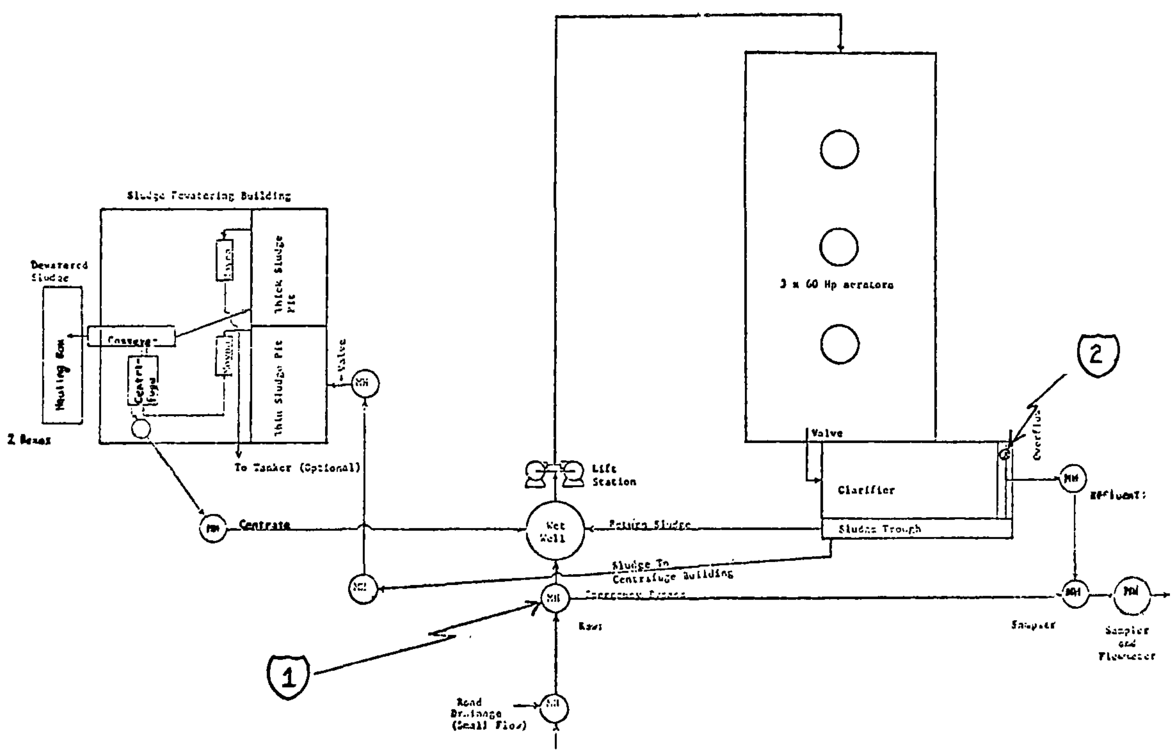
PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
B,D	0.17	100-200

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l) Inf.	BOD Eff.	BOD % Rem.	COD (mg/l) Inf.	COD Eff.	COD % Rem.	TSS (mg/l) Inf.	TSS Eff.	TSS % Rem.
3250	195	94.0	355	638	--	Unk.	490	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM



SAMPLING PROGRAM

Sample Location	No. of Samples
1. Influent to pretreatment system	3
2. Effluent from pretreatment system	3
Rescreening: 1. Influent to pretreatment	2
2. Effluent from pretreatment	4

SCREENING PROGRAM

SUMMARY OF PLANT
12439

SUMMARY OF SCREENING DATA

Biological	Concentration, Micrograms/Liter	
	Influent	Effluent
Acid Extractables		
2,4 - Dimethylphenol	L10	15
Pentachlorophenol	L10	L10
Phenol	L10	-
Base Neutral Extractables		
Di-N-Butyl Phthalate	19	-
Diethyl Phthalate	61	L10
Isophorone	1014	L10
Anthracene	14	L10
Acenaphthene	92	-
Bis (2 Chloroisopropyl) Ether	300	181
2,4 - Dinitrotoluene	65	-
Fluorene	27	L10
Butyl Benzyl Phthalate	719	-
Bis (2 Chloroethyl) Ether		L10
Phenanthrene	14	L10
Volatile Organics		
Benezene	73	L10
Chloroform	26	18
Methylene Chloride	640	120
Ethyl Benzene	82	17
Toluene	786	315
Chlorobenzene	12	-
1,1,1 - Trichloroethane	261	12
Tetrachloroethylene	26	-
Trichloroethylene	124	14
1,1,2 - Trichloroethane	19	L10
Carbon Tetrachloride		L10
1,1 - Dichloroethylene	L10	-
1,2 - Trans-Dichloroethylene	L10	
Metals		
Cr Chromium	9	15
Cu Copper	32	32
Pb Lead	-	14
Hg Mercury	0.67	0.76
Tl Thallium	5	8
Zn Zinc	29	153
Sb Antimony	L20	L20
As Arsenic	L10	L10
Cd Cadmium	L10	L10
Pb Lead	L10	
Ni Nickel	L10	L10
Ag Silver	L10	L10
Cyanide	L10	L10

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Primary Sedimentation
Activated Sludge
Aerated Lagoon
Landfill

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
C,D	0.01	100-200

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
Unk.	Unk.	--	6841	2297	66.4	10	125	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM

Raw Waste------➤Neutralization-----➤Primary Sedimentation-------➤Aeration Units (activated sludge)----➤Lagooning.

Design Considerations

Detention time of Aerators--2 hrs
Detention time of lagoons--- 60 days
Treatment Plant Capacity---30,000 gpd

Solvent Wastes---➤recovery

SAMPLING PROGRAM

Sample Location	No. of Samples
Industrial Stream Influent	2
Secondary Clarifier Effluent	

SCREENING PROGRAM

SUMMARY OF PLANT
12447

SUMMARY OF SCREENING DATA

Chemical	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
Phenol	280	
Base Neutral Extractables		
None		-
Volatile Organics		
Benzene	500	-
Chloroform	900	
Methylene Chloride	1700000	-
Toluene	700	
1,1,1 - Trichloroethane	720000	-
1,1 - Dichloroethylene	20	
1,2 - Dichloroethane	14000	
1,1 - Dichloroethane	54	
1,2 - Trans-Dichloroethylene	1100	-
Metals		
Sb Antimony	57	
Cr Chromium	91	
Cu Copper	86	
Pb Lead	21	
Hg Mercury	0.70	
Ni Nickel	50	-
Se Selenium	48	-
Ag Silver	4	-
Zn Zinc	311	
As Arsenic	L20	-
Cd Cadmium	L2	-
Tl Thallium	L100	-
Cyanide	19	-

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Deep Well Injection System
Equalization
Neutralization
Coarse Settleable Solids Removal
Primary Sedimentation
Physical/Chemical Treatment
Diatomaceous-Earth Filtration

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A,B,C,D	1.50	4000-4100

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
2600	N/A	--	7400	N/A	--	UNK.	N/A	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM

NOT AVAILABLE

SAMPLING PROGRAM

Sample Location	No. of Samples
Process Wastes From Building 197	5
Process Wastes From Building 42	5
Process Wastes To Injection Wells	4
Non-Contact Cooling Water to Outfall 001	5
Non-Contact Cooling Water to 85 Acre Pond	5

SCREENING PROGRAM

SUMMARY OF PLANT
12462

SUMMARY OF SCREENING DATA

Biological	Influent (Concentration, Micrograms/Liter)	Effluent (Concentration, Micrograms/Liter)
Acid Extractables		
4-Nitrophenol	1600	L400
Phenol	70	L20
Base Neutral Extractables		
None	-	-
Volatile Organics		
Methylene Chloride	-	70
Metals		
Hg Mercury	L0.20	1.30
Cu Copper	29	48
Cr Chromium	L10	17
Zn Zinc	89	122
Sb Antimony	28	50
As Arsenic	31	-
Se Selenium	60	56
Pb Lead	5	6
Cd Cadmium	L1	L1
As Arsenic	-	L20
Ni Nickel	L50	L50
Ag Silver	L1	L1
Tl Thallium	L100	L100
Cyanide	L30	

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Activated Sludge
Aerated Lagoon
Sludge Hauling

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
A	0.30	0-100

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
1000	156	84.4	4660	1300	72.1	960	1000	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM

Not available.

SAMPLING PROGRAM

Sample Location	No. of Samples
Raw water supply	1
Existing backwash lagoon effluent	1
Biological waste treatment system effluent	6
Process wastes influent line to the biological treatment system	3
Combined influent to the biological wastewater treatment system	2
Effluent from final clarifier	4

SCREENING PROGRAM

SUMMARY OF PLANT
12999

SUMMARY OF SCREENING DATA

Chemical	Concentration, Micrograms/Liter Influent	Effluent
Acid Extractables		
2,4 - Dimethylphenol	UNK.	4100
2 - Nitrophenol	UNK.	1100
Phenol	UNK.	16500
Base Neutral Extractables		
Nitrobenzene	UNK.	30
Volatile Organics		
1,1 - Dichloroethylene	UNK.	370
1,2 - Dichloroethane	UNK.	20
1,1,2 - Trichloroethane	UNK.	6650
Metals		
Cu Copper	36	35
Cr Chromium	L10	9
Zn Zinc	80	70
Sb Antimony	UNK.	90
As Arsenic	UNK.	7200
Se Selenium	UNK.	310
Cd Cadmium	-	L1
Pb Lead	-	L5
Ni Nickel	-	L50
Ag Silver		L2
Tl Thallium	-	L10

WASTEWATER TREATMENT PLANT UNIT OPERATIONS

Equalization
Neutralization
Primary Chemical Flocculation/Clarification
Detention Pond

PLANT CHARACTERISTICS

Subcategory	Wastewater Quantity (Mgal/d)	Employment
C,D	0.45	Unk.

