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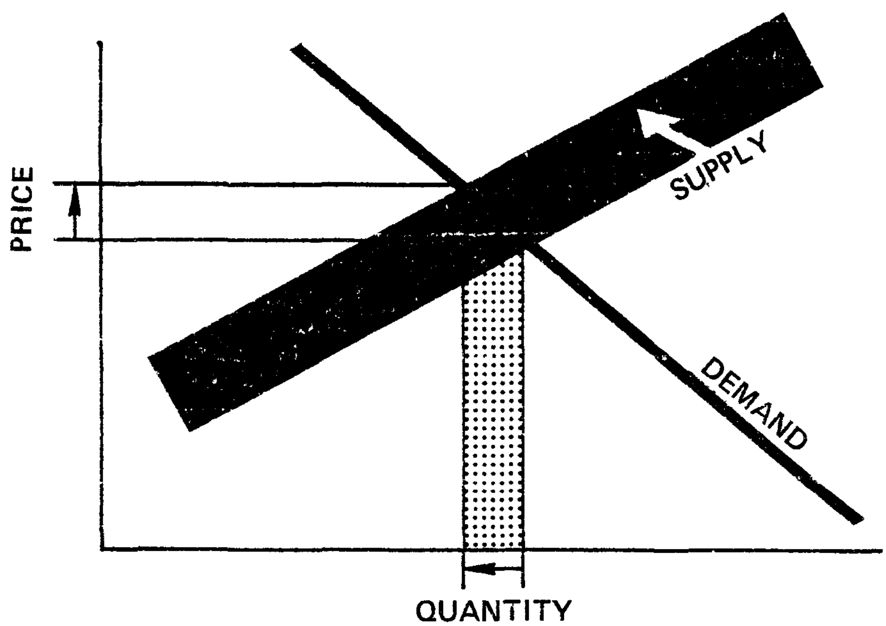
Economic Analysis of Proposed Effluent Standards and Limitations for the Pesticide Industry



ECONOMIC IMPACT ANALYSIS OF PROPOSED EFFLUENT STANDARDS AND LIMITATIONS FOR THE PESTICIDES INDUSTRY

Economic Impact Analysis

Prepared for

U. S. Environmental Protection Agency
Office of Analysis and Evaluation
Washington, DC 20460

by

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Cambridge, Massachusetts

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Preface

The attached document is a contractor's study prepared for the Office of Water Regulations and Standards of the Environmental Protection Agency ("EPA"). The purpose of the study is to analyze the economic impact which could result from the application of alternative BPT, BCT, BAT, PSES, NSPS and PSNS limitations and standards established under the Federal Water Pollution control Act (the Act), as amended.

The study supplements the technical study ("EPA Development Document") supporting the proposal of regulations under the Act. The Development Document surveys existing and potential waste treatment control methods and technology within particular industrial source categories and supports proposed limitations based upon an analysis of the feasibility of these limitations in accordance with the requirements of the Act. Presented in the Development Document are the investment and operating costs associated with various alternative control and treatment technologies. The attached document supplements this analysis by estimating the broader economic effects which might result from the required application of various control methods and technologies. This study investigates the effect of alternative approaches in terms of price increases, effects upon employment and the continued viability of affected plants, and other competitive effects.

The study has been prepared with the supervision and review of the Office of Analysis and Evaluation of the EPA. This report was submitted in fulfillment of Contract No. 68-01-6426, by Meta Systems Inc. This report reflects work completed as of November 1982.

This report is being released and circulated at approximately the same time as publication in the Federal Register of a notice of proposed rule making. It will be considered along with the information contained in the Development Document and any comments received by EPA on either document before or during proposed rule making proceedings necessary to establish final regulations.

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Section 1

Executive Summary

This study analyzes the economic impact of water pollution controls on the Pesticides Industry. This study was prepared under the supervision of the Office of Analysis and Evaluation, U.S. Environmental Protection Agency. As required by the Clean Water Act, this study presents for consideration the economic impacts of regulations proposed under the Act which would control the industry's discharge of its effluents. The regulations analyzed are Best Available Technology Economically Achievable (BAT), Pretreatment Standards for Existing Standards (PSES), New Source Performance Standards (NSPS), and Pretreatment Standards for New Sources (PSNS).

The impacts analyzed are: total costs of compliance, changes in price, output, profits and employment, plant closures, and investment in new capacity.

Economic Assessment Methodology

The major elements of the assessment methodology include industry- level impacts for price, output, employment and profit, a plant-level closure analysis for plants that incur wastewater treatment and solid waste removal costs, an assessment of costs to meet new source standards and an analysis of impacts on small businesses as required by the Regulatory Flexibility Act.

Industry-Level Impacts: Price, Output, Profits, Employment, Total Costs of Compliance

The industry-level analysis estimates the impacts of the proposed effluent guidelines on three major product groups in the industry: herbicides, insecticides, and fungicides, and on the industry as a whole. Impacts are estimated for prices, production, employment, and profits. The basic approach is to make a baseline forecast of these variables in the absence of the proposed effluent guidelines and then to estimate the changes resulting from the increase in production costs attributable to the guidelines.

The methodology utilizes a cost-price submodel and a demand-production submodel. The cost-price submodel was developed to disaggregate pesticide prices into a profit component and several cost components. The cost-price submodel is used to predict the price at which pesticide chemicals will be supplied to users. For the baseline, the cost components do not include additional treatment costs whereas the impact projection includes the treatment costs.

The economic impact analysis examines two possible price responses of the industry to added treatment costs. The first (Case A) is that the price increase equals the average cost increase due to treatment requirements for all plants in the industry. Note that this does not imply that all costs are passed through in the form of higher prices, since the average includes those plants which do not incur any additional costs.

The second assumption (Case B) is that no price increase occurs and the industry absorbs the entire amount of treatment costs as a reduction in profits. These assumptions were selected because only a fraction of the plants in the industry incur added treatment costs, making it unlikely that all costs can be passed through in the form of higher prices.

A demand-production submodel was developed to estimate quantities of pesticides chemicals that will be used given the two sets of projected prices; i.e., baseline conditions and conditions with standards imposed. This model relates pesticide demand to its major determinants, including agricultural acreage, the fraction treated by pesticides, the rate of application, and the pesticide price. With treatment costs passed through, pesticide prices are increased which alters the demand and, in turn, the production quantities. The derivation of the two submodels is discussed next.

Employment and profit impacts are estimated from the impacts on output and coefficients for average employees and profit per unit of output. Total costs of compliance are found simply by summing the estimates of costs of compliance made by the Technical Contractor for individual plants.

Plant-Level Impacts: Closure

Costs of various wastewater treatment levels were developed by the Technical Contractor on a plant-by-plant basis. The costs are expressed on an annualized basis and compared to the value of pesticide produced at each plant. A ratio of four percent annualized cost to value of production was used as a screening criterion and those plants which equal or exceed four percent are considered to be severely impacted.

The severely impacted plants were analyzed in terms of product lines, quantities and value of pesticides and other products made at the plant, period of production during the year and parent company ownership. Lacking plant-specific financial information, the above factors were used to arrive at qualitative judgments about plant and product line shutdowns, first considering only the effects of additional wastewater treatment costs.

Plant closures are estimated both for a baseline case and for the incremental impacts of the proposed effluent guidelines. Costs of compliance with hazardous solid waste management rules under the Resource Conservation and Recovery Act (RCRA) are included as part of the baseline, because these rules have already been promulgated, but their compliance costs have not otherwise been incorporated into the data base. Because impacts due to RCRA may be significant, it is important to identify them before determining the incremental impacts of the proposed effluent guidelines. Specifically, if a plant is predicted to close due to RCRA costs alone, then it cannot be counted as part of the incremental impact of the proposed effluent guidelines, even if those compliance costs are also high.

Small Business Analysis

An analysis is conducted to determine whether small firms bear disproportionate impacts under the proposed effluent guidelines. The method used is to classify all firms in the data sample as either large or small and then to compare the distribution of impacts on plants belonging to firms in the two sets. The impacts include number of plants with compliance costs, the distribution of the cost to sales ratio, and the number of closures.

We have defined small businesses to be those having less than $10 million in annual sales. Eighteen out of the 80 plants in the data base, 23 percent of the total, fall under this definition of a small business.

New Source Standards

Costs of treatment for new plants were estimated for direct and indirect dischargers by the Technical Contractor. Model plants were identified to develop high and low estimates of capital and annual O & M costs. Annualized treatment costs were calculated and compared to pesticide prices. In addition to assessing cost effects on pesticide prices, an analysis was made to determine if new production capacity is likely to be needed by 1985. This is based on current capacity, recent production levels and projected growth of pesticide use.

Industry Profile

The pesticide industry encompasses the production of pesticide chemicals and the formulation of those chemicals into useable forms. Both the producers of the active ingredients and the formulators of the end-use products are defined as being part of the broader organic chemicals industry.

There are three major product groups within the pesticides industry: herbicides, insecticides and fungicides. Other product groups include plant growth regulators, rodenticides, soil-conditioners and fumigants. Production of herbicides is currently greater than that of insecticides or fungicides, but the relative production dominance of the three pesticides types has varied over the past two decades. While herbicides production has experienced the most rapid growth since 1960, it did not take the lead until 1975 when 788 million pounds were produced. This compared in the same year to about 660 million pounds of insecticides and 155 million pounds of fungicides. In 1980, about 805 million pounds of herbicides valued at $2.7 billion were produced. In the same year, 506 million pounds of insecticides, valued at $1.3 billion, were produced and about 156 million pounds of fungicides, valued at $0.3 billion.

Both real and nominal prices of all pesticides have risen since 1967. Prices are heavily dependent on oil prices with the most dramatic increases occurring between 1974 and 1975 when average prices (in current dollars) of pesticide ingredients increased 47 percent. Prices were 180 percent higher in 1980 than they were in 1970, however in terms of real prices (1967 index = 100) the change between 1970 and 1980 was less than 45 percent.

Prior to 1970, the formulation of pesticides was carried out by a large and diverse group of independent formulators and farm cooperatives, but in the mid-1970's chemical producers started to move into the formulating business. This trend of forward integration has continued and by one estimate, 80 percent of the formulated pesticides industry is controlled by chemical producers.[22] The pesticides industry currently is dominated by large chemical and pharmaceutical firms. The manufacturing of pesticides generally requires considerable capital, not only to build and operate plants, but also to undertake the research and testing that is required before a new pesticide can be marketed. Due to large capital requirements the barriers to new firms' entering the pesticide industry are considerable. Based on total value of industry production, eight firms account for about 80 percent of the market.[15]

Research and development is an essential part of the industry; the costs of R & D have risen considerably over the past ten years and are expected to continue to increase. A large part of the R&D cost increase has been attributed to federal regulations that pertain to the production and testing of pesticides. A likely consequence of continued increases in R&D costs will be further concentration of the industry. Dominant firms in the pesticide industry are likely to be those with existing expertise (in screening, testing and compliance with registration requirements), in particular, the pharmaceutical companies.

The use of pesticides is expected to grow over the next five years. The three major product types that make up the pesticide industry are expected to grow at different rates during the 1980-1985 period, with the value of herbicides growing at the highest annual rate (8.6 percent) and the value of insecticides growing at the lowest annual rate (7.8 percent).

Recommended Treatment Technologies and Costs

Direct and Indirect Dischargers

Treatment technologies were evaluated by the Technical Contractor so that they might be applied, singly or in combination, to achieve the required reduction of pollutants at each plant. These technologies are as follows:

Treatment Technologies

Steam stripping
Filtration
Chemical Oxidation
Activated carbon
Biological treatment
Metals separation
Resin adsorption
Hydrolysis

These technologies can be classified into four major groups: physical-chemical treatment, biological treatment, multimedia filtration, and carbon filtration. One or more of the technologies listed were selected for each manufacturing plant (based on wastewater characteristics and treatment currently in place) and this selection defined a limited number of treatment options. To achieve different levels of effluent treatment, the options for each plant are combined to define several treatment levels. For the indirect dischargers, the treatment levels are designated as follows:

Level 1: physical/chemical treatment,
Level 2: Level 1 plus biological treatment

For direct dischargers, the designated treatment levels are:

Level 1: physical/chemical and biological treatment,
Level 2: Level 1 plus multimedia filtration,
Level 3: Level 2 plus carbon filtration.

Capital investment and annual costs were estimated for the two pretreatment treatment levels and three direct discharge treatment levels. The options and costs were developed in incremental terms: for indirect dischargers, the second pretreatment treatment level includes the first and for direct dischargers, each subsequent treatment level includes the technologies of the preceding treatment level.

Annualized treatment costs are computed from capital and annual costs by converting the capital cost to an annual equivalent and adding it to O&M costs. Capital costs are converted to an annual equivalent by multiplying by a capital recovery factor (.218) based on the assumptions of a ten year equipment life, a 13 percent cost of capital, and a five year depreciation life; the derivation is shown in Appendix B. The annual equivalent of the capital cost is added to the estimated annual operating and maintenance (O&M) cost to calculate an annualized cost.

The total cumulative costs for the various treatment levels defined above are shown in Table 1-1 in 1982 dollars. The costs presented for each treatment level include costs associated with each lower level of treatment, e.g., costs for direct dischargers, Level 2 includes costs for BAT Level 1.

The treatment levels for direct and indirect dischargers are combined to form economic options which are defined as follows:

Economic Option	Direct Discharger Level	Indirect Discharger Level
1	1	1
2	2	1
3	3	1
4	1	2
5	2	2
6	3	2

The treatment costs for each economic option are shown as part of Table 1-1.

NSPS and PSNS

The Technical Contractor has also specified treatment levels for direct discharger and indirect discharger new sources for each of the ten subcategories (NSPS and PSNS, respectively). Pesticides were assigned to subcategories based on several considerations, including raw materials used in manufacturing, wastewater characteristics and treatability, and disposal and manufacturing processes. Wastewater treatment trains that meet new source standards were synthesized for each subcategory. The treatment level for NSPS corresponds to treatment Level 1 for direct dischargers and the treatment level for PSNS corresponds to treatment Level 1 for indirect dischargers.

Economic Impact Analysis

Industry-Level Impacts: Price, Output, Employment, Profit

Baseline and impact projections for the herbicides, insecticides and fungicides markets were made using the production projections, cost data, and price data available for each category. Impacts vary among the three categories of pesticides due to differing costs of treatment and different average prices. The elasticity of demand is assumed to be the same for each category as is the number of employees per pound of production.

Table 1-1. Total Cumulative Costs of Compliance for Indirect and Direct Treatment Levels and Economic Options (millions of 1982 dollars)

	Capital Costs	Annual O&M Cost	Annualized Cost
Indirect Discharger			
Subcategories 1-12			
Level 1	15.8	7.4	10.8
Level 2	58.0	14.8	27.5
Formulator/Packagers*			
Level 1	46.8	3.2	13.5
Level 2	46.8	3.2	13.5
Total			
Level 1	62.5	10.6	24.3
Level 2	104.8	18.0	40.9
Direct Discharger			
Level 1	30.1	19.0	25.5
Level 2	35.9	20.1	28.0
Level 3	51.4	36.9	48.1
Economic Option			
Subcategories 1-12			
1	45.9	26.4	36.3
2	51.7	27.5	38.7
3	67.2	44.3	58.9
4	88.1	33.8	53.0
5	93.9	34.9	55.4
6	109.5	51.7	75.6
Formulator/Packagers			
1-6	46.8	3.2	13.5

* Formulator/Packagers (Subcategory 13) are handled separately due to differences in the way data were aggrregated for this subcategory as opposed to Subcategories 1 through 12.

A comparison of the baseline and impact analyses indicates that the impact of additional treatment costs if passed through, would be to raise pesticide prices, reduce demand because of the higher prices, and reduce production, profits and employment as a result of the reduced demand. Table 1-2 shows the overall industry impacts for price increase and profit reduction for each treatment level and option in 1982 dollars. On a percentage basis such costs are estimated to be relatively insignificant. Prices for the industry as a whole will rise 0.19 to 1.36 percent (depending on the economic options) and profits will fall 0.08 to 0.59 percent.

If additional treatment costs are absorbed by pesticide manufacturers, prices and production are the same as in the baseline projection but profits will decrease by 2.0 to 12.0 percent depending on the economic option selected.

Plant Specific Impact Analysis

A plant by plant analysis was made to identify those plants that might be affected by new treatment standards. Up to 51 of the 117 plants that produce pesticides would incur some added costs, depending on the economic option. The annualized treatment costs were calculated as a percent of the value of pesticides produced at each plant. As an initial screening step, those plants with treatment costs less than four percent of pesticide value were screened out. Use of the criterion does not mean that plants below this level are unaffected; however, plant-specific financial data are not available to investigate the capability of each plant to absorb externally imposed treatment costs. Therefore, plants with treatment costs of four percent or more of pesticide value are judged to be severely impacted. The total number of such plants (direct and indirect dischargers) may be as high as 26 depending on the economic option. Table 1-3 shows the number of plants with incremental costs and the distribution of the cost/sales ratio for each treatment level.

To carry out an analysis of possible plant closures or product line shutdowns, a profile of the pesticide plants was developed. About 50 percent of the 117 plants formulate and package pesticides as well as produce the active chemical ingredients, 75 percent produce chemicals other than pesticides, 20 percent produce pesticides throughout the year and another 20 percent produce pesticides during fewer than 30 days a year. Also, 50 percent of the plants specialize in the production of one pesticide and 95 percent produce no more than four. While 12 of the plants produce 50 percent of the total value of pesticides, the value of output for almost half of the plants is less than $5 million annually.

A qualitative analysis of each severely impacted plant was conducted in order to judge which ones were likely candidates for plant closure or discontinuation of the pesticide product line. (This analysis contains confidential information about pesticide producers and is not included in

Table 1-2

Industry-Level Analysis Summary (exclusive of Formulator/Packagers)
(1982 dollars)

	Indirect Dischargers Level		Direct Dischargers Level			Combination Indirect and Direct Discharger Economic Options					
	1	2	1	2	3	1	2	3	4	5	6
Total Annualized Cost (1,000's)	10,800	27,462	25,570	27,949	48,126	36,407	38,748	58,926	53,028	55,410	75,588
Cost of Treatment per Pound of Pesticide (¢/lb.)	0.67	1.74	1.61	1.76	3.04	2.30	2.44	3.71	3.35	3.50	4.77
Case A: Average Cost Passthrough											
% Price Increase	0.19	0.49	0.46	0.50	0.87	0.66	0.70	1.06	0.96	1.00	1.36
% Profit Reduction	0.08	0.21	0.20	0.22	0.37	0.28	0.30	0.46	0.41	0.43	0.59
Case B: Average Cost Absorption											
% Price Increase	0	0	0	0	0	0	0	0	0	0	0
% Profit Reduction	2.0	4.0	4.0	4.0	7.0	6.0	6.0	9.0	8.0	8.0	12.0

Table 1-3. Summary of Plant-Level Impacts

	Plants With Incremental Costs	Distribution of Cost/Sales Ratio in Percent (Number of Plants)			
		0-1%	1-2%	2-4%	Over 4%
Indirect Dischargers					
Level 1	16	1	4	3	8
Level 2	34	6	3	6	19
Direct Dischargers					
Level 1	15	2	2	5	6
Level 2	18	5	2	5	6
Level 3	18	3	2	5	8

this report.) If a plant was predicted to close due to RCRA compliance costs, this was counted as a baseline closure, since that Act has already been promulgated. Incremental closures under each treatment level are defined as closures resulting from the sum of RCRA and BAT or PSES costs for those plants which are not baseline closures. Table 1-4 shows the results of the closure analysis for each treatment level. Separate results are shown for plant and product line closures. (In the latter case, only a portion of the plant is expected to close.)

No plants and three product lines are predicted to be closures in the baseline case which accounts for $0.7 million of pesticide product value. Under Level 1 for indirect dischargers there are two plants and five product line closures, for a total pesticide product value of $20.8 million or 0.6 percent of the industry product value. Under Level 1 treatment for direct dischargers, there are one plant and two product line closures, for a total pesticide product value of $12.4 million or 0.3 percent of the industry product value. With Level 2 for indirect dischargers, plant closures are six and product line closures are eight with a combined product value of $64.8 million or 1.6 percent of the industry value. Levels 2 and 3 do not increase closures of the direct discharge plants.

The aggregate effects of treatment combinations are shown in Table 1-5. (The values shown account for one plant that is both an indirect and direct discharger and therefore included under direct and indirect treatment levels in Table 1-4.) Under economic option 1, 2, or 3 (i.e., indirect discharger treatment Level 1 and any of the direct discharge treatment levels) there are three plant and seven product line closures; total value of pesticide production of these is $25.1 million or 0.7 percent of the industry total. Under economic options 4, 5, or 6 plant closures are seven, product line closures are ten and their total value of $69.1 million is 1.7 percent of the total industry value.

Small Business Analysis

This section analyzes the relative impact of the proposed effluent guidelines on small and large firms to determine if small firms face disproportionate impacts. Based on the discussion in the methodology section, small firms are defined as those having less than $10 million in annual sales. Since it was not possible to obtain sales data for all firms, the results are presented for a sample of 80 plants for which this data is available for the parent firm from the Dun and Bradstreet data base. This sample is a large fraction of the total number of 117 plants which comprise the definition of the pesticide industry used in this study and includes many plants owned by small firms, so the results are not likely to differ much from those for the entire pesticide industry.

Using the definition of small businesses given above, 18 out of the sample of 80 plants belong to small firms. The results indicate that

Table 1-4. Summary of Closures Due to Treatment Costs

Control Levels	No. of Closures: Plant	No. of Closures: Product Line	Value of Pesticide Production Lost: Million $	Value of Pesticide Production Lost: Percent of Total Industry Value
Baseline Case*	0	3	0.7	0.01
Indirect Dischargers				
Level 1	2	5	20.8	0.6
Level 2	6	8	64.8	1.6
Direct Dischargers				
Level 1	1	2	12.4	0.3
Level 2	1	2	12.4	0.3
Level 3	1	2	12.4	0.3

*Closures due to RCRA costs.