PERFORMANCE OF TREATMENT SYSTEM

BOD (mg/l)			COD (mg/l)			TSS (mg/l)		
Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.	Inf.	Eff.	% Rem.
Unk.	625	--	Unk.	1380	--	Unk.	31	--

WASTEWATER TREATMENT PLANT FLOW DIAGRAM

NOT AVAILABLE

SAMPLING PROGRAM

Sample Location	No. of Samples
Detention Pond Effluent	3
Raw Waste Feed for Bench Scale Treatment Units	2
Activated Sludge Effluent	1
Powdered Activated Carbon Treatment (PACT) Effluent	1

APPENDIX G

308 PORTFOLIO
PRIORITY POLLUTANT DATA

APPENDIX G

308 PORTFOLIO PRIORITY POLLUTANT DATA

Priority Pollutants by Plant			Concentrations (mg/l) Influent	Effluent
Plant 12003:	A CD	N*		
Copper				10
Nickel				80
Zinc				5
Plant 12018:	A CD	N*		
Zinc				100
Plant 12037:	CD	N*		
Methylene Chloride				12
Chromium				930
Copper				190
Lead				50
Mercury				0.3
Nickel				100
Zinc				40
Cyanide				89
Plant 12038:	ABCD	AS, AL, PC*		
Phenol				102
Chromium				20
Lead				100
Mercury				0.6
Cyanide				30
Plant 12052:	CD	AS*		
Phenol				1100
Chromium				21
Copper				45
Lead				100
Mercury				10.0
Nickel				100
Zinc				92
Cyanide				100
Plant 12056:	D	AC*		
Chromium				5
Zinc				17900
Plant 12057:	CD	N*		
Toluene				780

308 PORTFOLIO PRIORITY POLLUTANT DATA

Priority Pollutants by Plant			Concentrations (mg/l) Influent	Effluent
Plant 12062:	CD	N*		
Zinc				200
Plant 12065:	D	N*		
Cyanide				1000
Plant 12089:	B D	TF, AS, PP*		
Mercury				0.3
Plant 12102:	CD	N*		
Phenol				8000
Chromium				100
Copper				500
Lead				100
Mercury				1.0
Nickel				500
Zinc				1000
Cyanide				1000
Plant 12107:	B D	N*		
Phenol				290
Chromium				290
Lead				90
Plant 12123:	CD	N*		
Benzene				6
Carbon Tetrachloride				50
Chloroform				50
Methylene Chloride				15
Toluene				67
Chromium				108
Copper				73
Lead				13
Mercury				35.0
Nickel				50
Zinc				368
Cyanide				110
Phenol				30
Chromium				50
Zinc				370

308 PORTFOLIO PRIORITY POLLUTANT DATA

Priority Pollutants by Plant	Concentrations (mg/l) Influent	Concentrations (mg/l) Effluent
Plant 12161: A CD AS, PP*		
Phenol		14
Benzene	800	250
Chloroform	11000	6
Toleune	9100	17
Chromium		10
Copper		80
Lead		70
Mercury		2.0
Nickel		2100
Zinc		137
Plant 12186: CD AS, AL*		
Copper		240
Plant 12195: C N*		
Chromium		200
Copper		200
Lead		200
Mercury		0.1
Nickel		300
Zinc		400
Cyanide		10
Plant 12204: ABCD AS*		
Chromium	9	15
Plant 12224: D N*		
Copper		97
Zinc		177
Plant 12235: C N*		
Cyanide	34	14
Plant 12236: C AS*		
Cyanide	120	290
Plant 12244: C N*		
Chromium		500
Mercury		0.5
Plant 12245: ABC N*		
Toluene	290000	14000
Plant 12252: A CD P*		
Chromium		70

APPENDIX G (cont.)

308 PORTFOLIO PRIORITY POLLUTANT DATA

Priority Pollutants by Plant			Concentrations (mg/l) Influent	Effluent
Plant 12257:	ABCD	AS*		
Phenol				30
Chromium				100
Copper				50
Lead				50
Mercury				0.1
Nickel				1300
Zinc				250
Cyanide				10
Plant 12282:	BCD	SF*		
Mercury				80.0
Plant 12287:	D	AL*		
Phenol			31	10
Chromium			100	100
Zinc			80	80
Cyanide				20
Plant 12289:	D	N*		
Chromium				300
Copper				540
Lead				680
Mercury				7.0
Nickel				200
Zinc				2050
Cyanide				15
Plant 12302:	C	N*		
Toleune				9
Plant 12339:	A CD	AS, PC*		
Phenol				79
Chloroform				9
Methylene Chloride			22000000	742
Chromium				85
Copper				541
Lead			117	117
Mercury				4.0
Zinc			120000	983
Cyanide				2100
Plant 12342:	A CD	N*		
Phenol				210
Methylene Chloride				9300

308 PORTFOLIO PRIORITY POLLUTANT DATA

Priority Pollutants by Plant			Concentrations (mg/l) Influent	Effluent
Plant 12407:	C	AS, PC, PP*		
Chromium				70
Copper				23
Lead				90
Mercury				10.0
Zinc				21
Cyanide				2300
Plant 12411:	BCD	AL*		
Phenol				106
Chloroform				3990
Methylene Chloride				1650
Plant 12414:	D	N*		
Chromium				4
Copper				49
Lead				4
Nickel				7
Zinc				130
Plant 12420:	B D	AS*		
Phenol			168	160
Toluene			174	174
Copper				300
Lead				170
Nickel				260
Zinc				600
Cyanide				3
Plant 12440:	D	N*		
Phenol				750
Chloroform				300
Methylene Chloride				1000
Chromium				11
Copper				70
Lead				70
Mercury				0.1
Nickel				26
Zinc				80
Cyanide				200
Plant 12458:	CD	N*		
Phenol				192
Plant 12468:	D	N*		
Copper				140
Lead				24
Mercury				0.2
Nickel				100
Zinc				180

308 PORTFOLIO PRIORITY POLLUTANT DATA

Priority Pollutants by Plant	Concentrations (mg/l) Influent	Effluent
Plant 12475: C AS*		
Phenol	10	10
Plant 12477: BC N*		
Phenol		50
Chromium		2000
Copper		300
Lead		50
Mercury		5.0
Nickel		500
Zinc		5600
Cyanide		760
Plant 20033: CD P*		
Phenol	200	200
Chromium		250
Copper		110
Mercury		0.2
Nickel		200
Zinc		250
Plant 20037: D AS, AL, PP*		
Phenol		8
Plant 20245: A C AS*		
Phenol	130	34
Benzene	130	2
Chloroform	72	42
Methylene Chloride	4	2
Toluene	40000	1
Chromium	1700	86
Copper	37	23
Lead	8400	41
Mercury	0.6	0.1
Nickel	490	6
Zinc	37000	3500
Cyanide	1500	40
Plant 20246: C AS, MF*		
Phenol		172
Benzene		3
Chloroform		8
Methylene Chloride		6
Toluene		1
Chromium		19
Copper		55
Lead		2
Mercury		0.2
Nickel		2
Zinc		88
Cyanide		36

308 PORTFOLIO PRIORITY POLLUTANT DATA

Priority Pollutants by Plant			Concentrations (mg/l) Influent	Effluent
Plant 20254:	C	AL, PP*		
Phenol				65
Cyanide				70
Plant 20297:	C	TF, AS, PC*		
Phenol			1800	60
Cyanide			200	110
Plant 20321:	D	N*		
Copper				300
Zinc				2000
Plant 20342:	C	P*		
Phenol			21	12
Chloroform				20
Toluene				8
Chromium				50
Copper				50
Mercury				0.2
Nickel				50

*End-of-Pipe Treatment Abbreviations:

N = No Treatment
P = Primary
TF = Trickling Filter
AS = Activated Sludge
AL = Aerated Lagoon
PP = Polishing Pond
PC = Physical/Chemical
AC = Activated Carbon
MF = Multimedia Filter
SF = Sand Filtration