Dollar Amounts are in 1979 values.

Table 1-5. Results of Closure Analysis for Economic Options

Economic Option	Number of Shutdowns: Plants	Number of Shutdowns: Product Lines	Value of Pesticide Production (millions of 1979 dollars)	% of Total Value of Production
1	3	7	25.1	0.7
2	3	7	25.1	0.7
3	3	7	25.1	0.7
4	7	10	69.1	1.7
5	7	10	69.1	1.7
6	7	10	69.1	1.7

small firms bear a less than proportionate impact under economic option 1. Only two out of 18 plants owned by small firms have costs of compliance, none of which have a cost to sales ratio greater than four percent or are expected to close. In comparison, 22 of the 62 large plants have positive incremental costs, over one-third of the total; nine of the 22 plants have cost-to-sales ratios greater than four percent; and two plants and four product lines are predicted to close due to incremental costs.

Impact of New Source Standards (NSPS and PSNS)

The potential impacts of new source treatment standards for direct and indirect dischargers were analyzed by assuming that some new plants would be built. However, projections of the industry's production of fungicides (155 million pounds), herbicides (820 million pounds), and insecticides (625 million pounds) in 1985 indicate that little if any new capacity will be needed.

For the impact analysis, pesticides were grouped into 13 subcategories based on wastestream characteristics and treatment technologies. A "model" plant was selected for each subcategory for the purpose of estimating treatment costs. Treatment costs, expressed on a per pound of pesticide basis, were compared with pesticide prices.

There is wide variability of cost impacts among the subcategories of chemicals; treatment costs for direct dischargers range from 0 up to 73 percent of pesticide prices. For a comparable chemical subcategory and pesticide type (i.e., fungicide, herbicide, insecticide), treatment cost impacts, relative to prices, are less for indirect dischargers than for direct dischargers. In general, chemicals in subcategories 1, 6, 8, 9 and 10 show relatively low impacts with treatment costs no higher than 20 percent of pesticide prices. Of the three major types of pesticides, new herbicide plants generally are less severely impacted than fungicides or insecticides regardless of the chemical subcategory.

Limits of the Analysis

Treatment Technologies and Costs

The analysis relies on cost estimates for the Technical Contractor and the use of a specific capital recovery factor, which are subject to some uncertainty. The cost data are based on the actual characteristics of plants and then in-place treatment systems. The cost of capital is likely not to fall outside the range of 10 to 15 percent per year.

Industry-Level Impacts

The sources of possible error in the industry-level impact analyses are as follows:

1) The industry cost structure will change over time, that is the input coefficients of production inputs change; in the analysis, the structure is assumed to be constant out to 1985. Also, the forecasts of the 1985 values of the input price indices are subject to error.

2) The relation of price to cost may differ among herbicides, insecticides and fungicides. The analysis uses one elasticity for all three categories. Furthermore, the level of the analysis (three major pesticide groups) is quite aggregated. For example, no distinction is made in the price analyses between patented and commodity pesticide chemicals.

3) The cost component projection and crop projections rely on DRI and U.S.D.A. models which are subject to uncertainty about the major variables: acreage, fraction with pesticides use, and pesticide application rates.

4) The cost-price and production price relationships were estimated separately but are in fact, interdependent. This is not a major problem for long-run baseline forecasts, since all production cost increases must eventually be passed through. However, costs of compliance for existing sources might not be passed through completely, depending on demand conditions.

5) As described above, the treatment cost estimates used in the industry-level analyses have a number of uncertainties.

6) The effect of possible significant changes in imports and exports is ignored in the analysis.

7) Indirect effects on the employment, earnings, etc., of industries that provide inputs to the pesticide industry will occur, but have not been estimated in the industry-level analysis.

8) Price increase assumes an average cost passthrough.

Plant-Level Analysis: Closure

The criterion--annualized wastewater treatment or RCRA costs equal to or greater than four percent of the value of pesticides produced by a plant--was used to identify plants severely impacted. This criterion would undoubtedly vary by plant and parent company. However, plant-specific financial data are not available. In our judgement, the four percent criterion is reasonable only as a screening device to be used together with other available information. We also applied three, two and one percent criteria to compare with the values from the four percent screening cut off. The results of the application of these different criteria on two economic options are summarized as follows in Table 1-6:

Table 1-6. Effect of Screening Criterion on Number of Plants Identified as Severely Impacted

Treatment Option	Screening Criterion for Cost/Sales Ratio 4%	3%	2%	1%
Economic Option 1	13	15	21	27
Economic Option 6	30	32	42	46

The analysis of possible plant closures (of those plants identified as severely impacted) is also based on qualitative judgements about each plant sales, production and company affiliation. The aggregate effect of plant closures, expressed as a percent of total industry production value, is probably a better approximation of treatment impacts than identifying which specific plants are likely to shut down. Because of uncertainty, some plants' compliance costs have probably been overestimated and others underestimated. On balance, this should produce roughly the right number of closures, unless there is a significant bias to the costing procedure.

The costs used in the RCRA closure analysis are subject to two main weaknesses. First, only average costs for each disposal method were provided. This overstates the impact of RCRA on small plants. However, this bias is probably not large because many RCRA costs such as management costs are relatively fixed. Second, RCRA costs are probably understated by assuming that all of the costs of baseline treatment and storage of hazardous waste streams ($107 million) can be attributed to BPT rather than RCRA regulations. However, information to make an allocation between BPT and RCRA costs was not available.

New Source Pollution Standards

Treatment costs are sensitive to the particular pesticide chemical that might be produced by a new plant. In the analysis, treatment costs for ten model plants corresponding to ten subcategories of pesticides were used because it is not feasible to analyze each new chemical plant that might possibly be built. Thus, a high and low treatment cost is used for each model plant. For a specific model plant in a subcategory, the upper value of treatment cost may be as high as four times the low estimate even though the plant is described by a single value of plant capacity.

Prices for pesticides also vary greatly, (even for a given chemical subcategory and pesticides type, i.e., fungicide or herbicide or insecticides), a high price may be as great as six times the lowest price. The two major uncertainties (i.e., treatment cost and pesticide price) are recognized by examining the upper and lower values of the range for treatment costs and for pesticides prices in analyzing the ratio of treatment cost to pesticide sales value.

Treatment costs for new sources are assumed to be the same as those costs that would be incurred by a major modification of an existing plant.

If a new plant were built to produce a patent protected pesticide chemical, the price would be set to yield a desired profit considering all costs of production including treatment costs. Therefore, use of a treatment cost to value basis on existing average values would not be appropriate, although the price still might fall within the broad ranges considered in this analysis.

Section 2

The Economic Assessment Methodology

This section describes the methodology, assumptions and data sources used in the analysis of impacts of treatment costs on the pesticide chemicals industry. The following impacts are analyzed: prices, production, profit, employment, and plant closures. Total costs of compliance with the proposed effluent guidelines are also estimated. The impacts on the first four variables are estimated for the industry as a whole and for three major product groups: herbicides, insecticides, and fungicides. Closures are predicted for individual plants. Part of this analysis includes determining whether small businesses bear disproportionate impacts. Finally, the effects of costs for new sources on capacity expansion are analyzed.

The main elements of the economic assessment methodology utilize wastewater treatment costs developed by the Technical Contractor.[11] The waste streams of each plant producing pesticide active ingredients were studied by the Technical Contractor and one or more treatment levels (and associated costs) that enable the plant to meet the proposed effluent guidelines were identified. The plant-level analysis compares treatment cost estimates to sales of individual plants to identify possible plant closures and product line shut downs. The plant treatment costs are also used in the industry level analysis which analyzes the aggregate impact of plant costs on the pesticide chemicals industry and on the major markets in which pesticides are used.

Industry-Level Impacts: Price, Output, Profits, Employment

The industry-level analysis estimates the impacts of the proposed effluent guidelines on three major product groups in the industry: herbicides, insecticides, and fungicides, and on the industry as a whole. Impacts are estimated for prices, production, employment, and profits. The basic approach is to make a baseline forecast of these variables in the absence of the proposed effluent guidelines and then to estimate the changes resulting from the increase in production costs attributable to the guidelines.

The methodology utilizes a cost-price submodel and a demand-production submodel. The cost-price submodel was developed to disaggregate pesticide prices into a profit component and several cost components. The cost-price submodel is used to predict the price at which pesticide chemicals will be supplied to users. For the baseline, the cost components do not include additional treatment costs whereas the impact projection includes the treatment costs.

The economic impact analysis examines two possible price responses of the industry to added treatment costs. The first (Case A) is that the price increase equals the average cost increase due to treatment requirements for all plants in the industry. Note that this does not imply that all costs are passed through in the form of higher prices, since the average includes those plants which do not incur any additional costs. The second assumption (Case B) is that no price increase occurs and the industry absorbs the entire amount of treatment costs as a reduction in profits. These assumptions were selected because only a fraction of the plants in the industry incur added treatment costs, making it unlikely that all costs can be passed through in the form of higher prices.

A demand-production submodel was developed to estimate quantities of pesticides chemicals that will be used given the two sets of projected prices; i.e., baseline conditions and conditions with standards imposed. This model relates pesticide demand to its major determinants, including agricultural acreage, the fraction treated by pesticides, the rate of application, and the pesticide price. With treatment costs included, pesticide prices are increased under Case A which alters the demand and, in turn, the production quantities. The derivation of the two submodels is discussed next.

Cost-Price Submodel

The primary focus of this study is on the active ingredient stage of the pesticide manufacturing cycle, because this stage creates almost all the effluent. In 1978, the average price of pesticide active ingredients was $2.34/lb., according to the ITC[1] report. This price reflects the cost of organic chemical inputs, inorganic chemical inputs, fuel, electricity, labor, overhead, and profit.

Table 2-1 presents the 1978 price disaggregated into its constituent elements based on an analysis by A. D. Little.[2] Inorganic chemical inputs account for 14.1 percent of total cost, organic chemical inputs for 28.2 percent, utilities for 10.6 percent, labor for 17.5 percent, and fixed costs for 29.6 percent. The total cost is 88.0 percent of price or, to put it differently, price is a 13.6 percent mark-up over costs.

The disaggregation of price between costs and profits is based on an analysis of financial statements of pesticide-producing companies. The disaggregation of costs between materials, labor, utilities, and overhead is based on Census of Manufactures data for SIC group 28694 (pesticide organic chemicals)[3] and on publications reporting cost breakdowns for the process industries. The disaggregation of material costs between organic and inorganic chemical inputs is based on a review of pesticide process flowcharts prepared by Parsons.[4] It must be emphasized, however, that these disaggregations are approximations. Using the percentage given in Table 2-1, a pesticide cost index was developed for the 1967-1978 period by A. D. Little, Inc.[2] The formula for the index is:

$$IPC = 0.141\ IICP + 0.282\ IOCP - 0.106\ IUTC - 0.175\ IULC + 0.296\ IFC \quad (1)$$

Table 2-1. Baseline Average Pesticide Costs and Price, 1978

Cost Element	1978 $/lb.*	Baseline Share of Total Cost
Inorganic Chemicals Cost	0.29	14.1
Organic Chemicals Cost	0.58	28.2
Utilities Cost	0.22	10.6
Labor Cost	0.36	17.6
Fixed Costs	0.61	29.6
Total Costs	2.06	100.0
Pre-Tax Profit	0.28	13.6
Price	2.34	113.6

*per pound of active ingredients.

where

IPC = index of pesticide costs,
IICP = index of inorganic chemical prices,
IOCP = index of organic chemical prices,
IUTC = index of utility costs,
IULC = index of unit labor costs,
IFC = index of fixed costs.

Table 2-2 presents the index of pesticide costs for the 1967-1978 period, along with the component cost indices and an index of pesticide active in- gredient prices. The data in the table were used to fit a regression equa- tion relating pesticide prices to pesticide manufacturing costs. The estimated equation is presented below, with the t-statistics for each coefficient included in parentheses, the R^2 and the Durbin-Watson (DW) statistic for serial correlation:

$$\ln IPP = \underset{(-1.483)}{-0.647} + \underset{(13.268)}{1.147} \ln IPC \qquad (2)$$

$R^2 = 0.989$

DW = 1.263

Estimation period: 1967-1978

Estimation technique: Ordinary Least Squares (OLS) with Cochrane-Orcutt correction for autocorrelation

where

Table 2-2

Pesticide Price and Cost Indices
(All Indices, 1967 = 100)

		Index of Pesticide Price[1]	Index of Pesticide Cost[6]	Producer Price Index-Basic Organic Chemicals[2]	Producer Price Index-Basic Inorganic Chemicals[2]	Utility Cost Index[3]	Unit Labor Cost Index[4]	Fixed Cost Index[5]
(1)	1967	100.0	100.0	100.0	100.0	100.0	100.0	100.0
(2)	1968	101.5	101.4	99.0	103.9	100.0	101.6	103.0
(3)	1969	107.1	103.0	96.8	105.5	101.1	106.3	106.5
(4)	1970	111.7	106.2	98.1	105.1	105.6	113.4	110.4
(5)	1971	118.0	109.2	98.2	107.7	114.4	116.7	114.1
(6)	1972	114.9	11.0	96.2	108.7	121.1	119.3	117.7
(7)	1973	120.1	117.4	97.0	129.4	130.0	123.9	122.6
(8)	1974	146.6	147.5	164.9	139.2	172.2	138.8	131.2
(9)	1975	109.2	181.6	223.9	195.4	213.3	152.2	140.6
(10)	1976	216.8	191.6	235.4	210.4	230.0	159.6	146.1
(11)	1977	239.1	200.1	239.0	217.2	258.9	168.0	152.9
(12)	1978	248.7	208.6	237.4	224.7	287.8	180.5	161.6

1. Calcuated from U.S. International Trade Commission, *Synthetic Organic Chemicals*, U.S. Government Printing Office, Washington, D.C., various issues.
2. Bureau of Labor Statistics, Producer Prices and Price Indices, U.S. Government Printing Office, Washington, D.C., various issues.
3. The utility cost index reflects trends in unit industrial electricity prices only, since for the period before 1973, data on oil and gas prices paid by the industrial sector are not available. Edison Electric Institute, Statistical Yearbook, New York, 1979, is the source for electricity prices.
4. The unit labor cost index is designed to correspond to wage costs per unit of output. It is calculated by dividing the wage rate for SIC 2869 by the productivity index for manufacturing. Both the wage rate and productivity index are reported in Bureau of Labor Statistics, Employment and Earnings, U.S. Government Printing Office, Washington, D.C., various issues.
5. Calculated by multiplying the implicit price deflation for GNP by 0.66. From Economic Report of the President, 1980. U.S. Government Printing Office, Washington, D.C., 1980.
6. Calculated using (1) on page 4-4.

IPP = index of pesticide prices, and

IPC = index of pesticide costs (see Table 2-2).

The statistics accompanying equation (2) demonstrate that there is a close relationship between prices and costs. The R^2 is 0.989 and shows that 98.9 percent of the variation in price is associated with variation in cost. Equation (2) is linear in logarithms, which implies that the estimated coefficients can be interpreted as elasticities. The coefficient of the cost variable thus implies that a 10 percent rise in pesticide costs will cause a 11.5 percent rise in pesticide prices. The finding that prices have risen faster than costs suggests that pesticide producers have been able to increase profit margins on average over the 1967-1978 period. The t-statistic of 13.27 indicates that the coefficient of the cost variable is highly significant. However, the standard error of the cost index coefficient is too large (0.086) to reject the hypo- thesis that the true value of the coefficient is 1.0.Therefore, we cannot necessarily accept the implication that prices are rising more rapidly than costs.*

Equation (2) can be criticized for excluding other forces that have a direct bearing on price. For example, changes in the number of patented products and changes in the product mix can both affect price. Patents allow firms to obtain higher prices and hence profits on such products. Changing the product mix may change both the processes used (and hence the input cost coefficients) and the profitability of the products. Because of data limitations, a trend variable (TIME) was selected to approximate these other forces. The revised equation is presented below:

$$\ln IPP = \underset{(-0.750)}{-0.406} + \underset{(4.821)}{0.989} \ln IPC + \underset{(0.854)}{0.250} \ln TIME \qquad (3)$$

$R^2 = 0.990$

DW = 1.369

Estimation period: 1967-1978

Estimation technique: OLS with Cochrane-Orcutt

The t-statistic of the trend variable indicates that it is insignificant. Nevertheless, it is worth examining equation (3). The coefficient attached to the cost variable has decreased to 0.989. Alone, this coefficient implies that the pesticide producers pass the cost increases along to the consumer but do not increase profit margins. (Since the standard error is .205, this estimate is not significantly different from 1.0.) However, the actual relationship between changes in cost and changes in price depends on what is imbedded in the trend variable (TIME).

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*In addition, equation (2) only shows a relationship of cost and price indices, not of cost shares. Costs may increase for a variety of reasons other than price increases, including added regulatory costs, or changes in the mix or quality of pesticides produced. Therefore, equation (2) is only a rough indicator of profitability.

To the extent that costs have been increasing over time, profit margins may have been maintained, holding constant for product mix.

Equations (2) and (3) indicate that the elasticity of price with respect to cost is roughly 1.0. An elasticity of 1.0 is consistent with a mark-up model of pricing behavior: each percentage increase in costs is accompanied by the same percentage increase in price. Thus, profits as a percent of costs remain constant. Although profits may fluctuate in the short run due to imbalances in supply and demand, they can be expected to even out over time. In the long-run, all costs are passed through as higher prices, which is consistent with the elasticity of price to cost of 1.0.

1985 Price Forecasts. Based on the above results, baseline estimates of 1985 pesticide prices are made using the assumption that all costs are passed through and that profit remains a constant fraction of price. This is because all plants in the industry are assumed to face similar increases in production costs. The 1985 baseline value of each cost component represented in equation (1) is based on assumptions and energy price projections issued by the U.S. Department of Energy and chemical price projections by Data Resources Inc. The cost mark-up model derived from 1978 data was used to estimate baseline pesticide chemical prices in 1985. In addition to a price for the entire industry, price forecasts are made for the three major groups of pesticides: herbicides, insecticides and fungicides.

As noted previously, two assumptions are made about increases from the 1985 baseline price due to treatment costs which reflect the fact that only a fraction of all plants incur added treatment costs. In Case A, average treatment costs per pound (including plants with no treatment costs) are added to the baseline price to obtain the post-impact price. Profit margins are not assumed to increase proportionately; they remain unchanged from the baseline. In Case B, prices are not assumed to increase. Price increases are projected for all pesticides and for insecticides, herbicides, and fungicides for each treatment option.

Demand-Production Submodel

Continuing increases in the profitability of pesticide application and a growing awareness in the farm community of the existence of these benefits have caused a rapid rise in pesticide demand over the last 20 years. There are signs, however, that the industry is approaching maturity, with some markets completely saturated and others not far from it. This impending maturity makes it dangerous to forecast future pesticide demand by extrapolating from past trends, since it is unlikely that the industry will be able to sustain similar high growth rates in the future.

Unfortunately, data on pesticide usage by market are available only for selected years, thus precluding a disaggregated econometric analysis.

Consequently, a hybrid approach developed by A. D. Little, Inc.[2] was used for forecasting pesticide demand. First, an end-use model is used to project pesticide demand by subgroup based on constant application rates. The end-use projections are then adjusted to reflect increases in the real price of pesticides, using an econometrically-derived price elasticity.

In the end-use analysis, herbicide sales are projected for the following subgroups: (1) corn, (2) soybeans, (3) wheat, (4) cotton, (5) sorghum, (6) other agricultural uses, (7) non-agricultural and (8) exports.

Insecticide sales are projected for the following subgroups: (1) cotton, (2) corn, (3) soybeans, (4) wheat, (5) livestock, (6) other agricultural uses, (7) non-agricultural uses, and (8) exports.

Fungicide sales are projected for the following subgroups: (1) fruits and vegetables, (2) peanuts, (3) other agricultural uses, (4) non-agricultural uses, and (5) exports.

The approach used to model agricultural usage of pesticides is generally the same for each market subgroup and is described by the following identity:

$$DEM_i = ACR_i \times FRACT_i \times APPL_i \tag{4}$$

where:

DEM_i = pesticide usage on crop i,
ACR_i = acreage of crop i planted,
$FRACT_i$ = fraction of acreage of crop i treated with pesticides, and
$APPL_i$ = pesticide usage per acre for crop i.

Various U.S. Department of Agriculture (USDA) publications provide 1971 and 1976 values for the right-hand variables in equation (4). The 1985 forecasts of acreage were obtained from the highly detailed National Inter-Regional Agricultural Projection (NIRAP) model maintained by the USDA. Projections of the other two variables were developed by Arthur D. Little Inc.[2] pesticide market experts. See Section 5, Tables 5-3 to 5-5, for the forecasts.

Published data on non-agricultural pesticide use are not available. Imputed values for non-agricultural use were calculated for 1971 and 1976 by comparing the USDA survey data on agricultural pesticide use with data on aggregate pesticide production, exports, and imports.[5,6] (The imputed non-agricultural values were extremely high; USDA officials indicated that this was so because the agricultural pesticide usage numbers were understated.) The 1971 and 1976 imputed non-agricultural values are very close, indicating a stagnating demand that will persist through 1985.

The United States has traditionally been a large exporter of pesticides, while imports have been insignificant. Trend equations were used to generate initial 1985 forecasts for net exports which were then modified to reflect institutional factors.

The end-use model described above implicitly assumes that pesticide demand is not affected by price. Such an assumption is unwarranted as previous econometric research by Carlson and others has demonstrated.[7] In reaction to higher real pesticide prices, farmers are more likely to adopt integrated pest-management methods which are based on a selective application of pesticides, along with the use of other pest control methods. Also, increases in the real price of pesticides might convince the farmer to forego pesticide application on marginal areas and to defer application on new areas. Consequently, the end-use analysis must be augmented to take into account the depressing effects of real pesticide price increases. The augmented model is written as follows:

$$\text{PROD} = \text{EPROD} - (\text{PE} \times \text{PCPRICE} \times \text{EPROD}) \qquad (5)$$

where

PROD = U.S. production of pesticides in 1985,

EPROD = U.S. production of pesticides in 1985 as forecasted by the end-use model,

PE = price elasticity of demand for pesticides, and

PCPRICE = percentage change in real pesticide price between 1978 and 1985.