APPENDIX H

308 PORTFOLIO
TRADITIONAL POLLUTANT DATA

APPENDIX H

308 PORTFOLIO TRADITIONAL POLLUTANT DATA

Plant Code	Sub-Category	Major End-of-Pipe Treatment*	BOD(mg/l) Inf.	BOD(mg/l) Eff.	COD(mg/l) Inf.	COD(mg/l) Eff.	TSS(mg/l) Inf.	TSS(mg/l) Eff.
12000	D	N	80				80	
12001	D	AL		21				
12012	B D	P	611		916		273	
12015	D	AS, AC, OP	259	19	489	54	146	15
12016	D	N	1210				135	
12018	A CD	N	33		76		11	
12022	A C	TF, AS	1551	105				38
12023	D	N	4597				512	
12026	C	AS, AL, PP	1865	93	4240	946	84	326
12031	D	N	344				222	
12036	A	TF, AS, AL, PP	1340	13	2521	197	705	44
12037	CD	N	1811		6893		775	
12038	ABCD	Fermentation Wastes						
		AS, PC	6210	244	12023	1453	2264	306
		Chemical Wastes						
		AL, PC	5717	1140	1741	4470	4483	457
12040	B D	N	210		800		280	
12053	D	TF, AS, SF	229	8	1205	67	383	2
12062	CD	N	2600		2924		49	
12066	BCD	AS, AL	1195	331			116	251
12069	D	N	320		450		30	
12084	BCD	N	5772		10450		1465	
12087	C	P	27416		56902		2501	
12089	B D	TF, AS, PP		13				13
12095	CD	PC, OP					193	6
12097	CD	ASw/PAC, OP		28		289		29
12098	D	AS	465	693	2556	2886	354	336
12102	CD	N	2705		5124		143	
12104	D	SP	85	12	157	40	19	22
12119	A D	AS, PC		7		40		70
12125	D	PC		218	256	456	53	88
12132	A C	TF, AS, SP	2330	29	4800	203		29
12135	BCD	P	200		400		200	
12141	D	AS		4				12
12143	D	N	93		358		143	
12159	CD	N	79					
12160	D	AS, PC, MF	530	5			4128	43

APPENDIX H (cont.)

308 PORTFOLIO TRADITIONAL POLLUTANT DATA

Plant Code	Sub-Category	Major End-of-Pipe Treatment*	BOD(mg/l) Inf.	BOD(mg/l) Eff.	COD(mg/l) Inf.	COD(mg/l) Eff.	TSS(mg/l) Inf.	TSS(mg/l) Eff.
12161	A CD	AS, PP	987	72	2978	944	398	196
12168	ABCD	N	1300		3300		500	
12183	B	N	4		10		3	
12185	BC	N	47		154		7	
12186	CD	AS, AL		129		683		328
12187	C	TF	653		1950		124	
12191	BCD	P			1352		92	
12195	C	N	215		584			
12199	A CD	N	2180				650	
12204	ABCD	AS	1220	146	2628	407	2000	320
12205	D	AS, SP		60		81		40
12231	D	AL, SP	2500	200		600	100	50
12235	C	N	12374		22250			
12236	C	AS	1117	149	2674	553		90
12239	D	AS	1573	284	1608	290		174
12240	CD	PC		3636		8481		286
12248	D	AS	244	10	486	63		35
12257	ABCD	AS	3000	120			950	500
12261	C	AL, PC			15574	9880	3089	567
12275	BC	P	366					
12283	D	AS		35				50
12287	D	AL	30	56	50	51	12	13
12294	CD	AS, MF	1404	208	3288	658		28
12298	D	AS		15				26
12307	D	AS, AL	732	18	2390	83		90
12308	D	AS	130		372		67	
12317	D	AS, PC, MF	760	32	1064	107	39	50
12338	D	AS, SF	200	30			200	30
12339	A CD	AS, PC			430	2370		
12343	A CD	P	636					
12406	C	PC, PP, OP					420	10
12407	C	AS, PC, PP	54	45			30	17
12411	BCD	AL	7100	869	15700		369	1793
12420	B D	AS	7520	4636	12032	7418	4923	4048
12454	B D	TF		288				
12462	A	AS, AL		143		297		97
12463	B D	AS, SP, PC, OP	102	6		29		9

APPENDIX H (cont.)

308 PORTFOLIO TRADITIONAL POLLUTANT DATA

Plant Code	Sub-Category	Major End-of-Pipe Treatment*	BOD(mg/l) Inf.	BOD(mg/l) Eff.	COD(mg/l) Inf.	COD(mg/l) Eff.	TSS(mg/l) Inf.	TSS(mg/l) Eff.
12471	B	AL, PP, OP	50	14	169		93	59
12475	C	AS	10670	1960	16140	6440		2340
12476	D	AS	10670	1960	16140	6440		2340
12477	BC	N	327		725			
20037	D	AS, AL, PP		20				47
20165	BC	AL	200	32	541	113	47	24
20201	D	AS		6		50		14
20204	CD	AL	1600	370	1370			
20206	C	AL	1600	5	12000	340		10
20245	A C	AS	497	56	1350	74		32
20246	C	AS, MF,		13		128		33
20257	C	AS	484	143	1358	329		
20297	C	TF, AS, PC	380	20			147	36
20312	BCD	AL	1500	150			500	150
20319	D	TF, SP		15				9
20342	C	P	609		870		32	
20363	A CD	P	8460		16748		1535	

* ABBREVIATIONS:

N = No Treatment
P = Primary
TF = Trickling Filter
AS = Activated Sludge (w/PAC = with Powdered Activated Carbon)
AL = Aerated Lagoon
SP = Stabilization Pond
PP = Polishing Pond
OP = Other Polishing
PC = Physical/Chemical
AC = Activated Carbon
MF = Multimedia Filter
SF = Sand Filtration

APPENDIX I

308 PORTFOLIO
WASTEWATER FLOW DATA

APPENDIX I
308 PORTFOLIO
WASTEWATER FLOW DATA

Plant No.	Subcategory	Discharge Flow, MGD
DIRECT DISCHARGERS:		
12001	D	0.155
12006	D	0.125
12022	A C	1.300
12026	C	0.101
12030	D	0.030
12036	A	1.128
12038	A B C D	2.607
12053	D	0.004
12057*	C D	0.005
12073	C	0.015
12085	D	0.420
12089	B D	0.155
12095	C D	0.071
12097	C D	0.035
12098	D	0.002
12104*	D	0.367
12117	B D	0.010
12119	A D	0.032
12132	A C	0.460
12160	D	0.006
12161	A C D	1.332
12175	D	0.004
12187*	C	0.913
12194	D	0.002
12205	D	0.030
12235	C	0.171
12236	C	0.810
12239	D	0.002
12248	D	0.035
12256*	A B C D	7.250
12261	C	0.051
12264*	A B D	0.044
12267	D	0.005
12283	D	0.013
12287*	D	0.131
12294	C D	0.089
12298	D	0.003
12307	D	0.001
12308	D	0.059
12317	D	0.390
12338	D	0.001
12339	A C D	1.600
12406	C	0.310

APPENDIX I
308 PORTFOLIO
WASTEWATER FLOW DATA

Plant No.	Subcategory	Discharge Flow, MGD
12407	C	0.731
12459	D	0.073
12462	A	0.170
12463	B D	0.003
12471	B	0.043
20037	D	0.037
20165	B C	0.004
20245	A C	0.500
20246	C	1.250
20257	C	0.115
20319	D	0.003
20370	B C	0.140
20402	D	0.024

INDIRECT DISCHARGERS:

Plant No.	Subcategory	Discharge Flow, MGD
12000	D	0.140
12005	B	0.001
12007	D	0.527
12011	A B D	0.031
12016	D	0.009
12018	A C D	0.020
12023	D	0.020
12024	D	0.033
12031	D	0.001
12035	D	0.003
12037	C D	0.125
12040	B D	0.063
12043	C	0.001
12044	A D	2.973
12048	C D	0.089
12051	D	0.009
12054	D	0.008
12055	D	0.002
12056	D	0.110
12057*	C D	0.080
12058	D	0.005
12060	D	0.104
12061	B	0.042
12062	C D	0.075
12065	D	0.005
12066	B C D	0.259
12069	D	0.013
12073	C	0.815

APPENDIX I
308 PORTFOLIO
WASTEWATER FLOW DATA

Plant No.	Subcategory	Discharge Flow, MGD
12074	D	0.037
12076	D	0.001
12077	C D	0.022
12080	D	0.090
12083	D	0.217
12084	B C D	0.008
12087	C	0.232
12088	D	0.002
12093	C D	0.004
12100	C D	0.002
12104*	D	0.190
12107	B D	0.009
12112	C	0.005
12113	D	0.380
12115	A B D	0.010
12118	D	0.009
12120	D	0.001
12123	C D	0.404
12131	D	0.004
12135	B C D	1.650
12141	D	0.001
12143	D	0.037
12145	D	0.001
12155	C D	1.170
12166	D	0.004
12168	A B C D	0.159
12171	B C D	0.001
12178	B	0.005
12183	B	0.090
12186	C D	0.052
12187*	C	0.078
12195	C	0.080
12198	B D	0.012
12199	A C D	0.500
12204	A B C D	0.850
12206	D	0.130
12210	B C	0.002
12212	D	0.040
12219	D	0.053
12226	B	0.040
12230	B	0.001
12238	D	0.010
12240	C D	0.013
12244	C	0.042
12245	A B C	0.085
12246	C D	0.362