According to equation (5), U.S. production of pesticides in 1985 will be less than the end-use prediction if the real pesticide price increases between 1978 and 1985. The amount of this decrease will depend on the price elasticity and the percentage increase in real price. An econometric estimate of the price elasticity was made using data on aggregate U.S. pesticide production, crop acreage, and real active ingredient price.

Over the period 1967-1978, the application rate of pesticides has increased due to the advances in technology and increases in crop prices which made increased pesticide use profitable. Different alternative demand equations were estimated using a variable for crop acreage to capture these effects. The following equation shows pesticide demand as a function of crop acreage and the real price of pesticides:

$$\ln \text{PROD}_t = \underset{(-3.185)}{-6.109} + \underset{(6.91)}{2.302} \ln \text{ACRE}_t - \underset{(1.650)}{0.324} \ln \text{RPRICE}_t \qquad (6)$$

$R^2 = 0.83$

DW = 2.27

Estimation period: 1967-1978

Estimation technique: OLS with Cochrane-Orcutt

where

PROD = pesticide production (million lb.),

ACRE = acreage of principal crops planted,

RPRICE = real unit price for pesticide active ingredients.* (IPP in Table 2-2)

Equation (6) is linear in logarithms, which means that the estimated coefficients can be interpreted as elasticities. The influence of increased insecticide use is seen in the coefficient of ln ACRE. The remaining effect on demand is through the price of the pesticide. The coefficient of -0.324 for the price implies that if real pesticide prices rise by 10 percent, demand will decrease by 3.24 percent.

The t-statistics, which are enclosed in the parentheses beneath the coefficients, indicate that there is a 90 percent probability that the variables do have some impact. The R^2 value indicates that 83 percent of the variation in pesticide production can be explained by variation in crop acreage and pesticide price.

Equation (6) is relatively simple in that it employs a static formulation and was estimated by ordinary least squares (OLS) with a Cochrane-Orcutt correction for autocorrelation. Such an approach can be criticized for ignoring dynamics and the simultaneity bias problem inherent in estimating a demand/supply system. Equation (7), which addresses both these issues, is presented below. It contains a dynamic Koyck lag structure and was estimated by two-stage least squares (TSLS) with a Cochrane-Orcutt correction for autocorrelation:

$$\ln PROD = \underset{(-2.002)}{-4.357} + \underset{(2.459)}{1.437} \ln ACRE_1 - 0.296 \ln RPRICE + 0.453 \ln PROD_{t-1} \qquad (7)$$

$R^2 = 0.859$

DW = 2.371

Estimation Period: 1968-1978

Estimation Technique: TSLS with Cochrane-Orcutt

Instruments: Constant, ACRE, PROD, and IPC (pesticide manufacture cost index)

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*Using the overall price index assumes that insecticide prices increase at the same rate over the period 1978-85 as does the overall pesticide price.

In equation (7), the short-run price elasticity is -0.296 and the long-run price elasticity is -0.541 (calculated by dividing -0.296 by 1-0.453).* This implies that a 10 percent rise in real pesticide price will cause a 2.96 percent decrease in pesticide demand in that year, and if the price remains at the higher level, demand will drop another 2.45 percent in subsequent years relative to the forecast based on a constant real price.

For the projections, a price elasticity of -0.43 was used, which is the average of the elasticities from equations (6) and (7).

Employment

Reliable data on employment in the pesticides industry are not available. Therefore, industry employment was estimated for the 1985 baseline based on value of shipments per employee in 1977 for the SIC group 28694 (Pesticides and other Organic Agricultural Chemicals, Except Preparations). This value was then applied to the value of active ingredient pesticide chemicals manufactured to obtain a 1977 employment estimate. The 1985 baseline employment estimate was then derived by applying a production ratio (i.e., projected 1985 production/1977 production) to the 1977 employment estimate. The impact of treatment options on employment was derived from the 1985 production impacts using the cost-price and demand-production submodels. That is, the impact on employment is baseline employment multiplied by the percentage output reduction.

Profits

For the projected baseline, industry profit is estimated from the cost mark-up model. With regulations imposed on the industry, profits are estimated for two assumed cases. In Case A, the dollar profit per pound of pesticide is the same as in the baseline and only the costs associated with regulations are passed along as price increases. The impact on total profits results from the reduction in output. In Case B, producers are assumed to completely absorb the additional treatment cost, i.e., no price increase. In the second case, production quantities do not change from the baseline level, but profit margins are more severely affected compared to the first case.

Plant Impact Analysis: Closure

The Technical Contractor estimated costs of compliance for each plant in the study. To determine whether these costs impose a significant burden on individual plants, costs of compliance are compared with the value of pesticides production at each plant. A cutoff value of four

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*The Koyck lag structure implies this relationship between the annual elasticity in equation (7) and the long-run elasticity.

percent for the ratio of treatment costs to product value is used to identify plants which may close. All available data on these plants, including products produced, patents, and relation to other company business, are reviewed to assess whether the plant is likely to close as a result of compliance costs. In some cases, only one product line at a plant rather than the entire plant may shut down.

Information developed by the Technical Contractor[12] for plants manufacturing pesticide active ingredients included capital and annual operating costs for different treatment levels. The costs are expressed as an annualized cost by converting the capital cost to an annualized equivalent and adding it to the annual operating cost. Capital costs are converted to an annual equivalent by multiplying by a capital recovery factor which measures the annual rate of return an investment must achieve each year to cover the cost of the investment and maintain net earnings, including depreciation and taxes.

A capital recovery factor of 0.218, which was computed for the organic chemical industry by Meta Systems Inc, was assumed to be applicable to the production of active pesticide ingredients. The capital recovery factor is based on a 10 year life for the treatment equipment, a 13 percent cost of capital and five year depreciation life. The derivation of the capital recovery factor is given in Appendix B.

Information was obtained[2] on the annual production of pesticide ingredients at each plant and on the sales value of that output. The values of the pesticide ingredients were based on the ranges of values obtained from the technical 308 questionnaire. The mid-range of product value of the unformulated pesticides was used in computing a ratio of annualized treatment cost to value of sales. The total value of pesticide ingredients produced at each of the plants was estimated by multiplying the annual production figures and the estimated value for each active ingredient and then summing the results for all pesticide ingredients produced at the plant. The total additional annualized treatment costs were divided by the total estimated value of active pesticide ingredients at the manufacturer's level to obtain the ratio of treatment costs to pesticide ingredient value. This ratio was then used in an initial screening step of impact severity because more precise plant level financial data were not available.

Plants with treatment costs equal to or greater than four percent of pesticide value were identified for further analysis and plants below the 4 percent level were screened out. The use of this screening criterion does not mean that plants that fall below the level are unaffected by treatment costs. Rather, the 4 percent criterion serves as a rough indicator of those plants that may be severely impacted by treatment costs. We have observed (as discussed in the Industry Profile) that pre-tax profit margins range between 10 and 15 percent for pesticide producers. Given that plants generally must make some positive return greater than the return from immediately salvaging the plant, a loss of four percent in the rate of return could push a plant over the edge of profitability. Some sample calculations for the pulp and paper industry suggest that the return from salvage might be on the order of 2 to 3 percent.* Therefore, a plant with a 7 percent return would be pushed to the shutdown point if treatment costs were 4 percent of sales. A plant with a return of 7 to 10 percent would also be in a weakened financial condition, if it had other capital needs as well. In addition, a range of values for the cutoff ratio is considered.

For each treatment level, the total number of severely impacted plants was identified and the aggregate value of production determined. The next step was to review the available information for each plant where treatment costs exceeded four percent of sales value for any of the treatment levels. (The plant level data are considered confidential and therefore not included in this report). Although plant level financial data were not available, most of the information generally included plant location, types of product lines, quantities and value of pesticides and other product lines, period of pesticide production during the year, parent company ownership and likely attitudes of firms about relocating production at other company locations. This type of information developed by A. D. Little, Inc.[2] was used in conjunction with the treatment cost impact in arriving at judgements about whether or not severely impacted plants (or product lines) would be shut down.

Plant closures are estimated both for a baseline and for the incremental impacts of the proposed effluent guidelines. Costs of compliance with hazardous solid waste management rules under the Resource Conservation and Recovery Act (RCRA) are included as part of the baseline, because these rules have already been promulgated, but their compliance costs have not otherwise been incorporated into the data base. Because impacts due to RCRA may be significant, it is important to identify them before determining the incremental impacts of the proposed effluent guidelines. Specifically, if a plant is predicted to close due to RCRA costs alone, then it cannot be counted as part of the incremental impact of the proposed effluent guidelines, even if those compliance costs are also high.

Costs of compliance with RCRA requirements were estimated for each plant based on various methods of disposing of process and treatment wastes. Information was provided by the Technical Contractor about treatment methods used at each plant. RCRA disposal methods were assigned to individual plants using a set of rules (developed in discussion with the Technical Contractor) that addressed on-site versus off-site disposal capabilities as well as disposal methods such as incineration, deep well injection and landfill. Total RCRA costs were calculated for each plant based on the assignment of disposal methods.

A cutoff ratio of RCRA costs to plant product value of four percent was used to identify baseline closure candidates. Other available information about the plant or individual product lines was considered in assessing whether or not closure due to RCRA costs was likely.

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*See "Analyzing Economic Impacts in a Period of Inflation", EPA, Office of Analysis and Evaluation, March 25, 1982, unpublished draft.

In some cases, a plant will not close because of RCRA costs or BAT/PSES costs alone, but may close due to their combined effect. These cases are noted in Section 5. Again, these assessments represent best judgments based on rather general information about each plant and the magnitude of the additional costs.

Small Business Analysis

An analysis is conducted to determine whether small firms bear disproportionate impacts under the proposed effluent guidelines. The method used is to classify all firms in the data sample as either large or small and then to compare the distribution of impacts on plants belonging to firms in the two sets. The impacts include number of plants with compliance costs, the distribution of the cost to sales ratio, and the number of closures. The analysis is primarily concerned with small firms with limited resources or those which would face barriers to entry due to regulation. In light of these considerations, we have defined small businesses to be those having less than $10 million in annual sales. 18 out of the 80 plants in the data base, 23 percent of the total, fall under this definition of a small business.

New Source Standards

Treatment costs were estimated by the Technical Contractor for new plants, considering both direct and indirect dischargers.[13,14] Types of treatment subcategories were then postulated to handle different waste streams that might be generated by new plants. Model plant sizes were identified by the Technical Contractor for each subcategory. The treatment costs are considered high because the estimates are for "end-of-pipe" treatment whereas a new plant design would be likely to utilize in-plant waste stream controls to reduce total plant costs. However, no data are available to estimate the degree by which "end-of-pipe" treatment costs may be overestimated when these costs are used for analyzing new sources.

The major groups of pesticides--i.e., fungicide, herbicide and insecticide--that might be produced by a plant in each subcategory were identified and price ranges for the pesticides were determined to estimate ranges of product values for the model plants considered.[12,13,14]

As in the plant-level analysis, impacts are assessed primarily based on the ratio of annualized treatment costs (annualized capital costs plus O&M costs) to the plant's product value.

The likehood that new pesticide chemicals manufacturing plants will be built by 1985 is assessed. This assessment is based on existing plant capacities for producing the three major groups of pesticides and the demands for those products by 1985 as projected by Arthur D. Little Inc. and by Frost and Sullivan.[15]

Section 3

Industry Profile

The pesticide industry is a two-tiered business encompassing at one level, producers of pesticide chemicals (active ingredients) and at the second level, formulators who combine the active ingredients with substances such as diluents, emulsifiers and wetting agents so that the pesticides can be applied by the ultimate users. Many of the firms making the active chemical ingredients are also formulators, however, there are also numerous independent formulators.

Pesticide active ingredients are primarily synthetic organic chemicals that are covered in SIC 28694 (Pesticide and Other Organic Agricultural Chemicals, Except Preparation) which is part of SIC 2869, (Industrial Organic Chemicals N.E.C. (not elsewhwere classified)). The formulators and packagers of pesticide products are classfied in SIC 2879, (Pesticides and Agricultural Chemical Producers, N.E.C.).

As of January 1979, there were 7,875 pesticide producers or formulating plants according to the Establishment Registration System of the EPA. EPA has determined that formulators operate essentially as a "zero discharge" industry with only minor volumes of aqueous wastestreams. Furthermore, many of the formulating plants may carry out no actual formulating or manufacturing operations but are only involved in handling the formulated products.

According to the 1977 Census of Manufacturers, there were only 420 establishments whose primary business was classified in SIC 2879, the SIC group that includes pesticide formulators and, according to EPA and Technical Contractor data, there are only 117 plants in the U.S. that make pesticide chemical active ingredients.

U.S. pesticide manufacturers produced 1.5 billion pounds of pesticide active ingredient chemicals in 1980 valued at about $4.3 billion. These ingredients were formulated with various inert materials and then distributed to agricultural and other users. Table 3-1 gives historical production, value, and pricing data on the domestic pesticide chemicals manufacturing industry.

Structure of Demand

The most common categorization of pesticides is by type of pest controlled: weeds, insects, fungal diseases, and the like. In the agricultural sector (which constitutes the major market for pesticide products) it is estimated that, for every $1 spent on pesticides, the farmer obtains, on the average $5 in increased yields as a result of lower crop losses.[16] Three classes of products--herbicides, insecticides, and fungicides--compose virtually all domestic pesticide production, although small amounts of rodent and bird-control materials are also produced. In simple terms, herbicides are used to eliminate weeds, fungicides are used to protect plants from fungus, and insecticides are used to kill insects.

Table 3-1. Total U.S.. Pesticide Chemicals Production[1] (1967-1978)

Year	Production Million Pounds	Value[2] Million $ Current	Value[2] Million $ Constant[4]	Average Price[3] $/lb Current	Average Price[3] $/lb Constant[5]
1967	1,050	987	987	0.94	0.94
1968	1,192	1,137	1,120	0.95	0.91
1969	1,104	1,113	1,039	1.01	0.92
1970	1,034	1,074	961	1.04	0.90
1971	1,136	1,248	1,116	1.10	0.90
1972	1,157	1,295	1,127	1.12	0.88
1973	1,289	1,449	1,206	1.12	0.84
1974	1,417	1,958	1,336	1.38	0.95
1975	1,603	2,871	1,382	1.79	1.13
1976	1,364	2,768	1,277	2.03	1.21
1977	1,388	3,119	1,304	2.25	1.27
1978	1,417	3,289	1,322	2.32	1.22
1979	1,429	3,706	1,336	2.59	1.26
1980	1,468	4,281	1,380	2.92	1.30
Average Annual Growth (%)					
1967-1974	4.4	10.3	4.4	5.6	0.1
1974-1980	0.6	13.9	0.5	13.3	5.4

[1] Herbicides, insecticides, and fungicides.

[2] Value is the sum of the value columns in Tables 3-3, 3-4, and 3-5.

[3] Average price is value/total production.

[4] Constant dollars for pesticide values are calculated using pesticide price indices shown in Table 2-2 (1967=100).

[5] Constant dollars for pesticide average prices are calculated using a GNP Deflator (1967=100).

Source: U.S. International Trade Commission, Arthur D. Little, Inc., and Meta Systems Inc calculations.

Production of herbicides, insecticides, and fungicides has changed considerably over the past two decades. Figure 3-1 demonstrates the changes in production of these products. Herbicides have taken the lead in production only since 1975. The sharp decline in herbicide production in 1969 was due to a disruption in the supply of the intermediate chemicals used in manufacturing herbicides. This disruption was caused by an increase in demand for defoliants during the Vietnam War from which the industry took several years to recover. Insecticide production has been increasing since 1976 when it fell off by almost 100 million pounds. Fungicide production has stayed about the same over the past ten years.

Herbicides constitute the newest and most important group of pesticides. Table 3-2 shows that herbicides accounted for about 60 percent of the total value of pesticide chemical production in 1977 and 49 percent of the total quantity of pesticides produced. The relative contribution of each product class to total production of pesticide is also shown in Table 3-2.

Historical data on production and dollar value of herbicides, insecticides, and fungicides, are presented in Tables 3-3, 3-4, and 3-5, respectively. The tables demonstrate that all of the pesticide groups have experienced considerable growth since 1967.

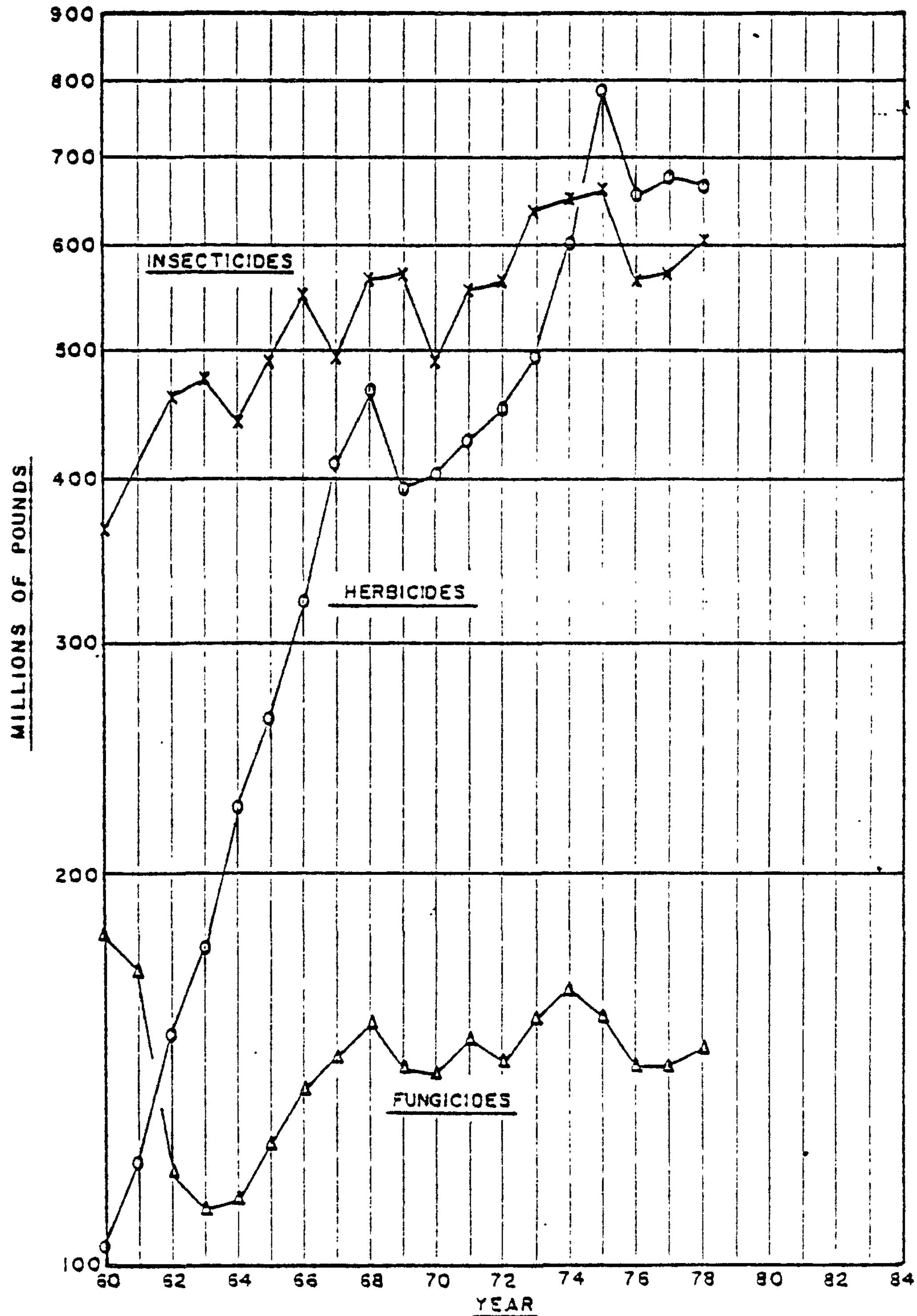
Herbicide production has grown most dramatically, increasing from 409 million pounds in 1967 to 805 million pounds in 1980, which is an average annual growth rate of 5.3 percent. The major agricultural markets for herbicides are corn, soybeans, wheat, and cotton.[17] Corn is particularly important, accounting for about half the agricultural herbicide market. The non-agricultural herbicides are used on lawns, parks, and golf courses, and in the control of vegetation along right-of-way areas.

Insecticides kill by contact with, or ingestion by, the insect. Insecticides can be aimed at a specific major pest, such as the boll weevil, or at a broad spectrum of insects. The major agricultural markets for insecticides are cotton, corn, peanuts, fruits and vegetables, with cotton accounting for about one-third the 1976 agricultural applications. Insecticides are also used by livestock farmers and in a variety of non-agricultural applications.

The 496 million pounds of insecticides produced in 1967 represented 90 million pounds more than the herbicide volume for that year, but by 1980, insecticide production of 506 million pounds was 300 million pounds less than that of herbicides. Thus, insecticides may be considered a relatively mature market; their 1967-1980 average annual growth rate of less than one percent is significantly lower than that of herbicides.

Fungicides represent a relatively minor group of pesticides. In 1980, production of 156 million pounds of fungicides represented only about 10 percent of total pesticide production and even less of pesticide value. Furthermore, the fungicide market is stagnant, with the 1978 production

Figure 3-1. Annual Pesticide Production by Product Type



Source: Arthur D. Little

Table 3-2. Estimated Composition of U.S. Pesticide Chemicals Production in 1977 (1977 Dollars)

Class	Production: Million Lbs.	Production: Percent	Value[1]: Million $	Value[1]: Percent	Average Unit Value: $/lb
Herbicides	674	49	1,867	60	2.77
Insecticides	570	41	1,049	34	1.84
Fungicides	143	10	203	6	1.42
Totals	1,387	100	3,119	100	

[1]Represents the value of active ingredients produced.