APPENDIX I
308 PORTFOLIO
WASTEWATER FLOW DATA

Plant No.	Subcategory	Discharge Flow, MGD
12247	C	0.029
12249	D	0.002
12250	D	0.047
12251	D	0.001
12252	A C D	0.865
12254	A D	0.213
12256*	A B C D	0.410
12257	A B C D	0.600
12260	D	0.125
12264*	A B D	0.127
12265	B D	0.003
12275	B C	0.426
12281*	D	0.034
12282	B C D	0.004
12287*	D	0.070
12289	D	0.003
12296	D	0.016
12300	B	0.160
12302	C	1.028
12305	D	0.034
12309	B C	0.007
12310	C D	0.018
12311	A B C D	0.240
12318	D	0.100
12322	D	0.010
12330	A B C D	1.606
12331	D	0.380
12332	C	0.045
12333	C D	0.017
12340	D	0.034
12342	A C D	0.701
12343	A C D	0.088
12345	D	0.020
12384	B	0.002
12401	A D	0.223
12411	B C D	0.300
12414	D	0.464
12415	D	0.080
12427	D	0.011
12429	D	0.005
12438	D	0.004
12441	C	1.300
12444	D	0.076
12454	B D	0.100
12458	C D	0.778
12465	D	0.018

APPENDIX I
308 PORTFOLIO
WASTEWATER FLOW DATA

Plant No.	Subcategory	Discharge Flow, MGD
12467	B	0.002
12468	D	0.038
12470	A	0.001
12472	B C	0.001
12473	B C	0.023
12474	D	0.003
12477	B C	2.400
20008	B D	0.005
20020	D	0.001
20033	C D	0.200
20034	D	0.001
20058	D	0.001
20064	D	0.001
20139	C D	0.060
20142	D	0.001
20169	D	0.026
20177	C	0.001
20187	D	0.002
20188	D	0.008
20203	C	0.034
20216	D	0.001
20229	D	0.025
20237	B	0.040
20240	C	0.002
20244	C	0.001
20247	B	0.059
20254	C	0.020
20263	D	0.002
20267	D	0.001
20270	D	0.002
20288	D	0.037
20310	C	0.190
20311	C	0.034
20312	B C D	0.900
20321	D	0.008
20328	D	0.001
20331	C	0.107
20339	D	0.500
20342	C	0.039
20349	C	0.018
20350	C D	0.003
20353	B C	0.006
20355	C	0.033

APPENDIX I
308 PORTFOLIO
WASTEWATER FLOW DATA

Plant No.	Subcategory	Discharge Flow, MGD
20363	A C D	0.125
20364	B D	0.006
20366	B C D	0.010
20443	B D	0.023
20453	D	0.010
20466	D	0.001
20473	B	0.001
20494	D	0.001
20519	D	0.010
20527	D	0.001

* These plants are combined direct/indirect dischargers. The value reported is for the appropriate portion of the total discharge.

Notes:

1. The above plants were the only ones to report flow data in the 308 Portfolio. For all others the discharge flows were unknown or negligible.

2. The discharge flows consist of wastewater from the following sources:
   - Direct process contact
   - Indirect process contact
   - Non-contact
   - Maintenance and equipment cleaning
   - Air pollution control

3. The discharge flows do not contain:
   - Non-contact cooling water
   - Sanitary/potable water
   - Storm water

APPENDIX J

WASTEWATER TREATMENT SYSTEMS

APPENDIX J

PHARMACEUTICAL INDUSTRY

WASTEWATER TREATMENT SYSTEMS

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12001	D	Industrial Wastes Equalization Primary Chemical Flocculation/ Clarification Aerated Lagoon Drying Beds Landfill	X
		Sanitary Wastes Activated Sludge Sand Filtration Mechanical Thickening Sludge to POTW	X
12003	A C D	Neutralization	
12007	D	Neutralization Sludge to Sewer System	
12011	A B D	Neutralization	
12012	B D	Equalization	
12014	B	Biological Treatment	X
12015	D	Equalization Primary Sedimentation Activated Sludge with Powdered Activated Carbon Secondary Chemical Flocculation/ Clarification Gravity Dewatering Aerobic Digestion Landfill	X
12022	A C	Cyanide Destruction Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Activated Sludge Trickling Filter Mechanical Thickening Chemical Conditioning Vacuum Dewatering Incineration Landfill	X

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12026	C	Equalization Neutralization Activated Sludge Aerated Lagoon Polishing Pond Anaerobic Digestion	X
12030	D	Retention for Radioactive Decay	
12036	A	Activated Sludge Trickling Filter Aerated Lagoon Waste Stabilization Pond Polishing Pond Aerobic Digestion Cropland Use	X
12038	A B C D	Fermentation Wastes Equalization Neutralization Coarse Setteable Solids Removal Primary Sedimentation Activated Sludge Tertiary Plant Centrifugal Dewatering Anaerobic Digestion Landfill	X
		Chemical Wastes Solvent Recovery Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Primary Chemical Flocculation/ Clarification Aerated Lagoon Tertiary Plant Centrifugal Dewatering Anaerobic Digestion Landfill	X
		Pretreatment Solvent Recovery In-Plant Evaporation Steam Stripping Tertiary Plant Heat Conditioning	X

APPENDIX J (continued)

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12038 (cont.)	A B C D	Thermal Oxidation Equalization Neutralization P/C: Thermal Oxidation Tertiary Plant	X
12042	A B D	Equalization Neutralization	
12043	C	Solvent Recovery Neutralization Coarse Settleable Solids Removal	
12044	A D	Neutralization	
12052	C D	Primary Sedimentation Activated Sludge	X
12053	D	Equalization Coarse Settleable Solids Removal Activated Sludge Trickling Filter Sand Filtration Mechanical Thickening Drying Beds Cropland Use	X
12056	D	De-Gasifier De-Mineralizer Neutralization Activated Carbon Filtration	
12066	B C D	Neutralization Activated Sludge Aerated Lagoon Mechanical Thickening Sludge to POTW	X
12077	C D	Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Dissolved Air Flotation Sludge to POTW	
12085	D	Activated Sludge Landfill	X

APPENDIX J (continued)

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12087	C	Solvent Recovery Neutralization Coarse Settleable Solids Removal Dissolved Air Flotation Sludge Hauling	
12089	B D	Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Activated Sludge Trickling Filter Polishing Pond Mechanical Thickening Anaerobic Digestion Drying Beds Cropland Use	X
12093	C D	Equalization Aerated Equalization Tanks	
12095	C D	Equalization Neutralization Coarse Settleable Solids Removal Primary Chemical Flocculation/ Clarification Physical/Chemical Treatment Secondary Neutralization Flotation Thickening Sludge Hauling	X
12097	C D	<u>Chemical Wastes</u> Equalization Neutralization Physical/Chemical Treatment Filtration/Presses Chemical Stabilization Chemical Conditioning Vacuum Dewatering Landfill	X
		<u>Floor Washes</u> Coarse Settleable Solids Removal Activated Sludge with Powdered Activated Carbon Physical/Chemical Treatment Secondary Chemical Flocculation/ Clarification Chemical Stabilization Chemical Conditioning Vacuum Dewatering Landfill	X

APPENDIX J (continued)

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12098	D	Activated Sludge Landfill	X
12102	C D	Equalization Neutralization	
12104	D	Equalization Neutralization Waste Stabilization Ponds Chemical Conditioning Mechanical Dewatering Landfill	X
12108	A C D	Neutralization	
12113	D	Equalization Neutralization	
12117	B D	Activated Sludge Chlorination Gravity Aerobic Digestion Dewatering	X
12119	A D	Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Activated Sludge P/C: Evaporation Anaerobic Digestion Drying Beds Sludge to POTW	X
12123	C D	Equalization Neutralization	
12125	D	Neutralization Physical/Chemical Treatment Secondary Neutralization	X
12132	A C	Solvent Recovery Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Primary Chemical Flocculation/ Clarification	X

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12132 (cont'd)	A C	Activated Sludge Trickling Filter Waste Stablization Ponds Flotation Thickening Centrifugal Thickening Centrifugal Dewatering Incineration Landfill	
12135	B C D	Cyanide Destruction Equalization Neutralization	
12141	D	Neutralization Primary Sedimentation Activated Sludge Sludge Hauling	X
12159	C D	Solvent Recovery Steam Stripping	
12160	D	Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Activated Sludge P/C: Evaporation Multi-Media Filtration Flotation Thickening Anaerobic Digestion Sludge Hauling	X
12161	A C D	Solvent Recovery Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Primary Chemical Flocculation/ Clarification Activated Sludge Polishing Pond Gravity Thickening Aerobic Digestion Composting Landfill Cropland Use	X
12175	D	Equalization	

APPENDIX J (continued)

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12186	C D	Neutralization Activated Sludge Aerated Lagoon Ozone Polishing	X
12187	C	Solvent Recovery Zinc Isolation Equalization Neutralization Coarse Settleable Solids Removal Dissolved Air Flotation Trickling Filter Gravity Thickening Sludge to POTW Vacuum Dewatering Landfill	X
12191	A B C	Neutralization	
12199	A C D	Solvent Recovery	
12204	A B C D	Solvent Recovery Mercury Collection Neutralization Coarse Settleable Solids Removal Primary Chemical Flocculation/ Clarification Activated Sludge with Pure Oxygen Mechanical Thickening Chemical Conditioning Vacuum Dewatering Composting	X
12205	D	Equalization Activated Sludge Sand Filtration Mechanical Thickening Aerobic Digestion Sludge to POTW	X
12210	B C	Aerated Lagoon	X
12231	A D	Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Aerated Lagoon Waste Stabilization Ponds Anaerobic Digestion Landfill	X

APPENDIX J (continued)

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12236	C	Weak Wastes	
		Cyanide Destruction	
		Solvent Recovery	
		Equalization	
		Neutralization	
		Primary Oil/Solvent Skimming	
		Strong Wastes	X
		Cyanide Destruction	
		Solvent Recovery	
		Equalization	
		Neutralization	
		Primary Sedimentation	
		Activated Sludge	
		Flotation Thickening	
		Chemical Conditioning	
		Vacuum Filtration	
		Landfill	
12239	D	Activated Sludge	X
		Landfill	
12240	C D	Equalization	X
		Neutralization	
		Physical/Chemical Treatment	
		Chlorination	
12246	C D	Solvent Recovery	
		In-Plant Evaporation	
12248	D	Equalization	X
		Coarse Settleable Solids Removal	
		Activated Sludge	
		Mechanical Thickening	
		Gravity Dewatering	
		Aerobic Digestion	
		Dewatering	
		Landfill	
12252	A C D	Equalization	
		Neutralization	
		Coarse Settleable Solids Removal	
12254	A D	Equalization	
		Neutralization	

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12256	A B C D	Solvent Recovery In-Plant Evaporation Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation w/Skimming	
12257	A B C D	Equalization Neutralization Activated Sludge Centrifugal Dewatering Cropland Use	X
12261	C	Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Aerated Lagoon P/C: Thermal Oxidation Secondary Neutralization Chlorination Vacuum Dewatering Landfill	X
12275	B C	Equalization Neutralization	
12282	B C D	Neutralization Coarse Settleable Solids Removal Primary Sedimentation Primary Chemical Flocculation/ Clarification Sand Filtration Gravity Dewatering Sludge Storage	X
12283	D	Activated Sludge Landfill	X
12287	D	Coarse Settleable Solids Removal Primary Sedimentation Aerated Lagoon	X
12294	C D	Solvent Recovery Equalization Neutralization Activated Sludge Multi-Media Filtration Centrifugal Thickening Centrifugal Dewatering Incineration Landfill	X

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12298	D	Activated Sludge Landfill	X
12305	D	Equalization Neutralization	
12307	D	Primary Sedimentation Activated Sludge Aerated Lagoon Chlorination Mechanical Thickening Flotation Thickening	X
12308	D	Activated Sludge Chlorination Landfill	X
12311	A B C D	Activated Sludge Mechanical Thickening Centrifugal Thickening Landfill	X
12317	D	Equalization Neutralization Coarse Settleable Solids Removal Activated Sludge Physical/Chemical Treatment Multi-Media Filtration Mechanical Thickening Aerobic Digestion Cropland Use	X
12330	A B C D	Neutralization	
12332	C	Equalization Neutralization Waste Stabilization Pond	X
12333	C D	Solvent Recovery Coarse Settleable Solids Removal Primary Sedimentation Multi-Media Filtration Landfill	X
12338	D	Coarse Settleable Solids Removal Primary Sedimentation Activated Sludge Sand Filtration Mechanical Thickening Anaerobic Digestion Sludge Hauling	X

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12339	A C D	Thermal Oxidation (3 Units) Neutralization Coarse Settleable Solids Removal P/C: Thermal Oxidation Tertiary Plant	X
		Oil Dehydration Neutralization P/C: Evaporation Tertiary Plant Centrifugal Dewatering Pyrolysis Landfill	X
		Sanitary Wastes Primary Separation Activated Sludge Tertiary Plant Mechanical Thickening Evaporation Aerobic Digestion Dewatering Pyrolysis Landfill	X
		Solvents Solvent Recovery Steam Stripping Tertiary Plant	X
12343	A C D	Neutralization	
12392	D	Neutralization	
12406	C	Neutralization Physical/Chemical Treatment Secondary Chemical Flocculation/ Clarification Polishing Pond Sludge Dewatering Landfill	X

APPENDIX J (continued)

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12407	C	Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Primary Chemical Flocculation/ Clarification Activated Sludge Physical/Chemical Treatment Polishing Pond Flotation Thickening Landfill	X
12411	B C D	Solvent Recovery Equalization Neutralization Aerated Lagoon Incineration	X
12420	B D	Activated Sludge Chemical Conditioning Centrifugal Dewatering Landfill	X
12438	D	Aerated Equalization Tanks	
12439	C D	Equalization Neutralization Primary Sedimentation Activated Sludge Aerated Lagoon Landfill	X
12441	C	Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation	
12447	A B C D	Deep Well Injection Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Physical/Chemical Treatment Diatomaceous-Earth Filtration	X

APPENDIX J (continued)

Plant Code No.	Subcategories	Treatment System	BPT Treatment
12454	B D	Primary Sedimentation Trickling Filter Anaerobic Digestion Landfill	X
12458	C D	Equalization Neutralization	
12459	D	Equalization Aerated Lagoon Polishing Pond Chlorination	X
12462	A	Activated Sludge Aerated Lagoon Sludge Hauling	X
12463	B D	Coarse Settleable Solids Removal Activated Sludge Waste Stabilization Pond Physical/Chemical Treatment Secondary Chemical Flocculation/ Clarification Flotation Thickening Sludge Hauling	X
12471	B	Coarse Settleable Solids Removal Aerated Lagoon Secondary Chemical Flocculation/ Clarification Polishing Pond Secondary Neutralization Chlorination Drying Beds Landfill	X
12475	C	Equalization Neutralization Activated Sludge Forest Land Use	X
12476	D	Equalization Neutralization Activated Sludge Forest Land Use	X
12477	B C	Equalization Neutralization	

APPENDIX J (continued)

Plant Code No.	Subcategories	Treatment System	BPT Treatment
20014	D	In-Plant Evaporation	
20017	D	Activated Carbon Filtration Landfill	X
20030	C D	In-Plant Evaporation	
20033	C D	Primary Sedimentation	
20037	D	Activated Sludge Aerated Lagoon Polishing Pond Landfill	X
20057	D	Primary Sedimentation Landfill	
20139	C D	Cyanide Destruction Solvent Recovery In-Plant Neutralization	
20153	D	Multi-Media Filtration	X
20165	B C	Aerated Lagoon	X
20177	C	Neutralization	
20195	D	P/C: Evaporation	X
20201	D	Solvent Recovery Activated Sludge	X
20203	C	Cyanide Destruction Chromium Reduction Metals Precipitation Solvent Recovery Equalization Neutralization Coarse Settleable Solids Removal Primary Chemical Flocculation/ Clarification Landfill	
20204	C D	Solvent Recovery In-Plant Neutralization Neutralization Aerated Lagoon Sludge Lagoon	X

APPENDIX J (continued)

Plant Code No.	Subcategories	Treatment System	BPT Treatment
20205	C	Solvent Recovery Neutralization Coarse Settleable Solids Removal Aerated Lagoon Landfill	X
20206	C	Solvent Recovery Equalization Aerated Lagoon Landfill	X
20234	C	Solvent Recovery Neutralization Primary Sedimentation	
20236	D	Activated Sludge	X
20237	B	Solvent Recovery Steam Stripping Equalization	
20244	C	Solvent Recovery Equalization Neutralization Primary Chemical Flocculation/ Clarification Landfill	
20245	A C	Solvent Recovery Steam Stripping In-Plant Neutralization Equalization Neutralization Coarse Settleable Solids Removal Primary Chemical Flocculation/ Clarification Activated Sludge Landfill	X
20246	C	Equalization Neutralization Primary Sedimentation Activated Sludge Multi-Media Filtration Chlorination Vacuum Filtration Incineration	X

APPENDIX J (continued)

Plant Code No.	Subcategories	Treatment System	BPT Treatment
20254	C	Solvent Recovery Neutralization Primary Sedimentation Aerated Lagoon Polishing Pond	X
20257	C	Equalization Neutralization Coarse Settleable Solids Removal Primary Sedimentation Activated Sludge Sludge Lagoon	X
20258	C D	Equalization Neutralization Activated Sludge	X
20263	D	Coarse Settleable Solids Removal	
20273	D	Coarse Settleable Solids Removal Sludge Hauling	
20297	C	Neutralization Coarse Settleable Solids Removal Primary Sedimentation Activated Sludge Trickling Filter P/C: Evaporation	X
20298	C	Metals Precipitation In-Plant Evaporation Neutralization Primary Sedimentation Activated Sludge Incineration Cropland Use	X
20310	C	Cyanide Destruction Solvent Recovery Steam Stripping Neutralization Coarse Settleable Solids Removal	
20312	B C D	Aerated Lagoon Landfill	X
20319	D	Coarse Settleable Solids Removal P/C: Oxidation Trickling Filter Waste Stabilization Pond Sludge Hauling	X

APPENDIX J (continued)

Plant Code No.	Subcategories	Treatment System	BPT Treatment
20339	D	Waste Stabilization Pond	X
20342	C	In-Plant Neutralization Coarse Settleable Solids Removal Sludge Hauling	
20349	C	Neutralization	
20355	C	Neutralization	
20356	C D	In-Plant Neutralization	
20363	A C D	Equalization Neutralization Primary Sedimentation	
20370	B C	Rotating Biological Contactor Chlorination Sludge Hauling	X
20373	C	Steam Stripping In-Plant Evaporation Neutralization Primary Sedimentation w/Skimming	
20376	D	In-Plant Evaporation	
20389	C	Aerated Lagoon	X
20402	D	Primary Sedimentation Waste Stabilization Pond Multi-Media Filtration	X
20423	D	In-Plant Evaporation	
20456	D	Primary Sedimentation	
20476	D	Metals Precipitation Ultraviolet Sterilization Chlorination	