Source: U.S. International Trade Commission, calculations by Meta Systems Inc.

level 33 million pounds less than that of 1960. Most fungicides are contact products and are used as a preventative measure. The plant is coated with the fungicide which protects it from disease. A new type of fungicide--and one that offers growth potential to the industry--is the systemic fungicide. These products, unlike the contact group, can actually reverse disease therapeutically.

The major agricultural markets for fungicides are fruits and vegetables, particularly citrus fruits; peanut and cotton farmers are also important users. Non-agricultural uses of fungicide are also significant, with the applicaton of pentachlorophenol as a wood preservative for poles and posts being the most important.

Structure of Supply

Producers of Pesticide Chemicals

There are difficulties in characterizing the suppliers of pesticides because there are few companies for which pesticides are considered a major source of revenue. There are no publicly-owned companies in which pesticides are considered the prime source of revenue. In 1977, 81 companies reported the manufacture of pesticide active ingredients to the U.S. International Trade Commission (ITC). These producers included petroleum companies (e.g., Shell), chemical companies (e.g., Dow and DuPont), and pharmaceutical-based firms (e.g., Eli Lilly and Pfizer).

Table 3-3. U.S. Herbicide Production (1967-1980)

Year	Production Million Pounds	Value[2] Million $	Average Price[1] $/lb
1967	409	617	1.51
1968	469	718	1.53
1969	393	662	1.68
1970	404	663	1.64
1971	429	781	1.82
1972	451	812	1.80
1973	496	843	1.70
1974	604	1,214	2.02
1975	788	1,781	2.26
1976	656	1,692	2.58
1977	674	1,867	2.77
1978	664	1,843	2.78
1979	658	2,020	3.07
1980	805	2,695	3.35
Average Annual Growth (%)			
1967-1974	5.7	10.1	4.2
1974-1980	4.9	14.2	8.8

[1]Average price is the quantity weighted average price of cyclic and acrylic herbicide merchant shipments in current dollars.

[2]Value is derived as weighted average price x production volume.

Sources: U.S. Tarriff Commission (to 1973), U.S. International Trade Commission (1974-1977), and Arthur D. Little, Inc., calculations.

Table 3-4. U.S. Insecticide Production (1967-1980)

Year	Production Million Pounds	Value[2] Million $	Average Price[1] $/lb
1967	496	304	0.61
1968	569	347	0.61
1969	571	383	0.67
1970	490	340	0.69
1971	558	385	0.69
1972	564	344	0.61
1973	639	492	0.77
1974	650	605	0.93
1975	659	916	1.39
1976	566	911	1.61
1977	570	1,049	1.84
1978	606	1,232	2.03
1979	617	1,407	2.28
1980	506	1,279	2.56
Average Annual Growth (%)			
1967-1974	3.9	10.3	6.2
1974-1980	-4.0	13.3	18.4

[1]Average price is the quantity weighted average price of cyclic and acrylic insecticide merchant shipments in current dollars.

[2]Value is derived as weighted average price x production volume.

Sources: U.S. Tarriff Commission and Arthur D. Little, Inc., estimates.

Table 3-5. U.S. Fungicide Production (1967-1980)

Year	Production Million Pounds	Value[2] Million $	Average Price[1] $/lb
1967	144	66	0.46
1968	154	72	0.47
1969	141	68	0.48
1970	140	71	0.51
1971	149	82	0.55
1972	143	93	0.65
1973	154	114	0.74
1974	163	139	0.85
1975	155	174	1.12
1976	142	165	1.16
1977	143	203	1.42
1978	147	214	1.46
1979	155	279	1.80
1980	156	307	1.97
Average Annual Growth (%)			
1967-1974	1.8	11.2	9.2
1974-1980	-0.7	14.1	15.0

[1]Average price is the quantity weighted average price of cyclic and acrylic fungicides merchant shipments.

[2]Value is calculated as weighted average price x production volume.

Sources: U.S. Tarriff Commission and Arthur D. Little, Inc., estimates.

The production of basic chemicals is the first and most complex phase of the pesticides industry. It involves the synthesizing of technical-grade chemicals from raw materials. There are twenty major classes of raw materials and chemical intermediates used in the manufacture of pesticides, and in recent years about 2.5 billion pounds of these raw materials, valued at over $1.6 billion, are consumed annually by the pesticide industry. Table 3-6 lists the major chemical groups and raw materials that are used in manufacturing pesticides. It also shows the proportional contribution that each group makes to the total estimated value of pesticide production.

Pesticides are generally manufactured in plants which also produce other organic chemicals, including pharmaceuticals, plastics, and resins. Approximately 95 percent of the plants produce no more than four pesticides, while almost 50 percent produce only one. The pesticides, with the exception of such high-volume products as the cotton insecticide, toxaphene, are not generally produced throughout the year. The plants in the industry also vary widely in size. The outputs of a number of plants are worth more than $75 million, and 12 of the 117 manufacturing plants account for slightly more than 50 percent of the total value of the outputs. In contrast, almost half of the plants have an annual market value for all pesticide chemicals of less than $5 million.

Table 3-7 lists production, value, and market share data for the top 18 pesticide producers. The top four companies account for about half of the industry's market share by value and the top eight firms account for 82 percent of the market share. Different segments of the pesticide industry, however, exhibit varying degrees of concentration; for example, the top four producers of corn insecticides account for 81 percent of the market share and the top four soybean insecticide producers have 77 percent of the market. Thus, within the various pesticide segments there are high levels of industrial concentration.

Profile of Pesticide Chemicals Plants

The EPA identified 117 separate plants (belonging to 81 companies) that produced pesticide chemicals in 1977. All 117 plants produce pesticide active ingredients, and 55 of the 117 also formulate and package the pesticide products. Thus about half the manufacturing plants are vertically integrated operations. While all the 117 plants produce pesticide chemicals, this is not necessarily their sole line of business, nor is it necessarily a business that they carry on continually. About three-quarters of the plants (87) produce various chemicals other than pesticides.

Table 3-8 shows a classification of the 117 manufacturing plants by major type of pesticides produced: herbicides, insecticides, fungicides, and mixed pesticide products. In classifying the plants, for purposes of the impact analysis, the fact that almost three-quarters of them also

Table 3-6. Raw Materials and Key Chemical Intermediates Used in Pesticide Manufacture

Product Group	Percent of Total Estimated Value of Production
Phenol and derivatives	25.3
Aniline derivatives	12.4
Cyanide derivatives	12.3
Carboxylic acid derivatives	11.3
Higher alkyl amines	8.5
Phosphorous pentasulfide	5.5
Benzene and related compounds	4.9
Phosgene	4.2
Chlorine	3.7
Phosphorous trichloride	3.2
Mercaptans	3.0
Bromine	2.6
Monomethylamine	1.2
Aldehydes	1.1
Carbon disulfide	0.4
L-Pinene	0.4
Cyclodienes	--
Total	100.0%

Source: U.S. Pesticides Market; Report #A907, Frost & Sullivan, Inc., New York, New York, May 1981.

Table 3-7. Pesticide Market by Producer, 1980
(1980 Dollars)

Company	Value ($MM)	Production (MM lbs.)	% Market Share by Value	% Cummulative Market Share
Monsanto	522-580	169-173	20	20
Ciba-Geigy	354-358	142-147	13	33
Stauffer	330	105-117	12	45
Eli Lilly	285-300	72-82	10	55
DuPont	220	75-99	8	63
Cyanamid	220	82	8	71
Union Carbide	150-160	57-73	6	77
Shell	132-155	40-55	5	82
FMC	135-140	55	5	87
Mobay	125-135	40-45	5	92
BASF-Wyandotte	75-100	20-25	3	95
Diamond-Shamrock	75	25-30	3	98
Rohm & Haas	41-46	13-15	1	99
Uniroyal	36	11	1	100
Velsicol	18	9-10	--	--
ICI	10-20	--	--	--
Olin	10-15	5	--	--
Standard Oil (Calif)	5	2-3	--	--
Total	2,773-2,913		100	

Source: U.S. Pesticides Market; Frost & Sullivan

Table 3-8

Profile of Pesticide Plants -- Subcategorization

Subcategory	Number of Plants
Herbicides	
Anilides-cyclic	3
Triazines-cyclic	2
Hydrazides-cyclic	3
Benzoics-cyclic	3
Phenoxies-cyclic	4
Dinitrophenols and anilines-cyclic	1
Ureas-cyclic	1
Miscellaneous	7
Total	24
Insecticides	
Aldrin-toxaphene-cyclic	3
Organophosphorus-cyclic	3
Carbamates-cyclic	2
Chloro-organic-cyclic	3
Nematocides-cyclic	1
Rodenticides-cyclic	2
Attractants and repellants-cyclic	2
Synergists-cyclic	2
Organophosphorus-acyclic	4
Miscellaneous	19
Total	41
Fungicides	
Polychloro-aromatics-cyclic	4
Chloroalkyl amides	1
Miscellaneous	8
Total	13
Mixed* Total	39
Total	117

*Production of pesticides is in more than one subcategory.

manufacture non-pesticide products is not considered. Thus, subcategorization and the associated discussion relate exclusively to the pesticide operations of the plants. Twenty-four plants mainly produce herbicides, and their average production value is twice that of insecticide producers and nine times that of fungicide producers.

Forty-one plants are classified as insecticide producers, 13 as fungicide producers, and the remaining 39 plants manufacture more than one type of product. The mixed-product plants tend to be larger than the single-product plants; their average production value is almost twice that of the herbicide producers.

The first three groupings can be further subdivided by the types of chemicals produced. Thus herbicides can be subdivided into anilides, triazines, hydrazides, benzoics, phenoxies, dinitrophenols/anilines, ureas, and miscellaneous. The major herbicides in the anilide group are alachlor and propachol. The former is used extensively on soybeans and corn, the latter on sorghum. The most important herbicide in the triazines group is atrazine, which dominates the corn market. The phenoxies group includes 2, 4-D, the use of which has come under environmental restriction.

Insecticides are subdivided into aldrin-toxaphene, cyclic organophosphorus, acyclic organophosphorus, carbamates, chloro-organics, nematocides, rodenticides, attractants/repellants, synergists, and miscellaneous. Acyclic organophosphorus is the most important group, and the insecticides in this group have a wide range of applications, particularly in corn and livestock. The cyclic organophosphorus group includes methyl parathion, which is used on wheat and corn. Insecticides in the aldrin-toxaphene group are used in cotton, soybeans, and livestock. The fungicides are subdivided into polychloro-aromatics, chloroalkyl amides, and miscellaneous.

Capacity Utilization. The pesticides manufacturing industry overall operated at a capacity utilization rate of 80 percent in 1979. Thus, while 1,429 million pounds of pesticide chemicals were produced in 1979, capacity was available to produce about 1,800 million pounds. The components of the industry (fungicides, insecticides, herbicides) varied with respect to utilization of available capacity and Table 3-9 lists production capacity and capacity utilization in 1979.

Formulators

It is difficult to describe pesticide formulators because there are a large number of small operators for which statistical information is not available. As mentioned earlier, while almost 8,000 plants were counted as formulators in 1979, in fact, many of these are distributors of formulated products.

Table 3-9

Pesticide Production and Capacity Utilization in 1979

Type of Pesticide	Production (million lbs.	Capacity (million lbs.)	Capacity Utilization
Fungicides	155	184	.84
Herbicides	657	888	.74
Insecticides	617	726	.85
All pesticides	1,429	1,786	.80

Source: U.S. Pesticide Market, Frost & Sullivan (capacity values calculated by Meta Systems Inc.

Technical grade pesticide chemicals are rarely used in the pure form manufactured by the chemical firms but are mixed with inert materials in the formulation stage. Mixing serves the dual purpose of stabilizing the chemicals and preparing them in a form that will be useful to end users. The form into which the chemicals are formulated depends upon such factors as the type of pest being controlled, the environment, the desired method of application and the properties of the technical grade chemical. Pesticides are produced as dry or liquid concentrates and are then generally formulated to meet application requirements. Dry concentrates include dusts, granules, and wettable powders. Liquid concentrates consist of solutions and stable suspensions.

New systems are being developed for the application of pesticides, the most current being micro-encapsulation, or controlled release. This process is still unproven on a large scale and is quite expensive, but its developers (Health-Chem and Penwalt) claim it has superior field life and efficiency.

Prior to 1970, the formulation of technical-grade pesticides was carried out by a variety of independent firms and agricultural cooperatives. Formulating firms bought pesticides from the basic manufacturers and formulated and packaged the products for sale. In the mid-1970's there was an overall domestic shortage of chemicals and during this period many of the technical-grade pesticide producers integrated forward and formulated their own chemicals captively. Although the chemical shortage is now over, most of the chemical manufacturers have chosen to stay in the formulating business. The current estimate in the Kline Guide is that 80 percent of the formulated pesticide industry is controlled by technical-grade producers.

Profitability

As mentioned earlier, most of the U.S. pesticide production is carried on by diversified companies and their sales of pesticides are a minor source of the firms' revenue. Therefore, the availability of reliable financial data on pesticide production is extremely limited. Investment analysts regard pesticide production as a very profitable business with profit margins much higher than is suggested by an analysis of income statements. For example, one investment house (Loeb Rhodes and Company) estimates that the average net margin in sales (after taxes and all charges) exceeds 20 percent. However, a detailed examination of the annual reports and 10-K statements of pesticide producers revealed that line-of-business, pre-tax profit margins in 1978 typically range between 10 and 15 percent. This finding is consistent with the Federal Trade Commission's statement that chemical industry pre-tax profit margins in 1978 averaged 10.6 percent (versus 8.0 percent for all manufacturing).[18]

There are many individual pesticide products on which profit margins exceed 40 percent. These are the proprietary (patented) products for which the absence of competition allows the patent-holder to price the product considerably higher than cost. The life of a patent is 17 years and pesticide manufacturers aggressively seek to develop new pesticides to maintain their pool of patented products. The National Agricultural Chemical Association reported that pesticide research and development expenditures in 1978 accounted for 8 percent of sales revenue. Nevertheless, in 1978, only 3 new pesticides were registered versus 28 registrations in 1966.[19]

The slowdown in the rate of new pesticide introduction is attributable, in part, to governmental regulation, which has increased both the time and cost required to commercialize a new pesticide. The regulation of pesticides dates back to 1910, but it was only in 1947 that the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as administered by the USDA, required pesticides to be federally registered. The Federal Environmental Pesticide Control Act (FEPCA) of 1972 and the Federal Pesticide Act of 1978, as administered by the EPA, define the current requirements for federal registration.

Research and Development

Research and development plays a major role in the continued success of chemical producers. Because of the cost and time required to develop new pesticides, R&D activities are concentrated in about 30 companies. These are, generally, large, multi-product companies which can afford risky ventures. Thus, to the extent that pesticide operations are very profitable, examples of such profitability are likely to be found among the large companies.

The amount of money invested annually on pesticide R&D increased from $61 million in 1967 to $290 million in 1978 (in current dollars).[15] This is due in part to the increased complexity of pesticide chemicals and new prohibitions on broad spectrum pesticides, but testing and regulatory requirements also play a major role in added R&D expenditures. The 1978 Amendments to the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) are estimated by Frost and Sullivan to add 33 percent to the cost of registering a new pesticide and over 50 percent to the costs of re-registration.[15]

On the average, the entire process of developing and testing a new pesticide takes six to eight years and costs about $15 million. In 1978 only three new pesticides were registered, compared to 1966, when 28 new pesticides were introduced, with an average development time of four years and a cost of $2 million. R&D costs in the pesticide industry are expected to increase.[20/21] The likely consequence of such an increase will be further concentration of the industry with only the largest firms either willing or able to afford the high R&D costs. High R&D costs and the uncertainty inherent in the commercialization of a new pesticide pose major barriers to new firms seeking to enter the industry. The successful companies in the future are likely to be those with existing technical bases (e.g., pharmaceutical companies) and/or those with long-term positions in the industry.

Imports and Exports

The U.S. is a net exporter of pesticides and in 1977 exports exceeded imports by 263 million pounds. Tables 3-10 through 3-12 present data on production, exports and imports of pesticide products for 1966 to 1977. As shown in Table 3-10, in 1977, the United States exported 109.4 million pounds of herbicides which amounted to 16 percent of domestic production. The 1977 export figures represent an increase of 87 million pounds since 1966. Imports of herbicides equalled 15.9 million pounds or 2.3 percent of total domestic production.

Insecticide exports (Table 3-11) were 146.3 million pounds or 25.7 percent of total production, in 1977, and imports represented .12 percent of domestic production. Exports of herbicides (Table 3-12) for the same year were 27.1 million pounds and accounted for 19 percent of domestic production, while imports were 2.5 million pounds or 1.7 percent of total production.

Table 3-13 presents annual growth rates for both volume and value of exports for the three major pesticide classes. From 1969 to 1977 the volume of herbicide exports grew by 15 percent annually while the value of those exports grew 22 percent a year. The volume of insecticides exported grew 1.7 percent per year and the dollar value of those exports grew in value by 15 percent a year. Fungicide exports grew 5 percent a year and the value of fungicide exports grew 20 percent ayear between 1969 and 1977.

Table 3-10. U.S. Production and Trade in Herbicides

Year	Production (MM lb)	Exports (MM lb)	Exports as a Percent of Production	Imports (MM lb)	Imports as a Percent of Production
1966	324	22.5	6.9	1.1	0.3
1967	409	32.4	8.0	2.7	0.7
1968	469	37.0	8.1	3.0	0.6
1969	393	34.8	8.9	2.3	0.6
1970	404	39.0	9.7	2.4	0.6
1971	429	42.3	9.9	5.7	1.0
1972	451	--	--	4.4	1.3
1973	496	80.6	16.3	7.6	1.5
1974	604	106.1	17.6	9.2	1.5
1975	788	106.7	13.5	12.2	1.6
1976	656	104.2	15.9	13.1	2.0
1977	674	109.4	16.0	15.9	2.3

Sources:

Production is from International Trade Commission, Synthetic Organic Chemicals (Washington, D.C., U.S. Government Printing Office) various issues.

Imports and exports are converted to an active ingredient basis by halving the values as reported in U.S. Department of Agriculture, The Pesticide Review (Washington, D.C., U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service).

Table 3-11. U.S. Production and Trade in Insecticides

Year	Production (MM lb)	Exports (MM lb)	Exports as a Percent of Production	Imports (MM lb)	Imports as a Percent of Production
1966	552	131.0	23.7	0.3	.05
1967	496	140.2	28.3	0.2	.04
1968	569	161.3	28.3	0.09	.02
1969	571	128.1	22.4	0.4	.07
1970	490	118.2	24.1	0.3	.06
1971	558	118.8	21.3	0.4	.07
1972	564	--	--	2.3	.40
1973	639	208.7	32.7	1.7	.30
1974	650	212.2	32.7	0.9	.14
1975	659	178.5	27.1	0.7	.01
1976	566	148.2	26.2	0.7	.12
1977	570	146.3	25.7	0.7	.12

Sources:

Production is from International Trade Commission, Synthetic Organic Chemicals (Washington, D.C., U.S. Government Printing Office) various issues.

Imports and exports are converted to an active ingredient basis by halving the values as reported in U.S. Department of Agriculture, The Pesticide Review (Washington, D.C., U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service).

Table 3-12. U.S. Production and Trade in Fungicides

Year	Production (MM lb)	Exports (MM lb)	Exports as a Percent of Production	Imports (MM lb)	Imports as a Percent of Production
1966	137	21.2	15.5	0.1	0.1
1967	144	19.2	13.3	0.2	0.1
1968	154	18.8	12.2	0.3	0.2
1969	141	18.1	12.8	0.2	0.1
1970	140	20.6	14.7	0.6	0.4
1971	149	21.5	14.4	1.4	0.9
1972	143	21.0	14.7	2.7	1.9
1973	154	29.2	19.0	2.0	1.3
1974	163	30.0	18.4	1.2	0.7
1975	155	23.9	15.4	2.4	1.5
1976	142	25.2	17.7	2.3	1.6
1977	143	27.1	18.9	2.5	1.7

Sources:

Production is from International Trade Commission, Synthetic Organic Chemicals (Washington, D.C., U.S. Government Printing Office) various issues.

Imports and exports are converted to an active ingredient basis by halving the values as reported in U.S. Department of Agriculture, The Pesticide Review (Washington, D.C., U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service).

Table 3-13. Annual Growth Rates for Volume and Value of Pesticide Exports (1969-1977)

Product Class	Production (%)	Value * (%)
Herbicides	15	22
Insecticide	1.7	15
Fungicide	5	20

* in current dollars.

Source: U.S. Pesticides Market, Frost & Sullivan.

Of the 49 million pounds of pesticides imported by the United States in 1977, West Germany was the originator of 31 percent, the United Kingdom of 29 percent and Japan of 10 percent.

Industry Outlook

Market forecasts for pesticide sales are complicated by the industry's dependence on such different variables as weather, farm income, predicted insect infestations, previous years' pesticide inventory, and changing health and environmental regulations. Regardless of the uncertainties in predicting changes in the production and value of pesticides, however, the use of pesticides can be expected to grow. In the United States alone, the application of pesticides has increased at an average rate of 3.4 percent a year or about 40 percent over the past decade. It is reasonable to expect a general trend of modest growth to continue over the next five years.

Production of pesticides was 1.4 billion pounds in 1980 and is expected to grow about 1.4 percent annually until 1985 when production is anticipated to reach 1.5 billion pounds according to one source (Frost and Sullivan[15]). The dollar value of this production is projected to increase by 8.4 percent a year from $4.3 billion in 1980 to $6.4 billion in 1985, expressed in current dollars. According to another source,[22] the average annual rate of growth in value of pesticide production, expressed in constant dollars, is projected at 5.0 percent between 1980 and 1985.

The three major product classes that make up the pesticide industry are expected to grow at different rates during the 1980-1985 period, with herbicides growing at the highest rate (in terms of both volume and value) and insecticides growing at the lowest annual rate. Table 3-14 shows the projected annual growth rates for the pesticide market by product class.