APPENDIX K

LONG TERM DATA SUMMARIES

APPENDIX K

PHARMACEUTICAL INDUSTRY
SUMMARY OF LONG TERM DATA

PLANT	SUBCAT	FLOW EFF	BOD INFLUENT	BOD EFFLUENT	BOD REMOVAL	COD INFLUENT	COD EFFLUENT	COD REMOVAL	TSS INFLUENT	TSS EFFLUENT	TSS REMOVAL	CYANIDE EFFLUENT
12015	D	0.101	232.528	9.696	0.958	552.682	43.977	0.920	124.254	10.046	0.919	ND
12022	A C	1.448	2141.616	110.245	0.949	ND	ND	ND	260.000	84.253	0.676	ND
12026	C	0.161	3669.956	108.136	0.971	7334.695	1221.750	0.833	87.943	283.679	-2.226	ND
12036	A	5.157	1570.773	7.019	0.996	3542.269	278.000	0.922	1059.129	17.359	0.984	ND
12097	CD	0.064	1577.262	48.687	0.969	1884.840	43.721	0.977	ND	26.803	ND	0.030
12098	D	0.006	ND	603.480	ND	ND	ND	ND	ND	392.080	ND	ND
12117	B	0.101	34.500	1.541	0.955	95.412	24.488	0.743	ND	16.000	ND	ND
12123	CD	0.932	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.307
12160	D	0.029	490.185	166.853	0.660	2160.444	516.687	0.761	1615.192	115.406	0.929	ND
12161	A CD	1.653	1538.897	21.932	0.986	4332.562	850.237	0.804	795.940	63.602	0.920	ND
12186	CD	0.037	ND	77.007	ND	ND	447.536	ND	ND	146.061	ND	ND
12187	C	1.065	ND	707.250	ND	ND	ND	ND	ND	60.500	ND	ND
12236	C	0.722	831.724	106.714	0.872	2421.750	396.382	0.836	ND	64.714	ND	0.282
12235	C	0.907	ND	ND	ND	ND	991.000	ND	ND	ND	ND	0.350
12236	C	0.849	710.614	132.817	0.813	1881.679	537.829	0.714	ND	61.036	ND	0.262
12248	D	0.110	294.442	26.000	0.912	473.902	95.847	0.798	ND	60.423	ND	ND
12257	ABCD	0.754	2961.696	228.375	0.923	ND	ND	ND	1009.375	715.268	0.291	ND
12294	CD	0.118	1584.286	44.679	0.972	3429.607	232.286	0.932	ND	52.868	ND	ND
12307	D	0.002	ND	11.349	ND	ND	106.387	ND	ND	31.472	ND	ND
12317	D	0.740	1003.722	7.810	0.992	1102.250	42.249	0.962	42.111	9.819	0.767	ND
12420	B D	0.164	ND	786.797	ND	ND	ND	ND	ND	966.396	ND	ND
12439	CD	0.040	ND	495.364	ND	ND	971.197	ND	ND	ND	ND	ND
12459	D	0.049	69.500	3.742	0.946	298.857	110.660	0.630	58.571	14.845	0.747	ND
12462	A	0.209	1804.981	726.806	0.597	5182.391	2490.448	0.519	2034.595	2020.433	0.007	ND

ND = NO DATA

APPENDIX K

LONG TERM DATA SUMMARY
BOD INFLUENT & EFFLUENT CONCENTRATION (MG/L)

PLANT CODE	SUB CAT	INFLUENT AVG	INFLUENT MIN	INFLUENT MAX	EFFLUENT AVG	EFFLUENT MIN	EFFLUENT MAX
12015	D	232.53	77.00	440.00	9.70	1.00	43.00
12022	A C	2141.62	315.00	8485.00	110.24	3.00	630.00
12026	C	3669.96	1665.00	5877.00	108.14	20.00	469.00
12036	A	1570.77	48.00	3400.00	7.02	1.00	40.00
12097	CD	1577.26	64.00	4692.00	48.69	0.0	228.30
12098	D	ND	ND	ND	603.48	15.00	5250.00
12117	B	34.50	0.0	126.00	1.54	0.0	5.00
12123	CD	ND	ND	ND	ND	ND	ND
12160	D	490.19	107.00	1660.00	166.85	13.00	653.00
12161	A CD	1538.90	105.00	4800.00	21.93	6.00	165.00
12186	CD	ND	ND	ND	77.01	6.70	264.70
12187	C	ND	ND	ND	707.25	500.00	908.00
12236	C	831.72	300.00	2280.00	106.71	6.00	366.00
12235	C	ND	ND	ND	ND	ND	ND
12236	C	710.61	1.00	1530.00	132.82	28.00	1050.00
12248	D	294.44	60.00	700.00	26.00	2.00	76.00
12257	ABCD	2961.70	2119.00	4414.00	228.37	51.00	770.00
12294	CD	1584.29	701.00	2726.00	44.68	4.30	185.00
12307	D	ND	ND	ND	11.35	0.90	91.00
12317	D	1003.72	44.00	2266.00	7.81	1.10	31.30
12420	B D	ND	ND	ND	786.80	20.00	4566.00
12439	CD	ND	ND	ND	495.36	32.00	2500.00
12459	D	69.50	18.00	114.00	3.74	0.0	9.90
12462	A	1804.98	60.10	5522.00	726.81	20.00	4140.00

ND = NO DATA

APPENDIX K

LONG TERM DATA SUMMARY
COD INFLUENT & EFFLUENT CONCENTRATIONS (MG/L)

PLANT CODE	SUB CAT	INFLUENT AVG	INFLUENT MIN	INFLUENT MAX	EFFLUENT AVG	EFFLUENT MIN	EFFLUENT MAX
12015	D	552.68	180.00	3070.00	43.98	9.00	179.00
12022	A C	ND	ND	0.0	ND	ND	0.0
12026	C	7334.70	2500.00	14000.00	1221.75	520.00	3040.00
12036	A	3542.27	166.00	5360.00	278.00	17.00	2951.00
12097	CD	1884.84	138.00	3393.00	43.72	4.00	797.00
12098	D	ND	ND	ND	ND	ND	ND
12117	B	95.41	19.00	236.00	24.49	0.90	73.00
12123	CD	ND	ND	ND	ND	ND	ND
12160	D	2160.44	244.00	9820.00	516.69	28.00	1911.00
12161	A CD	4332.56	240.00	23200.00	850.24	180.00	3580.00
12186	CD	ND	ND	ND	447.54	164.00	946.00
12187	C	ND	ND	ND	ND	ND	ND
12236	C	2421.75	1040.00	5676.00	396.38	178.00	1234.00
12235	C	ND	ND	ND	991.00	991.00	991.00
12236	C	1881.68	706.00	3266.00	537.83	136.00	1954.00
12248	D	473.90	159.00	1372.00	95.85	14.00	374.00
12257	ABCD	ND	ND	ND	ND	ND	ND
12294	CD	3429.61	2432.00	5045.00	232.29	119.00	587.00
12307	D	ND	ND	ND	106.39	6.00	571.00
12317	D	1102.25	44.00	2254.00	42.25	4.40	194.40
12420	B D	ND	ND	ND	ND	ND	ND
12439	CD	ND	ND	ND	971.20	50.00	4136.00
12459	D	298.86	112.00	437.00	110.66	0.0	325.00
12462	A	5182.39	81.00	36000.00	2490.45	0.0	11971.00

ND = NO DATA

APPENDIX K

LONG TERM DATA SUMMARY
TSS INFLUENT & EFFLUENT CONCENTRATIONS (MG/L)

PLANT CODE	SUB CAT	INFLUENT AVG	INFLUENT MIN	INFLUENT MAX	EFFLUENT AVG	EFFLUENT MIN	EFFLUENT MAX
12015	D	124.25	0.0	440.00	10.05	0.0	268.00
12022	A C	260.00	260.00	260.00	84.25	5.00	343.00
12026	C	87.94	11.00	226.00	283.68	50.00	615.00
12036	A	1059.13	30.00	2520.00	17.36	1.00	262.00
12097	CD	ND	ND	ND	26.80	1.30	936.90
12098	D	ND	ND	ND	392.08	52.00	2664.00
12117	B	ND	ND	ND	16.00	1.00	51.00
12123	CD	ND	ND	ND	ND	ND	ND
12160	D	1615.19	32.00	10910.00	115.41	5.00	490.00
12161	A CD	795.94	24.00	8220.00	63.60	5.00	2080.00
12186	CD	ND	ND	ND	146.06	20.00	940.00
12187	C	ND	ND	ND	60.50	37.00	95.00
12236	C	ND	ND	ND	64.71	10.00	560.00
12235	C	ND	ND	ND	ND	ND	ND
12236	C	ND	ND	ND	61.04	6.00	332.00
12248	D	ND	ND	ND	60.42	6.00	164.00
12257	ABCD	1009.37	510.00	1570.00	715.27	64.00	3320.00
12294	CD	ND	ND	ND	52.87	0.0	419.80
12307	D	ND	ND	ND	31.47	0.0	204.00
12317	D	42.11	0.0	116.00	9.82	0.40	74.20
12420	B D	ND	ND	ND	966.40	4.00	7890.00
12439	CD	ND	ND	ND	ND	ND	ND
12459	D	58.57	40.00	96.00	14.85	0.0	123.00
12462	A	2034.59	16.00	30239.00	2020.43	9.00	9585.00