The structure of the pesticides industry is not expected to change markedly in the next five years. Increasing research and development costs and rising raw materials prices can be expected to result in the exclusion of small companies from competition, but the top ten companies are likely to maintain their market shares relative to one another.

Table 3-14. Pesticide Market by Major Class--
Yearly Rate of Growth (1980-1985)

Product Class	Production (%)	Value* (%)
Herbicides	1.9	8.6
Insecticide	0.9	7.8
Fungicide	1.4	8.4
Total Industry	1.4	8.4

* In current dollars.

Source: U.S. Pesticide Market, Frost & Sullivan.

Section 4

Recommended Treatment Technologies and Associated Costs

The 1972 Federal Water Pollution Control Act (FWPCA) amendments (Public Law 92-0500) were primarily directed at the control of industrial and municipal wastewater discharges. The legislation and subsequent amendments (Clean Water Act of 1977, Public Law 95-217) require that EPA revise and promulgate effluent limitations and standards for all point sources of pollution. Under FWPCA amendments, EPA must develop technology-based effluent limitations for conventional pollutants (Section 301). Under another part of the legislation (Section 307), EPA must develop effluent standards for individual toxic chemicals and pretreatment standards for indirect industrial discharges to publicly owned treatment works. These permissible levels of pollutant discharge correspond to Best Practicable Control Technology Currently Available (BPT) and Best Available Technology Economically Achievable (BAT) and Pretreatment Standards for Existing Sources (PSES).

The law set specific timetables for achievement of discharge levels corresponding to these levels of treatment (July 1977 for BPT and July 1983 for BAT). These timetables were subsequently revised via the 1977 amendments and distinctions were made among pollutants. The original BPT and BAT regulations were modified by a new regulatory concept, Best Conventional Pollutant Control Technology (BCT) and the universe of pollutants was subdivided into conventional, nonconventional and toxics.

The law has also provided for toxic effluent standards for new sources and/or dischargers to municipal wastewater treatment facilities. These discharge categories are addressed by NSPS (New Source Performance Standards), and PSNS (Pretreatment Standards for New Sources).

The manufacture of pesticide chemicals involves the production of several hundred organic chemical compounds. These compounds are sometimes produced at facilities where manufacturing pesticide chemicals is the main, or the only business; in other facilities, pesticides represent only a small portion of the facility's production. Under the proposed effluent guidelines for the pesticide chemicals manufacturing industry, the EPA is considering new effluent limitations guidelines for existing plants--both for direct discharge to surface waters and for pretreatment (by indirect dischargers) prior to discharge to publicly owned treatment works (POTW). These new effluent limitations include not only the pesticides previously regulated by the EPA under BPCTCA* (primarily to meet certain pollution control parameters such as BOD, COD, or suspended solids), but also priority pollutants and certain pesticides, such as atrazine, which were excluded from the BPCTCA regulations.

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* Best Practicable Control Technology Currently Available; also referred to as BPT.

Cost Methodology

The cost estimates were developed by the Technical Contractor on a subcategory, rather than plant-by plant, basis. They show the range of costs potentially incurred by model plants of various flows and differing pesticide treatability. They were derived in the following manner:

1. Costs were generated for each treatment unit based on September 1979 dollars and corresponding to a Marshall and Swift Index value of 630. The total construction costs for each unit were prepared from manufacturers' estimates which were compared to actual plant data when available. The total construction costs include the treatment unit cost, land, electrical, piping, instrumentation, site preparation, engineering, and contingency fees. Annual and energy costs were calculated in accordance with the assumptions specified. Cost curves were prepared for dollars versus volume treated, and each of the components included in the individual treatment units was specified.

2. The total cost for each subcategory was derived by summing the costs for individual treatment units that are specified for each level of control. Treatment costs for each subcategory are based on flow rates of 0.01 MGD, 0.1 MGD, and 1 MGD which were representative of actual flows in the industry; flows below 0.01 MGD were provided with alternative costs for evaporation or contract hauling as is practiced in the industry. Treatment costs for zero dischargers, metallo-organic pesticide manufacturers and pesticide formulator/packagers, Subcategories 11, 12, and 13, respectively, are based on representative flow rates of 50 gpd, 500 gpd, and 5,000 gpd.

3. For pesticide manufacturers, a high and low cost for each treatment unit was introduced to reflect differences in degree of treatability or differences in recoveries obtainable. For example, in each case where pesticide removal was recommended, the costs for activated carbon, resin adsorption, and hydrolysis were compared. The effectiveness of these technologies has been demonstrated within the design ranges provided; however, each individual pesticide plant must determine by laboratory and/or pilot scale treatability studies the exact design criteria to meet effluent objectives. In general, this comparison resulted in the selection of carbon adsorption at 750 minutes detention time for the high cost, and hydrolysis at 400 minutes detention time for the low cost for each subcategory. In this cost comparison, 12-hour equalization, neutralization, dual media filtration, and pumping stations were assumed to be part of both activated carbon and resin adsorption systems.

High and low cost were also provided where steam stripping was the designated technology to account for the fact that stripped organics may either be returned to the process (in which case a recovery has been calculated) or that they become a wastestream which is normally disposed by incineration.

High and low costs have been provided for the incineration unit to reflect the fact that the size of the unit and especially the annual costs are quite different depending on whether a chlorinated hydrocarbon or aqueous oily waste is being disposed. A reduction of fuel consumption based on the fuel value of hydrocarbon wastestreams has been considered.

A high and low cost has been provided for evaporation ponds, corresponding to solar evaporation and spray evaporation alternatives which are determined by site-specific climatic conditions.

The high and low costs for annual and energy may appear reversed. This simply means that the annual cost for a high capital system may be less than the annual cost for a low capital system.

4. The flows upon which unit treatment costs are based have been split into three groups based on wastewater segregation. Wastestreams not compatible with biological treatment (i.e., distillation tower bottoms, stripper overhead streams, reactor vent streams, etc.) are most effectively disposed of by incineration. Based on the operating range of incinerators in the industry it has been assumed that 1 percent of the total flow from the plant requires incineration. This corresponds to a range of 100 to 10,000 gallons per day.

   Based on the actual operating practices in the industry, steam stripping, chemical oxidation, and metal separation have been costed at flows equal to one-third the total volume disposed by the plant for total flow rates of 0.1 MGD and 1 MGD. Flow rates of 0.01 MGD have been costed at full flow. Pesticide removal (hydrolysis, activated carbon, or resin adsorption) and biological treatment (equalization, neutralization, nutrient addition, aeration basin, etc.) have been costed based on the total flow.

5. Estimates of capital cost annual cost and energy were provided for each subcategory and each level of technology. The capital costs for Level 1 technology, excluding corporation or contract hauling, are a minimum of $290,000 and a maximum of $4,690,000 at a flow rate of 0.1 MGD for pesticide manufacturers (Subcategories 1 through 12); Level 3 technology is shown to cost a minimum of $854,000 and a maximum of $5,250,000. There are four subcategories (6, 11, 12, and 13) for which the flows were in the range of less than 10,000 gallons per day for which it may be more cost-effective to dispose of wastes by contract hauling or evaporation, than to construct a wastewater treatment plant.

The costs presented in this section for each plant are estimates by the Technical Contractor of the capital, annual, and energy expenses which could potentially be incurred to meet proposed effluent levels. The costs are based on the assumption that existing plants already have installed pesticide removal and/or biological oxidation systems where BPT regulations require them. These estimates are therefore the incremental costs above and beyond BPT.

Treatment Options

Existing Sources

A total of 267 manufactured pesticides were studied by the Technical Contractor. To meet the anticipated new EPA guidelines, the Technical Contractor considered a set of treatment technologies that could be applied singly, or in combination, to achieve the required reduction of pollutants,[12] these are:

Treatment Technologies

- Steam stripping
- Filtration
- Chemical Oxidation
- Activated carbon
- Biological treatment
- Metals separation
- Resin adsorption
- Hydrolysis

These technologies can be classified into four major groups: physical-chemical treatment, biological treatment, multimedia filtration, and carbon filtration. From the various treatment technologies listed, one or more were selected for each plant (based on wastewater characteristics and treatment currently in place) and this selection defined a limited number of treatment options. To achieve different levels of effluent treatment, the treatment options for each plant are combined to define several treatment levels. For the indirect dischargers, the treatment levels are designated as follows:

1: physical/chemical treatment (equals PSES Option 1 in Development Document; this is the selected option)

2: Level 1 plus biological treatment (equals PSES Options 1 and 2)

For direct dischargers, the designated treatment levels are:

Level 1: physical/chemical and biological treatment (equals BAT Option 2 in Development Document; this is the selected option)

Level 2: Level 1 plus multimedia filtraton (equals BAT Options 2 and 3)

Level 3: Level 2 plus carbon filtration (equals BAT Options 2, 3, and 4)

Capital investment and annual costs were estimated for the two pretreatment treatment levels and three direct discharge treatment levels. The options and costs were developed in incremental terms: for indirect dischargers, the second pretreatment level includes the first; and for direct dischargers, each subsequent treatment level includes the technologies of the preceding treatment level. The treatment levels for indirect and direct dischargers are combined to define "economic" options whose impacts are to be analyzed. The options are defined as follows:

Economic Option	Direct Discharger Level	Indirect Discharger Level
1	1	1
2	2	1
3	3	1
4	1	2
5	2	2
6	3	2

Of the 117 plants that manufacture pesticide active ingredients in the U.S., the Technical Contractor has identified 51 plants that might require additional treatment to meet new treatment standards. (Existing and additional treatment technologies required for a sample of 38 plants are described in Table 4-1.)

New Sources

The Technical Contractor has also specified treatment levels for direct discharger and indirect discharger new sources (NSPS and PSNS, respectively) for each of 13 subcategories. Pesticides were assigned to subcategories based on several considerations, including raw materials used in manufacturing, wastewater characteristics and treatability, and disposal and manufacturing processes. Wastewater treatment trains that meet new source standards were synthesized for each subcategory. The treatment level for NSPS corresponds to Level 1 for direct dischargers and the treatment level for PSNS corresponds to Level 1 for indirect dischargers.

Table 4-1

Present Wastewater Treatment and Estimated Treatment Required for Compliance with Effluent Limitations

Plant Code No.	Wastewater Treatment Already in Place	Estimated Additional Treatment Required
1	Gravity Separation	Stripping
2	Stripping, Equalization, Activated Carbon Neutralization	Stripping
3	Resin Adsorption, Neutralization, Equalization, Activated Carbon	Stripping, Biological Treatment, Activated Carbon, Multimedia Filtration
4	Neutralization, Equalization, Trickling Filters, Gravity Separation, Evaporation Pond	Multimedia Filtration, Activated Carbon, Stripping
5	Equalization, Aerated Lagoon, Gravity Separation, Neutralization	Multimedia Filtration, Activated Carbon
6	Gravity Separation	Stripping, Metal Separation, Multimedia Filtration, Activated Carbon
7	Gravity Separation, Vacuum Filtration, Resin Adsorption, Neutralization	Stripping
8	Equalization, Neutralization	Multimedia Filtration, Activated Carbon, Stripping
9	Ocean	Stripping
10	Equalization, Not Available	Stripping
11	Skimming, Gravity Separation, Stripping, Chemical Oxidation, Equalization, Activated Sludge	Multimedia Filtration, Activated Carbon
12	Equalization, Neutralization, Activated Sludge, Coagulation, Vacuum Filtration, Aerated Lagoon	Multimedia Filtration, Activated Carbon
13	Gravity Separation, Skimming, Hydrolysis, Neutralization, Equalization, Aerated Lagoon	Activated Carbon

Table 4-1

Present Wastewater Treatment and Estimated Treatment Required for Compliance with Effluent Limitations
(continued)

Plant Code No.	Wastewater Treatment Already in Place	Estimated Additional Treatment Required
14	Gravity Separation, Aerated Lagoon, Equalization, Stripping, Neutralization	Multimedia Filtration, Activated Carbon, Stripping
15	Neutralization, Equalization, Aerated Lagoon, Gravity Separation	Multimedia Filtration, Activated Carbon
16	Equalization, Gravity Separation, Multimedia Filtration, Activated Carbon, Neutralization	Activated Carbon, Steam Stripping, Multimedia Filtration
17	Neutralization, Equalization, Activated Sludge, Coagulation, Flocculation, Aerated Lagoon, Gravity Separation, Neutralization	Activated Carbon, Multimedia Filtration
18	Gravity Separation, Neutralization	Stripping
19	Chemical Oxidation, Aerated Lagoon, Trickling Filters, Neutralization	Multimedia Filtration, Activated Carbon, Stripping
20	Chemical Oxidation	Multimedia Filtration, Activated Carbon
21	API-type Separator, Equalization, Aerated Lagoon, Gravity Separation/ API-type Separator	Stripping
22	Skimming, Neutralization	Chemical Oxidation, Stripping
23	Gravity Separation	Stripping
24	--	Activated Carbon
25	Equalization, Neutralization Gravity Separation, Aerated Lagoon	Chemical Oxidation/ Stripping/Activated Carbon, Multimedia Filtration
26	Neutralization, Equalization	Stripping, Activated Carbon

Table 4-1

Present Wastewater Treatment and Estimated Treatment Required for Compliance with Effluent Limitations (continued)

Plant Code No.	Wastewater Treatment Already in Place	Estimated Additional Treatment Required
27	Neutralization	Activated Carbon, Stripping
28	Equalization, Gravity Separation, Skimming, Flocculation, Coagulation,	Activated Carbon
29	Equalization, Skimming, Gravity Separation, Neutralization, Multimedia Filtration, Activated Carbon	Hydrolysis
30	Not Available	Stripping, Activated Carbon
31	Neutralization	Activated Carbon, Stripping, Multimedia Filtration, Metal Separation
32	Neutralization, Equalization, Activated Sludge, Gravity Separation	Activated Carbon
33	Equalization, Not Available	Stripping, Multimedia Filtration, Activated Carbon
34	Gravity Separation, Equalization, Aerated Lagoon Coagulation, Flocculation	Multimedia Filtration, Activated Carbon, Stripping
35	Stripping, Resin Adsorption, Neutralization	Stripping, Resin Adsorption
36	Not Available	Stripping

It should be noted that impacts of NSPS are actually incremental to all requirements for existing sources. That is, even if specific NSPS and PSNS regulations are not promulgated, new source direct dischargers are still subject to BPT and BAT requirements and indirect dischargers to relevant POTW pretreatment requirements.

Treatment Cost Estimates

Existing Sources

Incremental Costs. The capital costs and annual operating costs for the additional treatment required at each of the 51 plants are shown in Table 4-2. The table shows the incremental costs of each treatment level above the costs of the previous treatment level; for indirect dischargers, the incremental capital costs of compliance sum to $12.6 and $33.8 million for Levels 1 and 2, respectively, and for direct dischargers, the sums are $24.1, $3.2, and $12.4 million for Levels 1, 2 and 3, respectively. The incremental annual O&M costs for indirect dischargers sum to $6.0 and $5.9 million for Levels 1 and 2, respectively, and for direct dischargers, the sums are $15.2, $0.2 and $13.4 million for Levels 1, 2 and 3, respectively. The incremental capital and O&M costs for each plant are listed in Table 4-2 in addition to the totals for the industry under each option.

Annualized treatment costs can be computed from capital and annual costs shown in Table 4-2 by the method explained earlier in the report. The incremental annualized treatment costs sum to $8.6 and $14.5 million for Indirect Levels 1 and 2, and $20.4, $0.9, $16.1 million per year for Direct Levels 1, 2 and 3.

Cumulative Costs for Existing Plants for Each Treatment Level. For the economic impact analysis, treatment levels 2 and 3 include the treatment requirements and costs of the lower treatment levels. For example, Direct Level 2 includes treatment requirements and costs for Direct Level 1. Table 4-3 presents the total cumulative costs (in 1979 dollars) of compliance for each treatment level. Table 4-4 presents the same information in 1982 dollars.

Formulator/Packagers. The Technical Contractor provided unit treatment costs for the Formulator/Packagers subcategory (13) and due to differences in the way data were aggregated, this subcategory is handled separately from Subcategories 1 through 12. The costs were developed on a model plant basis, as shown in Table 4-5. These costs apply only to indirect dischargers because Formulator/Packager direct dischargers are already regulated to zero discharge under BPT. The costs are specified for contract hauling of hazardous wastes and for solar evaporation. The annualized costs were calculated

Table 4-2

Incremental Treatment Costs for Affected Pesticides Plants
(1979 $1,000's)

Plant	Capital Costs					Annual Operating and Maintenance Costs				
	Indirect		Direct			Indirect		Direct		
No.	Level 1	Level 2	Level 1	Level 2	Level 3	Level 1	Level 2	Level 1	Level 2	Level 3
1	1,180	1,140				636	137			
2	330	1,260				145	155			
3		0					19			
4			978					229		
5			70	115	230			49	6	139
6		3,100					645			
7			160					51		
8			1,240	190	550			456	13	510
9				215					13	
10				410	1,809				32	2,128
11		0					4			
12			3,844	289	970			1,619	21	1,091
13		1,410					190			
14		0					13			
15		0					3			
16		0					0.015			
17		590					56			
18		0					9			
19		0					7			
20		600					54			
21	196	580				65	55			
22	120	770				24	77			
23			140					15		
24		680					66			
25	1,050	1,900				496	310			
26			628	140	340			248	8	235
27		720					71			
28			342					136		
29			100					36		
30			299	160	421			11	2	54

Table 4-2 continued

Incremental Treatment Costs for Affected Pesticides Plants
(1979 $1,000's)

Plant	Capital Costs					Annual Operating and Maintenance Costs				
	Indirect		Direct			Indirect		Direct		
No.	Level 1	Level 2	Level 1	Level 2	Level 3	Level 1	Level 2	Level 1	Level 2	Level 3
31			5,200	420	1,700			3,252	32	2,123
32	611	1,610				327	238			
33	708	1,140				257	136			
34	370					133				
35				660	3,883				52	4,110
36			10,110	490	2,220			8,499	40	2,665
37		740					72			
38	1,793	1,560				988	216			
39	53	1,000				18	107			
40		540					52			
41		680					64			
42	748	1,120	1,038	125	271	377	137	575	7	175
43	216	780				119	78			
44	0	700				7	68			
45	4,460	6,800				1,981	2,342			
46	0	880				15	97			
47		1,080					124			
48		840					91			
49	731	1,660				306	239			
TOTALS	12,566	33,880	24,149	3,214	12,394	5,894	5,933	15,176	226	13,430

Table 4-3. Total Cumulative Costs of Compliance for Indirect and Direct Treatment Levels and Economic Options (millions of 1979 dollars)

	Capital Costs	Annual O&M Cost	Annualized Cost
<u>Indirect Discharger</u>			
Subcategories 1-12			
Level 1	12.6	5.9	8.6
Level 2	46.4	11.8	21.9
Formulator/Packagers*			
Level 1	37.4	2.6	10.8
Level 2	37.4	2.6	10.8
Total			
Level 1	50.0	8.5	19.4
Level 2	83.8	14.4	32.7
<u>Direct Discharger</u>			
Level 1	24.1	15.2	20.4
Level 2	28.7	16.1	22.4
Level 3	41.1	29.5	38.5
<u>Economic Option</u>			
Subcategories 1-12			
1	36.7	21.1	29.0
2	41.3	22.0	31.0
3	53.7	35.4	47.1
4	70.5	27.0	42.3
5	75.1	27.9	44.3
6	87.5	41.3	60.4
Formulator/Packagers			
1-6	37.4	2.6	10.8

*Capital costs for Formulator/Packagers subcategory are exclusive of land costs.

Table 4-4. Total Cumulative Costs of Compliance for Indirect and Direct Treatment Levels and Economic Options (millions of 1982 dollars)

	Capital Costs	Annual O&M Cost	Annualized Cost
<u>Indirect Discharger</u>			
Subcategories 1-12			
Level 1	15.8	7.4	10.8
Level 2	58.0	14.8	27.5
Formulator/Packagers			
Level 1	46.8	3.2	13.5
Level 2	46.8	3.2	13.5
Total			
Level 1	62.5	10.6	24.3
Level 2	104.8	18.0	40.9
<u>Direct Discharger</u>			
Level 1	30.1	19.0	25.5
Level 2	35.9	20.1	28.0
Level 3	51.4	36.9	48.2
<u>Economic Option</u>			
Subcategories 1-12			
1	45.9	26.4	36.3
2	51.7	27.5	38.7
3	67.2	44.3	58.9
4	88.1	33.8	53.0
5	93.9	34.9	55.4
6	109.5	51.7	75.6
Formulator/Packagers			
1-6	46.8	3.2	13.5

by multiplying the plant portion of the capital costs by the capital recovery factor (see Appendix B) and adding the result to the annual O&M costs.

For all model plant sizes, contract hauling of hazardous wastes is the most expensive treatment option and solar evaporation at 5 inches per year (net evaporation) is the most expensive evaporation technology.

Total costs of compliance for indirect dischargers in the industry are estimated using model plant costs provided by the Technical Contractor and information about the number of plants with treatment costs. The Technical Contractor estimated treatment costs for three plant sizes: large, 5,000 gal/day; medium, 500 gal/day; and small, 50 gal/day. Total costs are estimated using the following formula:

$$\text{Total Cost} = \sum_{i=1}^{3} COST_i \times SHR_i \times NUM_i$$

where

$COST_i$ = representative average treatment cost of plant with flow size i

SHR_i = fraction of plants of size i with treatment costs

NUM_i = number of plants of size i in industry.

Treatment costs were estimated by the Technical Contractor for each size model plant for several technologies and specifications; these are shown in Table 4-5. Not all technologies are suitable for plants of all sizes. In general, plants with flow rates of less than 1,000 gal/day will find it more economical to use contract hauling, while larger plants would probably use evaporation unless there were severe space limitations. As a conservative assumption, plants using contract hauling are assumed to incur costs for hazardous wastes, while plants using evaporation are assumed to use 5 in/year solar evaporation.