ND = NO DATA

APPENDIX K

LONG TERM DATA SUMMARY
EFFLUENT FLOW (MGD) & EFFLUENT CYANIDE (UG/L)

PLANT CODE	SUB CAT	FLOW AVG	FLOW MIN	FLOW MAX	CYANIDE AVG	CYANIDE MIN	CYANIDE MAX
12015	D	0.101	0.056	0.142	ND	ND	ND
12022	A C	1.448	0.810	2.050	ND	ND	ND
12026	C	0.161	0.078	0.246	ND	ND	ND
12036	A	5.157	0.859	12.001	ND	ND	ND
12097	CD	0.064	0.004	0.173	0.030	0.030	0.030
12098	D	0.006	0.001	0.014	ND	ND	ND
12117	B	0.101	0.050	0.177	ND	ND	ND
12123	CD	0.932	0.250	1.000	1.307	0.004	14.200
12160	D	0.029	0.013	0.050	ND	ND	ND
12161	A CD	1.653	0.489	2.432	ND	ND	ND
12186	CD	0.037	0.003	0.102	ND	ND	ND
12187	C	1.065	0.890	1.290	ND	ND	ND
12236	C	0.722	0.153	1.061	0.282	0.100	8.000
12235	C	0.907	0.907	0.907	0.350	0.350	0.350
12236	C	0.849	0.519	1.245	0.262	0.100	0.620
12248	D	0.110	0.043	0.169	ND	ND	ND
12257	ABCD	0.754	0.444	0.989	ND	ND	ND
12294	CD	0.118	0.043	0.173	ND	ND	ND
12307	D	0.002	0.001	0.004	ND	ND	ND
12317	D	0.740	0.200	1.150	ND	ND	ND
12420	B D	0.164	0.022	0.230	ND	ND	ND
12439	CD	0.040	0.040	0.040	ND	ND	ND
12459	D	0.049	0.016	0.160	ND	ND	ND
12462	A	0.209	0.067	0.601	ND	ND	ND

ND = NO DATA

APPENDIX L

WASTEWATER DISCHARGE METHODS

APPENDIX L

PHARMACEUTICAL INDUSTRY
WASTEWATER DISCHARGE METHODS

Plant Code No.	Type of Discharge: Indirect	Direct	Zero	Comment	POTW[1] Treatment Level
12000	X				T
12001		X			
12003	X				P
12004	X				S
12005	X				S
12006		X			
12007	X				S
12011	X				S
12012	X				T
12014		X			
12015			X	Recycle/Reuse	
12016	X				S
12018	X			Land Application	S
12019	X				-
12021			X	No Process Wastewater	
12022		X			
12023	X				S
12024	X			Recycle/Reuse	-
12026		X			
12030		X		Private Treatment System	
12031	X				T
12035	X				T
12036		X			
12037	X				S
12038		X		Evaporation	
12040	X				S
12042	X				-
12043	X			Subsurface Discharge	S
12044	X			Subsurface Discharge	S
12048	X				S
12051	X				S
12052			X	Subsurface Discharge	
12053		X			
12054	X				-
12055	X				-
12056	X				S
12057	X	X			P
12058	X				S
12060	X				S
12061	X				S
12062	X				S
12063			X	Subsurface Discharge	
12065	X			Septic System	S
12066	X				T
12068	X				

APPENDIX L (cont'd)

Plant Code No.	Type of Discharge: Indirect	Direct	Zero	Comment	POTW[1] Treatment Level
12069	X				S
12073		X		Private Treatment System	
12074	X				T
12076	X				P
12077	X				P
12078	X				P
12080	X				S
12083	X				P
12084	X				T
12085		X			
12087	X			Contract Disposal	S
12088	X				P
12089		X			
12093	X				S
12094	X				T
12095		X			
12097		X		Deep Well Injection	
12098		X			
12099			X	Contract Disposal	
12100	X				-
12102			X	Ocean Discharge	
12104	X	X			P
12107	X				P
12108	X			Ocean Discharge	-
12110	X				P
12111	X				-
12112	X				T
12113	X				S
12115	X				S
12117		X		Private Treatment System	
12118	X			Subsurface Discharge	S
12119		X			
12120	X				S
12122	X				
12123	X				S
12125	X				-
12128	X				-
12129	X				-
12131	X				T
12132		X		Land Application	
12133			X	No Process Wastewater	
12135	X				S
12141	X				S
12143	X				S

APPENDIX L (cont'd)

Plant Code No.	Type of Discharge: Indirect	Direct	Zero	Comment	POTW[1] Treatment Level
12144	X				-
12145	X				T
12147	X				S
12155	X				S
12157	X				-
12159			X	Recycle/Reuse	
12160		X		Private Treatment System	
12161		X			
12166	X				-
12168	X			Evaporation	S
12171	X				S
12172	X				
12173			X	No Process Wastewater	
12174			X	Evaporation	
12175		X		Private Treatment System	
12177	X				-
12178	X				S
12183	X				S
12185			X	Ocean Discharge	
12186	X				S
12187	X	X		(Also Contract Disposal)	S
12191	X				S
12194		X		Private Treatment System	
12195	X				S
12198	X				S
12199	X				S
12201	X				S
12204	X				S
12205		X			
12206	X				S
12207	X				P
12210	X			Land Application	S
12211	X				-
12212	X				P
12217	X			Contract Disposal	S
12219	X				P
12224	X				S
12225			X	No Process Wastewater	
12226	X				-
12227	X				S
12230	X				-
12231			X	Subsurface Discharge	
12233	X				P
12235		X		Ocean Discharge	

APPENDIX L (cont'd)

Plant Code No.	Type of Discharge: Indirect	Direct	Zero	Comment	POTW[1] Treatment Level
12236		X			
12238	X				S
12239		X			
12240	X			Contract Disposal	S
12243	X				P
12244	X				T
12245	X			Evaporation	S
12246	X			Contract Disposal	P
12247	X				S
12248		X		Private Treatment System	
12249	X				S
12250	X				S
12251	X				S
12252	X				S
12254	X				S
12256	X	X		(Also Land Application)	S
12257	X			Land Application	T
12260	X				T
12261		X			
12263			X	Septic System	
12264	X	X			S
12265	X				S
12267		X			
12268	X				P
12269			X	Septic System	
12273	X				
12275	X				S
12277	X				
12281	X	X			P
12282	X				T
12283		X			
12287	X	X			S
12289	X				S
12290	X				-
12294		X			
12295	X				P
12296	X				S
12297			X	Contract Disposal	
12298		X			
12300	X				T
12302	X				S
12305	X				S
12306			X	Septic System	
12307		X			

APPENDIX L (cont'd)

Plant Code No.	Type of Discharge: Indirect	Direct	Zero	Comment	POTW[1] Treatment Level
12308		X			
12309	X				-
12310	X				P
12311	X				S
12312	X				S
12317		X			
12318	X				S
12322	X				P
12326			X	Septic System	
12330	X				P
12331	X				S
12332	X				S
12333	X				P
12338		X			
12339		X		Land Application	
12340	X				P
12342	X				S
12343	X				P
12345	X			Land Application	S
12375	X				S
12384	X				S
12385	X				T
12392	X				
12401	X				S
12405	X				-
12406		X			
12407		X			
12409	X				-
12411	X			Contract Disposal	S
12414	X				S
12415	X				T
12417	X				-
12419	X				T
12420	X				T
12427	X				S
12429	X				S
12433	X				S
12438	X				S
12439			X	Land Application	
12440	X				-
12441	X				S
12444	X				S
12447	X			Deep Well Injection	-
12454	X				S

APPENDIX L (cont'd)

Plant Code No.	Type of Discharge: Indirect	Direct	Zero	Comment	POTW[1] Treatment Level
12458	X				S
12459		X			
12460	X				-
12462		X			
12463		X		Land Application	
12464	X				-
12465	X				S
12466			X	Septic System	
12467	X				S
12468	X				S
12470	X				-
12471		X			
12472	X				P
12473	X				P
12474	X				S
12475			X	Land Application	
12476			X	Land Application	
12477	X				P
12479	X			Ocean Discharge	S
12481	X				P
12482	X				-
12495	X				S
12499	X				-
20006			X	No Process Wastewater	See
20008	X				Footnote
20012	X				No. 2
20014			X	Evaporation	
20015			X	No Process Wastewater	
20016			X	No Process Wastewater	
20017	X				
20020	X				
20026	X				
20030			X	Evaporation	
20032	X				
20033	X				
20034	X				
20035			X	No Process Wastewater	
20037		X			
20038			X	No Process Wastewater	
20040			X	No Process Wastewater	
20041			X	No Process Wastewater	
20045			X	No Process Wastewater	
20048			X	No Process Wastewater	
20049			X	No Process Wastewater	

APPENDIX L (cont'd)