Based on the model plant sizes, this implies that large plants will use solar evaporation with average plant costs of $760,000 and annualized costs of 211,800, while small plants will use contract hauling with annualized costs of $4,460. Since the average flow rate of medium-sized plants is 500 gal/day, it is assumed that half of them use evaporation and half use contract hauling, yielding average plant costs of $52,000 and annualized costs of $39,160. These are summarized below.

Table 4-5. Unit Treatment Cost Itemization for Contract Hauling and Evaporation for Fomulator/Packagers
(costs in 1979 dollars)

Model Plant Size	Treatment Technology	Costs				
		Capital				
		Land	Plant	Total	Annual O&M	Annualized*
50 GPD	Contract Hauling - Hazardous Wastes	-	-	-	4,460	4,460
	Solar Evaporation (5 in/yr)	11,828	16,172	28,000	4,064	7,590
500 GPD	Contract Hauling - Hazardous Wastes	-	-	-	44,600	44,600
	Solar Evaporation (5 in/yr)	56,000	104,000	160,000	11,048	33,720
5,000 GPD	Contract Hauling - Hazardous Wastes	-	-	-	446,000	446,000
	Solar Evaporation (5 in/yr)	440,000	760,000	1,200,000	46,120	211,800

*Includes annualized plant costs using capital recovery factor = .218

Plant Size	Average Treatment Costs (1979 Dollars) Capital	Annualized
Large	1,200,000	236,000
Medium	80,000	39,700
Small	0	4,460

There are estimated to be 850 indirect discharger formulator/packager plants in the industry, with the following size distribution:*

	No. Plants	Percent
Large	510	60
Medium	170	20
Small	170	20

of these plants, 55 are also pesticide manufacturers with production in other regulated subcategories. These plants are excluded from the formulator/packager analysis on the assumption that the treatment system they install for other production processes can accommodate wastewater flows from formulator/packaging operations without significant extra impact. These manufacturer plants are relatively large, so they are assumed to fall in equal numbers in the large and medium categories. Excluding them leads to the following revised counts which are used in the analysis.

	No. Plants	Percent
Large	482	61
Medium	143	18
Small	170	21
Total	795	100

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* ESE memorandum, 1-28-81.

According to the Development Document, approximately 90 percent of formulator/packagers do not generate process wastewater. Of the remaining ten percent which do generate process wastewaters, an undetermined number will incur costs under the proposed regulation. As a conservative assumption, all such plants are assumed to incur costs, so

$$SHR_i = .10 \text{ , } i = 1,2,3$$

Using the above values leads to the following estimate of total costs of compliance:

Total Plant Capital Costs	=	760,000 x 482 x .10	= 36,632,000
	+	52,000 x 143 x .10	= 743,600
	+	0 x 170 x .10	= 0
	=		37,375,600
Total Annualized Cost	=	211,800 x 482 x .10	= 10,208,760
	+	39,160 x 143 x .10	= 559,988
	+	4,460 x 170 x .10	= 75,820
	=		10,844,568

Cost Estimates for New Sources

Treatment costs for model plants were developed by the Technical Contractor for each subcategory. The treatment costs were estimated for new sources that are direct dischargers (NSPS) and for indirect discharges (PSNS). For each model plant, high and low cost estimates were made to account for possible variations with respect to treatability and the hazardous nature of wastestreams within a given subcategory. The model plant treatment costs are shown in Table 4-6.

Table 4-6

New Source Model Plant Treatment Costs
(Thousands of 1979 Dollars)

Subcategory	Average Daily Production (1000 lbs.)	NSPS Capital Cost	NSPS O&M Cost	NSPS Annualized Cost	PSNS Capital Cost	PSNS O&M Cost	PSNS Annualized Cost
1	20.9	1300 to 2200	204 to 441	487 to 921	360 to 1150	132 to 373	210 to 624
2	22.7	1500 to 2500	286 to 592	613 to 1137	60 to 1730	260 to 488	273 to 865
3	26.8	3300 to 8000	762 to 3296	1481 to 5040	1420 to 6000	568 to 3022	878 to 4330
4	7.74	1700 to 2700	523 to 860	894 to 1449	800 to 1700	410 to 723	584 to 1094
5	25.6	2300 to 4200	526 to 1615	1027 to 2534	1000 to 3000	357 to 1411	575 to 2065
6	12.7	0	42 to 100	42 to 100	0	42 to 100	42 to 100
7	4.35	1600 to 2200	389 to 741	738 to 1221	800 to 1400	336 to 672	510 to 977
8	76.9	1600 to 2800	239 to 644	588 to 1254	500 to 1800	179 to 557	288 to 949
9	39.3	1800 to 3200	187 to 778	579 to 1476	710 to 2100	254 to 658	409 to 1116
10	50.0	2800 to 5200	1044 to 1752	2886 to 1654	1400 to 3600	872 to 1613	1177 to 2398
11	5.0	0	0	0	0	0	0
12	5.0	0	4.46	4.46	0	4.46	4.46
13	5.0	0	4.46	4.46	0	4.46	4.46

Section 5

Economic Impact Analysis

To assess the economic impact of the wastewater treament options, the industry-level and plant-level analyses described in Section 2 are used. In the industry-level approach, publicly available data are used to assess the economic state of the industry in 1985 with and without the costs for the different treatment levels included; the costs that will be incurred by the industry due to the Resource Conservation and Recovery Act (RCRA) are ignored in this portion of the impact analysis.

For the analysis of individual plants, proprietary data are used to assess impacts. Possible plant and product line closures are investigated for the various treatment levels with the effects of RCRA included in the baseline. Following the industry and plant level assessments, the effect of treatment costs on small businesses is analyzed. The section concludes with an analysis of New Source Performance Standards (NSPS) and Pretreatment Standards for New Sources (PSNS).

Proposed effluent standards could impose annualized costs (expressed in 1979 dollars) on the pesticide chemicals industry of $8.6 million for Level 1 treatment and $21.9 million for Level 2 treatment on indirect dischargers, $20.4 million, $22.3, and $38.5 million for Levels 1, 2, and 3 treatment, respectively, on direct dischargers, and between $29.1 million for economic option 1 and $60.4 million for economic option 6. In 1985, industry production of pesticides is forecast to be 1.584 billion pounds and have a value of $4.4 billion in 1979 dollars.[1] Thus, the possible effects of treatment costs could range from 1.8 to 3.8 cents per pound or 0.7 to 1.4 cents per dollar value of pesticide production depending on the economic option.

Industry-Level Analysis of Impacts on the Pesticide Chemicals Industry

The baseline projection describes the state of the industry in 1985 without the imposition of new treatment standards, and is compared with a projection of the industry as it would be after compliance with new standards; the differences between the two projections are attributed to the standards.

Baseline and Impact Projections of Cost and Price

To develop 1985 baseline price projections, each production cost item for pesticide chemicals in 1978 was projected to 1985. For this purpose, energy and chemical price predictions of the U.S. Department of Energy and information developed by Data Resources Inc. were reviewed. Based on analysis of past trends, this assessment led to the selection of the following 1978-1985 annual nominal escalation rates*: inorganic chemicals, 11 percent; organic chemicals, 16 percent; utilities, 11 percent; labor, 7 percent; and fixed costs, 5 percent. The general inflation rate for prices over the period 1978-85 is assumed to be 9 percent per year. The result of these escalations is to raise the cost by $2.08/lb (or 101 percent) to $4.14/lb. expressed in 1985 dollars. Assuming a constant markup model, the price will rise 101 percent from $2.34/lb. in 1978 to $4.70/lb. in 1985. These costs and prices, shown in Table 5-1 in terms of 1978 and 1985 dollars, are next adjusted to 1979 values to put item on a comparable basis with the treatment costs that were developed by the Technical Contractor in terms of 1979 dollars.

Given a 9 percent per year annual inflation rate, this implies a 0.596 adjustment factor for converting 1985 prices to 1979 dollars. Therefore, the 1985 average pesticides price in constant 1979 dollars is $2.80 per pound.

Table 5-1 presents the baseline average unit cost and price projections for 1985 in current and constant 1979 dollars for all pesticide active ingredients, along with the 1978 values. As the table shows, the pre-tax profit rises from $0.28/lb. in 1978 to $0.56/lb. in 1985 ($0.33/lb. in 1979 dollars). Pre-tax profit as a percent of cost remains at 13.6 percent reflecting the assumption of a constant markup.

Table 5-1

Baseline Cost and Price Projections

	$/lb. of Active Ingredient			Percentage of Total Cost	
	1978 (1978$)	1985 (1985$)	1985 (1979$)	1978	1985
Cost item					
Inorganic chemicals	0.29	0.60	0.36	14.1	14.5
Organic chemicals	0.58	1.64	0.98	28.2	39.6
Utilities	0.22	0.46	0.27	10.6	11.1
Labor	0.36	0.58	0.35	17.5	14.0
Fixed costs	0.61	0.86	0.51	29.6	20.8
Total costs	2.06	4.14	2.47	100.0	100.0
Pre-tax profit	0.28	0.56	0.33	13.6	13.6
Price	2.34	4.70	2.80	113.6	113.6

*Nominal escalation rates incorporate price changes due to inflation, real changes in prices (i.e., changes expressed in constant dollars) and changes in amounts of inputs to production. These escalation rates reflect information available in 1980 and 1981; use of more recent information would cause these forecasts to be revised. However, we do not believe such changes would affect the results of the analysis significantly.

To compare the real change in price and profit between 1978 and 1985, we assume a nine percent average annual rate of inflation over that period. Thus, the 1985 forecasts can be converted to 1978 dollars by dividing them by 1.83. This means that in 1978 dollars, the 1985 average price will be $2.57/lb. and the 1985 profit will be $0.31/lb. The 1978 price was $2.34/lb. and the unit profit was $0.28/lb. Thus, in real terms, the 1985 price and profit will be 9.8 percent higher than in 1978.

The direct impacts of possible new control options are calculated based on the Technical Contractor's cost estimates. The first eight lines of Table 5-2 show total annualized costs and annualized cost per pound of production for individual treatment levels and each economic option. The cost data are presented for the entire industry as well as the separate product groups: herbicides, insecticides, and fungicides. The costs to indirect dischargers range from a low of .25¢/lb. of insecticides for Level 1 treatment to a high of 5.99¢/lb. of fungicides for Level 2 treatment. The costs to direct dischargers ranged from a low of .26¢/lb. of insecticide for Level 1 treatment to a high of 3.77¢/lb. of herbicide for Level 3 treatment. Costs per pound in 1985 (expressed in 1979 dollars) for economic options range from 1.84¢/lb to 3.81¢/lb for the industry as a whole, and from 2.66¢/lb to 4.64¢/lb. for herbicides, from 0.51¢/lb to 1.92¢/lb for insecticides, and 2.83¢/lb to 7.10¢/lb for fungicides.

Faced with these cost increases, the industry can treat them similarly to other cost increases and mark them up so as to maintain the baseline profit to cost ratio, or pass the costs along without markup, or absorb the costs and maintain baseline prices. For the impact analysis, we have analyzed two cases. In the first case (Case A) treatment costs are assumed to be passed along, but not marked up.* With this assumption we attempt to depict the industry's response to new regulations that will impose costs on only part of the industry, thus tending to constrain the desire of affected producers to maintain the baseline profit to cost ratio. For the second case (Case B) we assume that treatment costs will be totally absorbed by the producers, thus baseline prices and production remain unchanged.

Table 5-2 also shows the impact projections of percentage price increases for the year 1985 for the cost passthrough case (Case A). For example, the average price will increase .19 percent for Level 1 treatment of indirect dischargers, .46 percent for Level 1 treatment of direct dischargers, and 0.66 percent for economic option 1. Average profit per pound, expressed in 1979 dollars, will remain constant at $0.33/lb under the Case A assumption of cost passthrough. However, because output decreases in response to price increases (see next subsection), profit for the pesticide manufacturing industry as a whole will decrease by 0.08 to

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*As pointed out in Section 2, this case represents an "average" cost passthrough which includes plants with zero incremental costs. Therefore, plants with positive costs do not recover the full amount of those costs.

Table 5-2

Industry-Level Analysis Summary (exclusive of Formulator/Packagers)
(1979 dollars)

	Indirect Dischargers		Direct Dischargers			Combination Indirect and Direct Discharger Economic Options					
	Level			Level							
	1	2	1	2	3	1	2	3	4	5	6
Total Annualized Cost											
(1,000's)	8,633	21,952	20,440	22,341	38,470	29,103	30,974	47,103	42,389	44,293	60,422
Herbicides (1977)	3,849	7,084	17,787	18,791	30,610	21,636	22,640	34,459	24,871	25,875	37,694
Insecticides	1,522	5,704	1,612	2,402	6,166	3,134	3,924	7,688	7,316	8,106	11,870
Fungicides	3,262	9,614	1,069	1,148	1,694	4,331	4,410	4,956	10,233	10,312	10,858
Cost per Pound											
(¢/lb.)	0.54	1.39	1.29	1.41	2.43	1.84	1.95	2.97	2.68	2.80	3.81
Herbicides (1985)	0.47	0.87	2.19	2.31	3.77	2.66	2.79	4.24	3.06	3.19	4.64
Insecticides	0.25	0.92	0.26	0.39	1.00	0.51	0.63	1.24	1.18	1.31	1.92
Fungicides	2.13	5.99	0.70	0.75	1.11	2.83	2.88	3.24	6.69	6.74	7.10
Case A: Average Cost Passthrough											
% Price Increase	0.19	0.49	0.46	0.50	0.87	0.66	0.70	1.06	0.96	1.00	1.36
Herbicides	0.14	0.26	0.66	0.70	1.14	0.81	0.84	1.29	0.93	0.97	1.41
Insecticides	0.10	0.38	0.11	0.16	0.41	0.21	0.26	0.51	0.49	0.54	0.79
Fungicides	1.22	3.42	0.40	0.43	0.63	1.62	1.65	1.85	3.82	3.85	4.05
% Profit Reduction	0.08	0.21	0.20	0.22	0.37	0.29	0.30	0.46	0.41	0.43	0.59
Herbicides	0.06	0.11	0.28	0.30	0.49	0.35	0.36	0.55	0.40	0.41	0.60
Insecticides	0.04	0.16	0.05	0.07	0.18	0.09	0.11	0.22	0.21	0.23	0.34
Fungicides	0.52	1.47	0.17	0.18	0.27	0.69	0.71	0.80	1.64	1.66	1.74
Case B: Average Cost Absorption											
% Price Increase	0	0	0	0	0	0	0	0	0	0	0
Herbicides	0	0	0	0	0	0	0	0	0	0	0
Insecticides	0	0	0	0	0	0	0	0	0	0	0
Fungicides	0	0	0	0	0	0	0	0	0	0	0
% Profit Reduction	2.0	4.0	4.0	4.0	7.0	6.0	6.0	9.0	8.0	8.0	12.0
Herbicides	1.0	1.0	3.0	4.0	6.0	4.0	4.0	7.0	5.0	5.0	7.0
Insecticides	0.3	1.0	0.3	0.4	1.0	0.8	1.0	1.0	2.0	2.0	2.0
Fungicides	1.0	2.0	0.2	0.2	0.3	1.0	1.0	1.0	2.0	2.0	2.0

1.47 percent for indirect dischargers, 0.05 to 0.49 percent for direct dischargers, by 0.28 to 0.59 percent depending on the economic option selected, and from 0.09 to 1.74 percent depending on the option and its effect on specific pesticide groups.

For the cost absorption case (Case B) treatment cost per pound is the same as shown in Table 5-2, baseline prices are unchanged and profit reduction is equal to treatment cost. Percent changes in profit for Case B are shown on the bottom line of Table 5-2.

Baseline and Impact Production Projections

Table 5-3 contains the baseline projections of herbicide production and Tables 5-4 and 5-5 present similar information with respect to insecticides and fungicides. The projections are based on work done in 1979 by the U.S. Department of Agriculture and Arthur D. Little, Inc. While there may have been changes in the market since then, uncertainty in these projections is not expected to affect the results of the analysis significantly.

Under the baseline scenario, we forecast that pesticide production will grow at a compound annual rate of 1.60 percent from 1,417 million pounds in 1978 to 1,584 million pounds in 1985. This overall baseline growth rate reflects an annual growth of 3.2 percent in herbicide production, 0.6 percent in insecticide production, and 0.9 percent in fungicide production. The projected growth rates are considerably lower than those recorded historically. During the 1960-1978 period, herbicide production grew at a rate of 10.9 percent, insecticide production grew at a rate of 2.8 percent, and fungicide production decreased at a rate of 1.1 percent. The difference in projected growth rates between fungicides and insecticides is caused by the differing pesticide requirements caused by new agricultural practices. The projected slowdown primarily reflects the fact that most of the major markets for pesticides are close to saturation.

For Case A, the average cost passthrough case, the effect of additional effluent treatment costs is to increase price and, in accordance with the demand model, to lower demand. The total reductions in production expected to accompany the treatment options are presented in Table 5-6. (Percent reductions for production are the same as for profit reduction shown in Table 5-2.) Reductions for the industry as a whole range from 270 to 3,371 million pounds per year for indirect dischargers, 263 to 5,908 million pounds per year for direct dischargers, and 4.6 million pounds per year for economic option 1 to 9.3 million pounds per year for economic option 6. Projections of production reductions are shown for the major groups, herbicides, insecticides, and fungicides as well as the overall industry. The estimation of demand reductions is based on the demand elasticity of -0.43 and the percentage price changes calculated for individual product groups shown in Table 5-2. The values shown for those groups do not sum exactly to the industry totals due to the aggregation procedure. The estimates for the groups are, nevertheless, indicative of the approximate comparative magnitudes and distribution of effects among herbicides, insecticides, and

Table 5-3

Herbicide Baseline Projections

Market	Acres (millions) 1971	1976	1985	Fraction Treated 1971	1976	1985	Application Rate (lb. per acre) 1971	1976	1985	Usage (million lb.) 1971	1976	1985
Corn	75.3	84.1	90.0	0.79	0.91	0.95	1.7	2.7	3.0	101.1	207.1	256.5
Soybeans	43.5	50.3	65.5	0.70	0.90	0.90	1.2	1.8	2.0	36.5	81.1	117.9
Wheat	53.8	80.2	103.9	0.43	0.39	0.50	0.5	0.7	1.2	11.6	21.9	62.3
Cotton	12.4	11.7	11.9	0.82	0.82	0.90	1.9	1.9	1.9	19.6	18.3	20.4
Sorghum	20.8	18.7	22.1	0.46	0.49	0.70	1.2	1.7	1.7	11.5	15.7	26.3
Other agricultural										68.9	65.9	80.0
Total agricultural										249.2	410.0	563.4
Nonagricultural										141.7	155.1	155.0
Net exports										37.9	91.1	130.0
Price adjustments												-36.0
Total production										428.8	650.2	812.4

Notes:

1. The 1971 and 1976 production data are on an active-ingredient basis and are reported in U.S International Trade Commission, *Synthetic Organic Chemicals*, Washington, D.C. (various issues).

2. The 1971 and 1976 export values are reported on a formulated basis in U.S Department of Agriculture, *The Pesticide Review*, Washington, D.C. (various issues). They were converted to an active-ingredient basis by halving the values (a procedure discussed with Theodore Eichers of the U.S. Department of Agriculture). The production data are already on an active-ingredient basis.

3. The 1971 and 1976 values on agricultural pesticide usage and acreage cultivated are from U.S. Department of Agriculture, *Farmers Use of Pesticides*, Washington, D.C. (1975 and 1978).

4. The 1985 values for fraction of acreage treated and application rate per acre were developed by Arthur D. Little industry experts (assuming constant real pesticide prices) after a review of an unpublished document prepared by Austin Fox of the U.S. Department of Agriculture, entitled *Agricultural Input Projections and Related Information*, Washington, D.C. (July 1979).

5. The 1985 values for acreage (except corn) are generated by the NIRAP Model and are contained in U.S. Department of Agriculture, *Adjustment Potential in U.S. Agriculture*, Washington, D.C. (undated, probably mid-1979).

Table 5-4

Insecticide Baseline Projections

Market	Acres (millions)			Fraction Treated			Application Rate (lb. per acre)			Usage (million lb.)		
	1971	1976	1985	1971	1976	1985	1971	1976	1985	1971	1976	1985
Cotton	12.6	11.7	11.9	.59	.60	.70	9.8	9.2	8.5	73.4	64.1	70.8
Corn	75.3	84.1	90.0	.28	.38	.60	1.2	1.0	1.0	25.5	32.0	54.0
Soybeans	43.5	50.3	65.5	.08	.07	.40	1.6	2.3	2.0	5.6	7.9	26.2
Wheat	53.8	80.2	103.9	.08	.15	.20	.4	.6	.5	1.7	7.2	10.4
Livestock										14.8	10.8	15.0
Other agricultural										92.1	86.0	95.0
Total agricultural										214.1	208.0	271.4
Nonagricultural										225.2	210.4	215.0
Net exports										118.4	147.7	160.0
Price adjustment												-27.4
Total production										557.7	566.1	619.0

Notes:

1. The 1971 and 1976 production data are on an active-ingredient basis and are reported in U.S International Trade Commission, *Synthetic Organic Chemicals*, Washington, D.C. (various issues).

2. The 1971 and 1976 export values are reported on a formulated basis in U.S Department of Agriculture, *The Pesticide Review*, Washington, D.C. (various issues). They were converted to an active-ingredient basis by halving the values (a procedure discussed with Theodore Eichers of the U.S. Department of Agriculture). The production data are already on an active-ingredient basis.

3. The 1971 and 1976 values on agricultural pesticide usage and acreage cultivated are from U.S. Department of Agriculture, *Farmers Use of Pesticides*, Washington, D.C. (1975 and 1978).

4. The 1985 values for fraction of acreage treated and application rate per acre were developed by Arthur D. Little industry experts (assuming constant real pesticide prices) after a review of an unpublished document prepared by Austin Fox of the U.S. Department of Agriculture, entitled *Agricultural Input Projections and Related Information*, Washington, D.C. (July 1979).

5. The 1985 values for acreage (except corn) are generated by the NIRAP Model and are contained in U.S. Department of Agriculture, *Adjustment Potential in U.S. Agriculture*, Washington, D.C. (undated, probably mid-1979).

Table 5-5

Fungicide Baseline Projections

Market	Usage (million lb.) 1971	1976	1985
Peanuts	4.4	6.8	7.0
Fruits and vegetables	33.2	35.1	40.0
Other agricultural	4.3	1.1	5.0
Total agricultural	41.9	43.0	52.0
Nonagricultural	87.2	76.2	78.0
Net exports	20.1	22.9	30.0
Price adjustment			-6.8
Total production	149.2	142.1	153.2

Notes:

1. The 1971 and 1976 production data are on an active-ingredient basis and are reported in U.S International Trade Commission, Synthetic Organic Chemicals, Washington, D.C. (various issues).

2. The 1971 and 1976 export values are reported on a formulated basis in U.S Department of Agriculture, The Pesticide Review, Washington, D.C. (various issues). They were converted to an active-ingredient basis by halving the values (a procedure discussed with Theodore Eichers of the U.S. Department of Agriculture). The production data are already on an active-ingredient basis.

3. The 1971 and 1976 values on agricultural pesticide usage and acreage cultivated are from U.S. Department of Agriculture, Farmers Use of Pesticides, Washington, D.C. (1975 and 1978).

4. The 1985 values for fraction of acreage treated and application rate per acre were developed by Arthur D. Little industry experts (assuming constant real pesticide prices) after a review of an unpublished document prepared by Austin Fox of the U.S. Department of Agriculture, entitled Agricultural Input Projections and Related Information, Washington, D.C. (July 1979).

5. The 1985 values for acreage (except corn) are generated by the NIRAP Model and are contained in U.S. Department of Agriculture, Adjustment Potential in U.S. Agriculture, Washington, D.C. (undated, probably mid-1979).

Table 5-6

1985 Industry-Level Summary
Effect of Treatment Options on Production

	Indirect Dischargers Level		Direct Dischargers Level			Combination Indirect and Direct Discharger Economic Options					
	1	2	1	2	3	1	2	3	4	5	6
Production Reduction (Case A) (1,000 lb./yr.)	1,326	3,371	3,133	3,431	5,908	4,495	4,757	7,234	6,539	6,802	9,279
Herbicides	501	923	2,304	2,449	3,989	2,828	2,950	4,490	3,247	3,372	4,912
Insecticides	270	1,014	288	427	1,096	559	697	1,366	1,304	1,440	2,109
Fungicides	801	2,252	263	282	416	1,064	1,084	1,218	2,514	2,534	2,668
Production Reduction (Case B) (1,000 lb./yr.)	0	0	0	0	0	0	0	0	0	0	0
Herbicides	0	0	0	0	0	0	0	0	0	0	0
Insecticides	0	0	0	0	0	0	0	0	0	0	0
Fungicides	0	0	0	0	0	0	0	0	0	0	0

fungicides. For Case B, which assumes cost absorption, additional effluent treatment costs will have no effect on production.

Table 5-7 summarizes the 1985 baseline and impact projections of production and price for economic option 1 by the three major pesticide groups. Total production is reduced by approximately 5 million pounds, which is less than 0.3 percent. (If the most stringent option were shown, the reduction from the baseline would be 9.2 million pounds which is 0.6 percent.) Average industry price for the impact projection is about 0.7 percent higher than for the baseline.

Table 5-7

Summary of Baseline and Impact Projection; Production and Prices for Economic Option 1 and Case A: Average Cost Passthrough (in 1979 dollars)

	1985 Baseline		1985 Impact Projection	
	Production (million lbs)	Price ($/lb)	Production (million lbs)	Price ($/lb)
Herbicides	812	3.30	808	3.33
Insecticides	619	2.42	618	2.43
Fungicides	153	1.75	152	1.78
Total or average	1,584	2.80*	1,578	2.82*

*Average, based on price of each pesticide group, weighted by production.

Baseline and Impact Employment Projections

Reliable data on employment by the pesticide manufacturing industry are not available. Therefore an estimate was developed based on 21 establishments in SIC group 28694 for the year 1977. Table 5-8 presents data on employment and shipments showing that shipments per employee averaged about $216,400. In 1977, the pesticide active ingredient industry had a production of 1.388 billion pounds valued at $3.123 billion. Assuming $216,000 of production per employee, this implies an employment of 14,500 and an output of 96,000 lbs. per employee. By 1985, we expect pesticide production to increase under the baseline projection from 1.388 billion pounds to 1.584 billion pounds, an increase of 196 million pounds. Assuming constant labor productivity, this implies an increase in baseline employment of 2,040 of 1985.

Table 5-9 shows the Case A reductions in baseline employment that will result from the imposition of the proposed treatment options, the reductions range from 14 for Level 1 treatment for indirect dischargers, to 61 for Level 3 treatment for direct dischargers to 47 for economic option 1 and 97 for economic option 6. The percentage reductions in employment are the same as those for profit shown in Table 5-2, since the changes are proportionate. The impact of the treatment options on Case B employment will be zero.

Table 5-8

Relationship Between Employment and Shipments for SIC Group 28694

Product	(1977) Value of Shipments ($000,000s)	Employment (000s)	Shipments per Employee ($000s)
Pesticides and other organic agricultural chemicals	1,666.1	7.7	216.4

Source: U.S. Bureau of the Census, 1977 Census of Manufacturers, U.S. Government Printing Office, Washington, D.C. (1980).

Profit

Profits were calculated by multiplying production by the unit profit rate. In the baseline scenario, 1985 production is 1.584 billion pounds and the unit profit is $0.33 in 1979 dollars thus implying an industry profit of $523 million. In the impact scenario, production is reduced while the unit profit rate remains at $0.33/lb. As shown in Table 5-2, the impact of additional treatment is predicted to reduce industry-level profits by from 0.04 to 1.47 percent for indirect dischargers, 0.05 to 0.49 percent for direct dischargers, and from 0.28 percent to 0.59 percent for economic options 1 and 6, respectively, or $1.52 to $3.09 million expressed in 1979 dollars.

The above profit analysis (Case A) assumes producers will increase prices to compensate for the average added cost of treatment. For Case B, producers are forced to absorb the increased costs and cannot raise prices, and the profit impacts will be more severe. Under Case B, there would be no impact on production, and pesticide manufacturers would sell 1.584 billion pounds at reduced profits; profits would decrease by 6.0 percent or $30.0 million for economic option 1 up to 12.0 percent or $60.4 million for economic option 6 expressed in 1979 dollars.

Formulator/Packagers

Table 5-10 shows the total cumulative compliance costs that may be borne by the Formulators/Packagers subcategory.

Because such a small percentage of the subcategory will experience costs, those Formulator/Packagers that do incur costs can be expected to absorb them. Given the Case B assumption of cost absorption, the impact of the regulations on the prices, output and employment of Formulator/Packagers will be zero, and profits will be reduced by $10.8 million annually.

Table 5-9

1985 Industry-Level Summary
Effect of Treatment Options on Employment

	Indirect Dischargers		Direct Dischargers			Combination Indirect and Direct Discharger					
	Level		Level			Economic Options					
	1	2	1	2	3	1	2	3	4	5	6
Reduction in Employment (Case A)	14	35	33	36	61	47	49	75	68	71	97
Herbicides	5	10	24	25	41	29	31	47	34	35	51
Insecticides	3	11	3	4	11	6	7	14	14	15	22
Fungicides	8	23	3	3	4	11	11	13	26	26	28
Reduction in Employment (Case B)	0	0	0	0	0	0	0	0	0	0	0
Herbicides	0	0	0	0	0	0	0	0	0	0	0
Insecticides	0	0	0	0	0	0	0	0	0	0	0
Fungicides	0	0	0	0	0	0	0	0	0	0	0

Table 5-10

Total Cumulative Costs of Compliance for Formulator/Packagers
(millions of 1979 dollars)

	Costs		
	Capital	Annual O&M	Annualized
Formulator/Packagers	37.4	2.6	10.8

Agricultural Sector

Because the agricultural sector constitutes the major market for pesticides, it is important to understand how agriculture is affected by higher pesticide prices resulting from treatment costs. The effect of additional treatment cost is to increase average active ingredient prices 0.80 to 1.65 percent for economic options 1 and 6, respectively. Active ingredient prices equal 58 percent of the price of the pesticide acquired by the farmer which means that the price of the pesticide at the farm level will increase approximately 0.46 to 0.96 percent.

Based on discussions with the United States Department of Agriculture, pesticide costs (excluding application) are estimated to account for about 6 percent of farm crop variable production costs. Thus, a 0.96 percent increase in pesticide prices should increase crop variable costs by 0.06 percent. Crop variable costs equal about 40 percent of farm revenue. Therefore, assuming a cost passthrough at the farm level, we would expect to see farm crop prices rise 0.02 percent. Table 5-11 presents data on crop prices, variable costs, and pesticide costs that were used to arrive at these assumptions.

Summary Comment

The pesticide industry is characterized by considerable heterogeneity. Therefore, the above analysis must be interpreted with caution. The plant-level analysis which follows, deals with such heterogeneity by assessing the impact of treatment costs on a plant-specific basis.

Plant-Specific Impact Analysis

An assessment is made of the economic impact on individual plants identified as incurring additional treatment costs. We then identify the

Table 5-11

Costs of Producing Major Crops - 1977
Percent

Crop	Price[1]	Chemicals as a % of Variable Cost[2]	Custom Operations as a % of Variable Cost[2]	Chemical and Operations Cost as a % of Variable Cost	Variable Cost as a % of Price	Chemicals as a % of Price	Custom Operations as a % of Price	Chemicals and Custom Operations as a % of Price
Corn	2.02/bu.	9.3	5.7	15.0	54.0	5.0	3.1	8.1
Cotton	.523/lb.	11.6	8.7	20.3	63.7	7.4	5.5	12.9
Wheat	2.33/bu.	3.1	7.6	10.7	57.5	1.8	4.4	6.2
Sorghum	1.82/bu.	5.7	8.0	13.7	54.9	3.1	4.4	7.5
Soybeans	5.88/bu.	17.7	6.0	23.7	29.8	5.3	1.8	7.1
Peanuts	.21/lb.	23.0	1.7	24.7	50.5	11.6	0.9	12.5
Barley	1.78/bu.	3.9	6.6	10.5	58.4	2.3	3.8	6.1
Oats	1.10/bu.	1.0	7.7	8.7	44.6	0.4	3.4	3.8
Rice	9.49/cwt.	9.1	8.1	17.2	54.9	5.0	4.4	9.4
Flaxseed	4.54/bu.	7.4	8.8	16.2	54.2	4.0	4.8	8.8
Average						4.6	3.6	8.2

1. U.S. Department of Agriculture, Agricultural Statistics, 1979, U.S. Government Printing Office, Washington, D.C., 1980.

2. Cost of chemicals, custom operations, and variable cost per unit are from U.S. Department of Agriculture, Costs of Producing Selected Crops in the United States - 1978 and Projections for 1979, U.S. Government Printing Office, Washington, D.C., 1979. Cost of custom operations includes cost of application as well as cost of chemicals not reported separately. These factors are taken into account when deriving the total cost of chemicals to the former as a fraction of price (income) at 6 percent (see text).

ones that are severely impacted and, among those, the plants that face closure or shutdown of pesticide product lines. The imposition of RCRA standards are considered, as well as the imposition of treatment costs resulting from the proposed effluent guidelines.

Treatment Costs as a Percent of Pesticide Chemical Value

To assess the cost burden of the proposed treatment levels, the estimated treatment costs and the value of the active ingredients (prior to the formulation and packaging operations) were analyzed. Results for indirect dischargers are given for Levels 1 and 2 and for direct dischargers for Levels 1, 2, and 3.

Information was obtained on the annual production of pesticide ingredients at each plant and on the value of that output.[2] In an initial screening step, the ratio of annualized treatment costs to the value of pesticide active ingredients (using sales as the measure of value) was calculated for each plant.

Table 5-12 displays the cost-to-sales ratio, (expressed as a percent). Up to 51 plants may incur additional treatment costs depending on the economic option selected. The five columns on the left side of the table display the results for each treatment level for indirect and direct dischargers separately.

The six columns on the right side of Table 5-12 show the cost-to-sales ratio for the six economic options. For example, the right hand column shows the treatment cost as a percent of sales if the highest level of treatment is required for both direct dischargers Level 3 and indirect dischargers Level 2. Economic Option 1 shows the cost-to-sales ratio if Level 1 is applied to the indirect dischargers and Level 1 is applied to direct dischargers.

Plants with treatment costs equal to or greater than four percent of product value are identified by an asterisk in Table 5-12 so that plants below the 4 percent level can be screened out. (The rationale for the screening criterion is discussed in Section 2.) Under economic option 6, the highest level of treatment, 26 of the 51 plants would incur a treatment cost equal to, or greater than four percent of the sales value of the chemicals produced. Of the 26 plants, 18 are indirect dischargers, seven are direct and one plant (No. 186) is both a direct and indirect discharger. There are 9 plants with costs equal to or greater than 20 percent of sales and three plants with costs in excess of 100 percent of sales.

If economic option 1 were imposed, a total of 13 plants would have treatment costs in excess of four percent of sales; of these, five plants are direct dischargers, seven are indirect and one plant (No. 186) is both a direct and indirect discharger.

Table 5-12

Annualized Costs as a Percentage of Sales

Plant	Indirect Dischargers: Pretreatment Level		Direct Dischargers: Treatment Level			Economic Option					
No.	1	2	1	2	3	1	2	3	4	5	6
1	1.11	1.62				1.11	1.11	1.11	1.62	1.62	1.62
2	1.81	4.67*				1.81	1.81	1.81	4.67*	4.67*	4.67*
3		4.63*							4.63*	4.63*	4.63*
4			14.73*	124.73*	14.73*	14.73*	14.73*	14.73*	14.73*	14.73*	14.73*
5			5.84*	8.65*	19.80*	5.84*	8.65*	19.80*	5.84*	8.65*	19.80*
6			7.80*	8.02*	12.46	7.80*	8.02*	12.46*	7.80*	8.02*	12.46*
7			0.60	4.23*	5.84*	0.60	4.23*	5.84*	0.60	4.23*	5.84*
8	2.79	6.36*				2.79	2.71	2.79	6.36*	6.36*	6.36*
9	3.68	7.13				3.68	3.68	3.68	7.13*	7.13*	7.13*
10		2.09							2.09	2.09	2.09
11			2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45
12	4.26*	4.26*				4.26*	4.26*	4.26*	4.26*	4.26*	4.26*
13				0.43	11.73*		0.43	11.73*		0.43	11.73*
14			1.40	1.51	2.72	1.40	1.51	2.72	1.40	1.51	2.72
15				0.40	0.40		0.40	0.40	0.40	0.40	0.40
16			11.14*	11.29*	14.57*	11.14*	11.29*	14.57*	11.14*	11.29*	14.57*
17				0.09	1.90		0.09	1.90		0.09	1.90
18		9.36*							9.36*	9.36*	9.36*
19		0.13							0.13	0.13	0.13
20	20.13*	28.25*				20.13*	20.13*	20.13*	28.25*	28.25*	28.25*
21			3.09	3.20	4.83*	3.09	3.20	4.83*	3.09	3.20	4.83*
22		1.36							1.36	1.36	1.36
23		0.68							0.68	0.68	0.68
24		0.30							0.30	0.30	0.30
25		2.00							2.00	2.00	2.00
26	0.40	4.73*				0.40	0.40	0.40	4.73*	4.73*	4.73*
27		3.65							3.65	3.65	3.65
28		2.03							2.03	2.03	2.03
29		0.08							0.08	0.08	0.08

Table 5-12

Annualized Costs as a Percentage of Sales
(continued)

Plant	Indirect Dischargers: Pretreatment Level		Direct Dischargers: Treatment Level			Economic Option					
No.	1	2	1	2	3	1	2	3	4	5	6
30		6.80*							6.80*	6.80*	6.80*
31		0.61							0.61	0.61	0.61
32	1.44	3.87				1.44	1.44	1.44	3.87	3.87	3.87
33		24.65*							24.65*	24.65*	24.65*
34	6.67*	11.38*	9.90*	10.32*	13.21*	16.56*	16.98*	19.87*	21.28*	21.70*	24.59*
35	2.04	11.84*				2.04	2.04	2.04	11.84*	11.84*	11.84*
36	6.64*	16.56*				6.64*	6.64*	6.64*	16.56*	16.56*	16.56*
37	11.67*	380.00*				11.67*	11.67*	11.67*	380.00*	380.00*	380.00*
38			1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
39		0.68							0.68	0.68	0.68
40	1.25	2.50				1.25	1.25	1.25	2.50	2.50	2.50
41	9.99*	22.93*				9.99*	9.99*	9.99*	22.93*	22.93*	22.93*
42			0.51	0.57	0.98	0.51	0.57	.098	0.51	0.57	0.98
43	33.33*	673.33*				33.333*	33.33*	33.33*	673.33*	673.33*	673.33*
44		2.11							2.11	2.11	2.11
45			2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
46		2393.33*							2393.33*	2393.33*	2393.33*
47		10.96							10.96*	10.96*	10.96*
48	14.20*	32.55*				14.20*	14.20*	14.20*	32.55*	32.55*	32.55*
49			0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77

Screening criteria of three, two and one percent were also applied to get a sense of how alternative criteria would affect the plant by plant analysis. Considering economic options 1 and 6 only, the four percent criterion results in 13 plants (economic option 1) and 26 plants (economic option 6) being severely impacted. Applying the other screening criteria, the number of plants severely impacted under economic options 1 and 6 respectively, are: with three percent, 14 and 28 plants; with two percent, 18 and 38 plants; with one percent 24 and 42 plants.

Table 5-13 is a summary of the impacts of all treatment options regardless of the magnitude of the cost; the impacts are described as the number of plants incurring treatment costs under each option and the value of production of those plants. The number of plants impacted depends on the particular treatment level selected. For example, if Level 1 is imposed on indirect dischargers and Level 3 on direct dischargers, 30 plants producing pesticide chemicals valued at $671 million would be affected; this represents 18.1 percent of the total value of pesticides. The effect of economic option 1 must be read from the lower portion of Table 5-13 because the upper portion of the table, which does not combine treatment levels for direct and indirect dischargers, includes double counting of one plant that is both a direct and indirect discharger.

If the most stringent economic option (option 6) is imposed, 48 plants are affected and these plants account for 28.9 percent of the total value of pesticides produced by the 117 plants.

Formulator/Packagers

The plant-specific impact analysis of the Formulator/Packager subcategory uses the model plant sizes, flows and costs developed by the Technical Contractor. The model plants were designated small, medium, and large with average flow rates of 50, 500, and 5,000 gallons per day, respectively. Based on an average 10 gallons of flow to 1,000 pounds of product ratio, the small, medium, and large plants have daily production of 5,000, 50,000, and 500,000 pounds, respectively. To convert pounds of product to gallons of liquid concentrate we used a 7:1 ratio, based on the BPT economic impact analysis* estimates of dry powder versus liquid concentrate values, and estimate that the small, medium, and large plants have the capacity to produce 710, 7,100, and 71,000 gallons per day of liquid concentrate, respectively.

Product value was estimated by multiplying the daily production by 330 days of production to obtain annual production and then multiplying this by the price of the formulated product. In the BPT study, the range of

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* USEPA, Office of Water Planning and Standards, "Economic Analysis of Effluent Limitations Guidelines for the Pesticides Chemicals Manufacturing Point Source Category". EPA-230/2-78-065f, February 1978, pp. 40-41.

Table 5-13

Summary of Plants Incurred by Treatment Costs

	Number of Plants	Value of Pesticide Production (millions of 1979 dollars)	Percent of Value of Production, Total Industry
Total Industry	117	3706	100.0
Plants Impacted by:			
<u>Indirect Dischargers</u>			
Level 1	16	249	6.7
Level 2	34	450	12.1
<u>Direct Dischargers</u>			
Level 1	15	430	11.6
Level 2	18	630	17.0
Level 3	18	630	17.0
Economic Option 1	30	671	18.1
Economic Option 2	33	870	23.4
Economic Option 3	33	870	23.5
Economic Option 4	48	872	23.5
Economic Option 5	48	1071	28.9
Economic Option 6	48	1071	28.9

formulated product prices was $7-14/gallon for liquid concentrates and $1-2/pound for dry powders (in 1975 dollars). Assuming that the prices of formulated products escalated at the same rate as manufactured pesticide prices, and using the price indices in Table 2-2, the prices of formulated products range from $10.4 to $20.9/gallon for liquids and from $1.5-3/ pound for powders in 1979 dollars.

The impact ratios are in terms of total annualized costs to product value and were calculated only for the small size plant because the impact will be greatest for the smallest plants. From Section 4, the total annualized treatment costs for the small model plant are about $4,460. From the discussion above, the daily production is 5,000 pounds (or 710 gallons), thus making annual production 1.65 million pounds (or 234 thousand gallons). Using the prices derived above, this level of production has a value that ranges from $2.5 million to $4.9 million. The cost to value impact ratio is therefore between .1 percent and .2 percent. These impacts are not considered to be significant.

The analysis of the Formulator/Packagers subcategory is based on the assumption that 1,000 pounds of product result in 10 gallons of flow. It can be shown how sensitive the analysis is to changes in this assumption. That is, how many gallons of flow per 1,000 pounds will cause the impact ratio to exceed 2 percent? In this case, for the impact ratio to exceed 2 percent, the flow per 1,000 pounds of product would have to exceed 200 gallons.

Closure Analysis of Plants and Product Lines

An assessment of the severely impacted plants--those with treatment costs four percent or more of the value of the pesticide products--was made to identify potential plant closures or product line shutdowns. Plant-specific financial data are not available, consequently the assessment primarily is a qualitative analysis based on market trends and general plant characteristics.