Plant Code No.	Type of Discharge: Indirect	Direct	Zero	Comment	POTW[1] Treatment Level
20050	X				
20051			X	No Process Wastewater	
20052	X			Septic System	
20054			X	Contract Disposal	
20055			X	No Process Wastewater	
20057	X				See
20058	X				Footnote
20062	X				No. 2
20064	X				
20070			X	No Process Wastewater	
20073			X	No Process Wastewater	
20075			X	No Process Wastewater	
20078			X	No Process Wastewater	
20080			X	No Process Wastewater	
20081	X				
20082			X	No Process Wastewater	
20084			X	No Process Wastewater	
20087			X	No Process Wastewater	
20089	X				
20090			X	No Process Wastewater	
20093			X	No Process Wastewater	
20094			X	No Process Wastewater	
20099			X	No Process Wastewater	
20100			X	No Process Wastewater	
20103			X	No Process Wastewater	
20106			X	No Process Wastewater	
20108			X	Evaporation	
20115			X	Septic System	
20117	X				
20120	X				
20125			X	No Process Wastewater	
20126	X				
20134			X	No Process Wastewater	
20139	X				
20141			X	No Process Wastewater	
20142	X			Contract Disposal	
20147	X				
20148			X	No Process Wastewater	
20151			X	No Process Wastewater	
20153	X				
20155	X				
20159			X	No Process Wastewater	
20165		X		Contract Disposal	
20169	X				

APPENDIX L (cont'd)

Plant Code No.	Type of Discharge: Indirect	Direct	Zero	Comment	POTW[1] Treatment Level
20173			X	No Process Wastewater	
20174	X				
20176			X	No Process Wastewater	
20177	X				
20178			X	No Process Wastewater	
20187	X				
20188	X				See Footnote No.2
20195			X	Evaporation	
20197			X	No Process Wastewater	
20201		X			
20203	X			Land Application	
20204			X	Land Application	
20205	X				
20206			X	Land Application	
20208			X	No Process Wastewater	
20209			X	No Process Wastewater	
20210			X	No Process Wastewater	
20215			X	No Process Wastewater	
20216	X				
20218			X	No Process Wastewater	
20220	X				
20224	X				
20225			X	No Process Wastewater	
20226			X	No Process Wastewater	
20228			X	No Process Wastewater	
20229	X				
20231	X				
20234	X				
20235			X	No Process Wastewater	
20236			X	Contract Disposal	
20237	X				
20240	X				
20241			X	No Process Wastewater	
20242			X	No Process Wastewater	
20244	X				
20245		X			
20246		X			
20247	X				
20249			X	No Process Wastewater	
20254	X				
20256			X	No Process Wastewater	
20257		X		Contract Disposal	
20258	X				
20261	X				

APPENDIX L (cont'd)

Plant Code No.	Type of Discharge: Indirect	Direct	Zero	Comment	POTW[1] Treatment Level
20263	X				
20264	X				
20266			X	No Process Wastewater	
20267	X				
20269	X				
20270	X				
20271			X	No Process Wastewater	
20273	X				See
20282	X				Footnote
20288	X				No. 2
20294			X	No Process Wastewater	
20295			X	No Process Wastewater	
20297		X			
20298		X			
20300			X	No Process Wastewater	
20303	X				
20305			X	No Process Wastewater	
20307	X				
20308			X	No Process Wastewater	
20310	X			Contract Disposal	
20311	X				
20312	X				
20316			X	No Process Wastewater	
20319		X			
20321	X				
20325			X	No Process Wastewater	
20328	X				
20331	X				
20332			X	No Process Wastewater	
20333	X				
20338			X	No Process Wastewater	
20339	X				
20340			X	Evaporation	
20342	X				
20346	X				
20347			X	No Process Wastewater	
20349	X				
20350	X				
20353	X				
20355	X				
20356	X				
20359	X				
20361	X				
20362	X				

APPENDIX L (cont'd)

Plant Code No.	Type of Discharge: Indirect	Direct	Zero	Comment	POTW[1] Treatment Level
20363	X				
20364	X				
20366	X				
20370		X		Contract Disposal	
20371	X				
20373			X	Land Application	
20376			X	Evaporation	
20377	X				
20385	X				See
20387			X	Contract Disposal	Footnote
20389	X				No. 2
20390			X	No Process Wastewater	
20394			X	No Process Wastewater	
20396			X	No Process Wastewater	
20397			X	No Process Wastewater	
20400	X				
20402		X			
20405	X				
20413			X	Contract Disposal	
20416			X	No Process Wastewater	
20421			X	No Process Wastewater	
20423	X			Evaporation	
20424			X	No Process Wastewater	
20425			X	No Process Wastewater	
20435			X	No Process Wastewater	
20436			X	No Process Wastewater	
20439	X				
20440			X	No Process Wastewater	
20441	X				
20443	X				
20444			X	No Process Wastewater	
20446	X				
20448			X	No Process Wastewater	
20450	X				
20452			X	No Process Wastewater	
20453	X				
20456	X				
20460	X				
20462			X	No Process Wastewater	
20464			X	No Process Wastewater	
20465	X				
20466	X				
20467			X	Subsurface Discharge	
20470			X	No Process Wastewater	

APPENDIX L (cont'd)

Plant Code No.	Type of Discharge: Indirect	Direct	Zero	Comment	POTW[1] Treatment Level
20473	X			Deep Well Injection	
20476	X				
20483			X	No Process Wastewater	
20485			X	No Process Wastewater	
20486			X	No Process Wastewater	
20490	X				
20492	X				
20494	X				
20496			X	No Process Wastewater	
20498			X	No Process Wastewater	See
20500			X	No Process Wastewater	Footnote 2
20502			X	No Process Wastewater	No. 2
20503	X				
20504			X	No Process Wastewater	
20507			X	No Process Wastewater	
20509			X	No Process Wastewater	
20511			X	No Process Wastewater	
20518			X	No Process Wastewater	
20519	X				
20522			X	No Process Wastewater	
20526			X	Contract Disposal	
20527	X				
20529			X	No Process Wastewater	

[1]POTW Treatment Level Symbols:
P - Primary
S - Secondary
T - Tertiary

[2]Data on POTW treatment level was not requested from the Supplemental 308 (20000 series) plants

APPENDIX M

ENGINEERING NEWS-RECORD (ENR) INDICES

APPENDIX M

ENGINEERING NEWS - RECORD (ENR) CONSTRUCTION COST INDICES *

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Index
1964	918	920	922	926	930	935	945	948	947	948	948	948	936
1965	948	957	958	957	958	969	977	984	986	986	986	988	971
1966	988	997	998	1006	1014	1029	1031	1033	1034	1032	1033	1034	1019
1967	1039	1041	1043	1044	1059	1068	1078	1089	1092	1096	1097	1098	1070
1968	1107	1114	1117	1124	1142	1154	1158	1171	1186	1190	1191	1201	1155
1969	1216	1229	1238	1249	1258	1270	1283	1292	1285	1299	1305	1305	1269
1970	1309	1311	1314	1329	1351	1375	1414	1418	1421	1434	1445	1445	1385
1971	1465	1467	1496	1513	1551	1589	1618	1629	1654	1657	1665	1672	1581
1972	1686	1691	1697	1707	1735	1761	1772	1777	1786	1794	1808	1816	1753
1973	1838	1850	1859	1874	1880	1896	1901	1902	1929	1933	1935	1939	1895
1974	1940	1940	1940	1961	1961	1993	2040	2076	2089	2100	2094	2101	2020
1975	2103	2128	2128	2135	2164	2205	2248	2274	2275	2293	2292	2297	2212
1976	2305	2314	2322	2327	2357	2410	2414	2445	2465	2478	2486	2490	2401
1977	2494	2505	2513	2514	2515	2541	2579	2611	2644	2675	2659	2660	2557
1978	2672	2681	2693	2698	2733	2753	2821	2829	2851	2851	2861	2869	2776
1979	2872	2877	2886	2886	2889	2984	3052	3071	3120	3122	3131	3140	3003

* Construction Cost Index - Base Year 1913 = 100

APPENDIX M

CHEMICAL ENGINEERING (CE) PLANT COST INDICES*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Index
1972	136.5	136.0	137.0	137.1	137.1	136.5	136.5	137.0	137.8	138.2	138.4	139.1	137.2
1973	140.8	140.4	141.5	141.8	142.4	144.5	144.6	145.0	146.4	146.7	147.5	148.2	144.1
1974	150.0	150.7	153.8	156.7	161.4	164.7	168.8	172.2	174.8	176.0	177.4	177.8	165.4
1975	179.6	179.5	180.7	180.7	181.0	181.8	181.8	181.9	183.7	185.4	185.7	186.6	182.4
1976	187.1	187.5	188.4	188.9	190.2	191.1	192.0	193.9	195.6	196.3	196.4	197.4	192.1
1977	198.7	198.5	199.3	200.3	201.4	202.3	204.7	206.4	208.8	209.0	209.4	210.3	204.1
1978	210.6	213.1	214.1	215.7	216.9	217.7	219.2	221.6	221.6	223.5	224.7	225.9	218.8
1979	225.9	231.0	232.5	234.0	236.6	237.2	239.3	240.7	243.4	245.8	246.8	247.6	238.7
1980	249.9	255.1											

* CE Plant Cost Index - Base Year 1957-59 = 100