Faced with an increase in costs, plants have the option of raising prices (Case A), absorbing the cost increases in the form of lower profits (Case B), or some combination of the two. The price-raising option is precluded if (1) other producers of the product do not incur equivalent treatment costs, or (2) the market for the product is weak. Cost absorption could cause a plant to discontinue pesticide production, although this action is not synonymous with a plant shutdown because a plant could be producing plastics, pharmaceuticals, or other chemicals at the same facility. However, discontinuation could mean a shutdown if the plant were basically dedicated to pesticides. Also, discontinuation of pesticide production at a specific plant could result in shifting that production to another plant location in which case the firm would not necessarily reduce its total output of pesticides. These possibilities were considered in the analysis of each plant severely affected by added treatment costs.

Pretax profits on sales in the pesticide manufacturing industry have averaged 10 to 15 percent in recent years and, as discussed earlier in the report, plants with treatment costs exceeding four percent of pesticide value are not necessarily going to cease operations. The particular circumstances of each plant were analyzed in order to judge the likelihood of shutdown. The analysis took into consideration type of pesticide chemical, volume and value of production of pesticides and non-pesticide products, parent company resources, etc., however, as noted earlier, plant-specific financial data were not available. Before the impacts of treatment costs were examined, the effects of the Resource Conservation and Recovery Act were first considered so that closures that would be caused solely by RCRA would not be attributed to treatment costs. If a plant was predicted to close due to RCRA compliance costs, this was counted as a baseline closure, since that Act has already been promulgated.

Costs of compliance with RCRA requirements were estimated for each of 51 plants that incur costs. Total cost of RCRA compliance are $2.2 million for an average of about $43,400 per plant. Three product lines and no plants were identified as likely candidates for closure; all the product lines are small with the largest one having an annual value of production of $100,000.

The ratio of RCRA costs to product value for the four plants ranges from 40 percent to 161 percent, indicating a substantial impact.

Table 5-14 presents a summary of the plants severely impacted by the imposition of treatment levels. Part I of Table 5-14 shows the results if the various treatment levels are imposed. For example, if Level 1 is imposed on the indirect dischargers, eight plants will be severely impacted and the value of the pesticides they produce ($55.5 million) is 1.5 percent of the total value of production. If Level 2 is applied to indirect dischargers, the number of plants severely impacted is 19 and the value of their production ($116.9 million) is 3.1 percent of the total value. Level 1 or 2 for direct dischargers affects six plants severely and they account for 4.8 percent of total value; if Level 3 is imposed on direct dischargers, eight plants are severely impacted and they account for 8.1 percent of total value.

Part II of Table 5-14 indicates the number of plants and product lines that possibly will shutdown as a result of the various treatment options--RCRA included. For example, if Level 1 is imposed on indirect dischargers, two plant and five product line shutdowns are anticipated and their value will amount to 0.6 percent of the total value of pesticides production. Imposing Level 2 on indirect dischargers raises the number of closures to 14 (a total of six plants and eight product lines) with a percent of total value of 1.6. Level 1 for direct dischargers indicates three shutdowns which account for 0.3 percent of total value; imposition of Levels 2 or 3 does not increase the number of shutdowns. The aggregate effects of combinations of treatment options for indirect and direct dischargers are not displayed in Table 5-14 and the numbers shown cannot be simply added because one plant would be counted twice; that plant is both a direct and indirect discharger.

Table 5-15 shows the aggregate effects on indirect and direct dischargers for all feasible combinations of treatment levels. As seen from the table, potential shutdowns represent less than two and a half percent of the total value of pesticide production. (Note that the imposition on direct dischargers of treatment levels more stringent than Level 1 does not increase the number of shutdowns of direct dischargers.) For the more stringent options resulting in seven plant and ten product line shutdowns (those which include Level 2 for indirect dischargers), two plants and one product line account for approximately half of the $63.6 million in value associated with those closures. For the less stringent economic options, one plant and one product line account for about $15 million (about 60 percent) of the value associated with the ten shutdowns.

The results shown in Table 5-14 and 5-15 are based on plant-by-plant assessment conducted for the 26 plants, which is the greatest number that may be severely affected by the most stringent economic option. There are, however, two other plants for which treatment costs are somewhat above four percent of the sales value but available data are inadequate to make certain judgements regarding the plants closure potential. Both plants are indirect dischargers; one is at treatment Level 1 and 2 and the

Table 5-14

Summary of Plants Severely Impacted by Treatment Costs

	No. of Plants*	No. of Product Lines	Value of Pesticide Production (millions of 1979 dollars)	% of Total Value of Production
I Plants severely impacted (i.e., treatment costs greater than 4% value of production) by treatment options.**				
Indirect Dischargers				
Level 1	8	-	55.5	1.5
Level 2	19	-	116.9	3.1
Direct Dischargers				
Level 1	6	-	176.4	4.8
Level 2	6	-	176.4	4.8
Level 3	8	-	301.6	8.1
II Plants and/or product lines where shutdown is possible with treatment imposed.				
Baseline Case***	0	3	0.7	0.01
Indirect Dischargers				
Level 1	2	5	20.8	0.6
Level 2	6	8	64.8	1.6
Direct Dischargers				
Level 1	1	2	12.4	0.3
Level 2	1	2	12.4	0.3
Level 3	1	2	12.4	0.3

*One plant (No. 186) is both an indirect and direct discharger and is counted in both totals.

**Impacts are defined in terms of total pesticide value at the plant, not individual product lines. Therefore, Part I does not distinguish between plants and product lines.

***Closures due to RCRA costs.

Table 5-15

Summary of Closure Analysis for Economic Options

Economic Options	Number of Shutdowns: Plants	Number of Shutdowns: Product Lines	Value of Pesticide Production Lost (millions of 1979 dollars)	% of Total Value of Production
1	3	7	25.1	0.7
2	3	7	25.1	0.7
3	3	7	25.1	0.7
4	7	10	63.6	1.7
5	7	10	63.6	1.7
6	7	10	63.6	1.7

other is at treatment Level 2 only. More specific plant-level detail is necessary in order to make a certain decision on these two plants and the Agency is currently soliciting that information.

Table 5-16 provides detail on the closure analysis. The table indicates which of the 26 severely impacted plants may experience either plant or product line shutdown as a result of the various treatment levels. The plants are identified in the table by a) dominant pesticide product line, b) production quantity, c) pesticide value and d) type of discharge, (indirect or direct).

Small Business Analysis

This section analyzes the relative impact of the proposed effluent guidelines on small and large firms to determine if small firms face disproportionate impacts. Based on the discussion in Section 2, small firms are defined as those having less than $10 million in annual sales. Since it was not possible to obtain sales data for all firms, the results are presented for a sample of 80 plants for which these data are available for the parent firm from the Dun and Bradstreet data base. This sample is a large fraction of the total number of 117 plants which comprise the definition of the pesticide industry used in this study and includes many plants owned by small firms, so the results are not likely to differ much from those for the entire pesticide industry.

Using the definition of small businesses given above, 18 out of the sample of 80 plants belong to small firms. Table 5-17 shows the distribution of the following items for the small firm plants, the large firm plants, and all plants in the sample under economic option 1: total number of plants; number of plants with positive incremental costs of compliance; numbers of plants whose cost-to-sales ratio falls in a given range; and number of plant closures.*

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*The plant and firm data on which these results are based are given in Appendix A.

Table 5-16

<u>Summary of Closure Analysis</u>
(YES = plant or product line shutdown is possible)

Type of Discharger	Plant Number	Type of Product (1)	Production Amount (000 lbs)	Product Value ($000,000)	PSES Treatment Level		BAT Treatment Level		
					1	2	1	2	3
INDIRECT									
↓	1	H	12864	15.0	NO	*	NA	NA	NA
	2	M	184.8	3.0 (2)	NO	YES	↓	↓	↓
	3	I	10779	16.5	NO	YES			
	4	H	7540	11.16	NO	YES			
	5	I	2415	5.0	*	*			
	6	M	1900	2.5	NO	YES			
	7	H	6988	6.85	YES	YES			
	8	M	3739.9	7.5	NO	NO			
	9	M	2200	2.5	NO	YES			
	10	I	225	0.86	NO	YES			
	11	H	690.2	2.5	NO	YES (4)			
	12	M	2206.5	2.5	YES	YES			
	13	M	30300.7	29.549	NO	NO			
	14	M	3500	2.5	NO	YES			
	15	H	5878	3.275	YES	YES			

Table 5-16
(continued)

Summary of Closure Analysis
(YES = plant or product line shutdown is possible)

Type of Discharger	Plant Number	Type of Product (1)	Production Amount (000 lbs)	Product Value ($000,000)	PSES Treatment Level 1	PSES Treatment Level 2	BAT Treatment Level 1	BAT Treatment Level 2	BAT Treatment Level 3
DIRECT									
↓	16	M	5276	3.0	NA	NA	YES	YES	YES
	17	M	402	1.31	↓	↓	YES	YES	YES
	18	M	45311	56.2			NO	NO	NO
	19	M	127900	11.7(3)			NO	NO	NO
	20	M	22146	45.616			NO	NO	NO
	21	H	97280	96.1			NO	NO	NO
	22	M	24520	79.5			NO	NO	NO
INDIRECT & DIRECT									
	23	M	3444	8.102	YES	YES	YES	YES	YES
				TOTAL SHUTDOWNS	4	14	3	3	3

Source of data is ADL report and revisions, except where noted.

[1] H = Herbicides
I = Insecticides
F = Fungicides
M = Mixed products

[2] Value estimated from production quantity multiplied by average cost per lb. obtained from Int. Trade Commission statistics 1977.

[3] Pesticide value is over 75 million but only $11.7 million is impacted.

[4] Strong parent company may keep plant operational.

*Inadequate information available.

NA - Not applicable.

The results in Table 5-17 indicate that small firms bear a less than proportionate impact under economic option 1. Only two out of 18 plants owned by small firms have costs of compliance, none of which have a cost to sales ratio greater than four percent or are expected to close. In comparison, 22 of the 62 large firm plants have positive incremental costs, over one-third of the total; nine of the 22 plants have cost-to-sales ratios greater than four percent; and two plants and four product lines are predicted to close due to incremental costs.

New Source Standards

The potential impacts of NSPS (New Source Performance Standards) and PSNS (Pretreatment Standards, New Source) if new plants or expansions are built by pesticide manufacturers or pesticide formulator/packagers are described. The impacts are expressed in terms of treatment costs as a percent of sales. Also, the prospects for manufacturing plant expansions occurring in the next four to five years are discussed. Costs incurred by new source ("greenfield") sites are assumed to be the same as those that would be incurred by a major modification of an existing site.

Impacts of PSNS and NSPS Treatment Costs. In studies by the Technical Contractor[12,13,14] specific pesticides were classified in one of 13 subcategories, and estimates of treatment costs for each subcategory were developed. Pesticides were assigned to a subcategory based on several considerations including raw materials used in manufacturing, wastewater characteristics and treatability, disposal, and manufacturing processes. Wastewater treatment trains that meet new source standards were synthesized for each subcategory. The level of treatment obtained by applying NSPS to direct dischargers is equivalent to Level 1 when applied to

Table 5-17. Results of Small Business Analysis: Economic Option 1

	Number of Plants		Number of Plants With Cost-to-Sales Ratio of				Number of Closures	
	Total	Compliance Costs	0-1%	1-2%	2-4%	4%	Plant	Product Line
Owned by Small Firms	18	2	1	0	1	0	0	0
Owned by Large Firms	62	22	2	2	9	9	2	4
Total	80	24	3	2	10	9	2	4

existing sources. Pretreatment standards recommended by the Technical Contractor for indirect dischargers are equal to direct discharge treatment Level 1 without biological oxidation (because this treatment is provided by POTWs) and are achieved with Level 1 treatment for indirect dischargers.

For each subcategory, treatment costs are based on model plant sizes selected by the Technical Contractor. Table 5-18 lists the unit prices of each pesticide group by subcategory. Table 5-19 lists the plant sizes for the subcategories and three major pesticide groups that could be produced. Note that plants assigned to four of the subcategories are not compatible with production of all three major pesticide groups; herbicides and insecticides would not be produced by a plant in subcategory 3, 6 or 7 and fungicides would not be produced by a plant in subcategory 8.

The information shown in Table 5-19 was obtained from 1979 ITC data (as shown in Table 5-18) and where sufficient detail was available, the range of values takes into account the compatibility of specific pesticide chemicals with a subcategory. For example, the price of the fungicide PCP (pentachlorophenol) is listed by the ITC as $0.44 per pound. This chemical can be placed in subcategory 2 only, and the average price of PCP sets the lower price shown in Table 5-19 for subcategory 2 fungicides. The lower price shown for fungicides in other subcategories excludes consideration of PCP. Similarly, only subcategory 5 includes the fungicide napthenic acid, copper salt ($0.86 per pound) in establishing the price range shown in the table. In this instance, we assume treatment of the waste stream requires metals separation which is part of the treatment designed for the model plant in subcategory 5. For fungicides, the lower price shown for subcategory 1 ($0.77) is set by chloropicrin which is not compatible with any of the other subcategories.

It is assumed that if a new plant were to be constructed, it would produce only one of the three major groups of pesticides--fungicides, herbicides or insecticides. Therefore, a range of values is shown in Tables 5-18 and 5-19 for each type of pesticide rather than an average value for all three types.

Capital and operating costs were developed by the Technical Contractor for each subcategory. The estimates are considered to be high in that treatment costs for NSPS and PSNS would probably never be greater than the cost for the same level of treatment for an existing plant. A new plant would be designed to maximize production efficiency, and therefore would incorporate some treatment process components in the basic design of the facility; this has not been taken into account in the estimates used here. High and low treatment cost estimates were developed because each subcategory includes a group of chemicals rather than a specific chemical. This grouping of chemicals was done to limit the number of subcategories to a reasonable figure. Within a subcategory, production of different chemicals can affect the hazardous nature of the wastes and the treatability of the wastestream; the high and low cost estimates account for such variability. The capital and O&M costs for each model plant were combined into a total annualized cost in an intermediate step.

Table 5-18

Types of Pesticides and Price Ranges by Subcategory

Treatment Subcategory	Plant Size,[1] Average Daily Production (1,000 lb.)	Price Ranges for Types of Pesticides ($/lb.)[2] Fungicide	Herbicide[3]	Insecticide[4]
1	20.9	1.20 to 2.74	2.84 to 3.99	0.77 to 3.15
2	22.7	0.44 to 2.74	2.84 to 3.99	1.17 to 3.15
3	26.8	1.20 to 2.74	*	*
4	7.74	1.20 to 2.74	2.84 to 3.99	1.17 to 3.15
5	25.6	0.86 to 2.74	2.84 to 3.99	1.17 to 3.15
6	12.7	1.20 to 2.74	*	*
7	4.35	1.20 to 2.74	*	1.17 to 3.15
8	76.9	*	2.84 to 3.99	1.17 to 3.15
9	39.3	1.20 to 2.74	0.84 to 3.99	1.17 to 3.15
10	50	1.20 to 2.74	2.84 to 3.99	1.17 to 3.15
11	5.0	0.86 to 2.74	0.84 to 3.99	0.77 to 3.15
12	5.0	1.34 to 10.44	1.34 to 10.44	1.34 to 10.44
13	5.0	1.50 to 3.00	1.50 to 3.00	1.50 to 3.00

*Pesticide identified in column heading is not compatible with treatment subcategory.

[1]Plant size selected by Technical Contractor for development of NSPS and PSNS treatment costs.

[2]Based on value of merchant shipments reported in Synthetic Organic Chemicals, United States Production and Sales 1979. United States International Trade Commission.

[3]Includes plant growth regulators.

[4]Includes rodenticides, soil conditioners and fumigants.

Table 5-19

Value of Pesticide Production of Model Plants

Treatment Subcategory	Plant Size,[1] Annual Production (1,000 lb.)	Value of Production ($1,000)[2]		
		Fungicide	Herbicide[3]	Insecticide[4]
1	6,897	8,276 to 18,898	19,587 to 27,519	5,311 to 21,726
2	7,491	3,296 to 20,525	21,274 to 29,889	8,764 to 23,597
3	8,844	10,613 to 24,233	*	*
4	2,554	3,065 to 6,998	7,253 to 10,190	2,988 to 8,045
5	8,448	7,265 to 23,147	23,992 to 33,707	9,884 to 26,611
6	4,191	5,029 to 11,483	*	*
7	1,435	1,722 to 3,932	*	1,679 to 4,520
8	25,377	*	72,071 to 101,254	29,691 to 79,938
9	12,969	15,563 to 35,535	10,894 to 51,746	15,174 to 40,852
10	16,500	19,800 to 45,210	46,860 to 65,835	19,305 to 51,975
11	1,650	1,419 to 4,521	1,386 to 6,583	1,270 to 5,197
12	1,650	2,211 to 17,226	2,211 to 17,226	2,211 to 17,226
13	1,650	2,475 to 4,950	2,475 to 4,950	2,475 to 4,950

*Pesticide identified in column heading is not compatible with treatment subcategory.

[1]Plant size selected by Technical Contractor for development of NSPS and PSNS treatment costs; annual production based on 330 days of plant operation.

[2]Based on value of merchant shipments reported in Synthetic Organic Chemicals, United States Production and Sales 1979. United States International Trade Commission. Value is obtained by multiplying the annual production by the prices listed in the ITC.

[3]Includes plant growth regulators.

[4]Includes rodenticides, soil conditioners and fumigants.

The annualized treatment costs (high and low values) are expressed on a per pound basis of pesticide produced by the model plant and also expressed as a percent of pesticide value. (Annual pesticide production assumes 330 days per year of production). Tables 5-20 (for NSPS) and 5-21 (for PSNS) summarize the annualized treatment cost impacts relative to pesticide prices for direct and indirect dischargers, respectively. The percentage range shown for any given row and major pesticide group is based on the high and low price per pound of pesticide shown in the ITC, whereas the high and low column headings reflect the variability in treatment costs for the different chemicals included within a subcategory.

For the direct dischargers (Table 5-20), treatment cost impacts are greatest for pesticides in subcategory 7 where costs range from 16 percent (for the higher priced insecticides that can be produced in new plants requiring relatively low treatment costs) to 73 percent (for lower priced insecticides that require relatively high treatment costs). For subcategories 4 and 7, treatment costs are generally greater than 10 percent (herbicide production in low treatment cost plants is the only exception at 9 percent) of pesticide prices, regardless of which type of pesticide a new plant might produce. Treatment cost impacts for subcategories 6 and 8 are lowest and range from zero to five percent of pesticide prices.

A treatment cost greater than 20 percent of pesticide price is used to identify severe impacts that seriously threaten the feasibility of building a profitable new plant. The selection of 20 percent is admittedly arbitrary. If construction is for a new plant to produce an existing, non-patented pesticide, the 20 percent criterion is high. However, if the new plant is to produce a new pesticide protected by patent rights, the selling price could be established to recover treatment costs in addition to pesticide development costs (which are probably much greater than treatment costs). Use of this 20 percent criterion suggests that new plants for chemicals in subcategories 1, 6, 8, 9 and 10 would not be seriously threatened. For pesticides in subcateogry 2, new plants being considered for the production of some of the lower priced fungicides would be judged infeasible--unable to meet profit objectives of the firm--and hence would not be built.

Table 5-21 presents similar information for indirect dischargers. As may be expected, the effect of treatment costs on pesticide prices is less than in the case of direct dischargers; for indirect dischargers, the biological treatment is carried out by the POTWs whereas for the direct dischargers the biological treatment is done at the new plant. Again, it is new plants in subcategory 7 that would be more severely impacted than plants associated with any of the other subcategories; treatment costs range from 11 percent to 58 percent of prices depending on the particular chemicals. Using the 20 percent cost criterion to judge economic feasibility suggests that plants constructed to produce any of the chemicals in subcategories 1, 6, 8, 9 and 10 would be feasible. Also, new plants to produce herbicide and insecticide chemicals in subcategories 2 and 5 would not incur treatment costs that exceed 20 percent of the prices of those pesticides.

Table 5-20

Summary of NSPS Treatment Costs on Price of Pesticides

Treatment Sub-category	Annual Production (1,000 lbs.)	Annualized Treatment Cost Per Pound ($)		Treatment Cost as Percent of Pesticide Price (%)**					
				Fungicides		Herbicides		Insecticides	
		High[1]	Low[1]	High[1]	Low[1]	High[1]	Low[1]	High[1]	Low[1]
1	6,897	0.13	0.07	5 to 11	3 to 6	3 to 5	1 to 2	4 to 17	2 to 9
2	7,491	0.15	0.08	5 to 34	3 to 18	4 to 5	2 to 3	5 to 13	2 to 7
3	8,844	0.57	0.17	21 to 48	6 to 14	*	*	*	*
4	2,554	0.57	0.35	21 to 48	13 to 29	14 to 20	9 to 12	18 to 48	11 to 30
5	8,448	0.30	0.12	11 to 35	4 to 14	7 to 10	3 to 4	9 to 27	4 to 10
6	4,191	0.024	0.01	1 to 2	0 to 1	*	*	*	*
7	1,436	0.85	0.51	31 to 71	19 to 43	*	*	27 to 73	16 to 44
8	25,377	0.05	0.02	*	*	1 to 2	0.5 to 1	2 to 4	1 to 2
9	12,696	0.11	0.04	4 to 9	1 to 3	3 to 13	1 to 7	4 to 9	1 to 3
10	16,500	0.175	0.10	6 to 15	4 to 8	4 to 6	2 to 4	5 to 15	3 to 9
11	-	-	-	-	-	-	-	-	-
12	1,650	0.003	0.003	.03 to .2	.03 to .2	.03 to .2	.03 to .2	.03 to .2	.03 to .2
13	1,650	0.003	0.003	.1 to .2	.1 to .2	.1 to .2	.1 to .2	.1 to .2	.1 to .2

[1]High and low estimates are attributable to different pesticides that are included in a subcategory.

*Pesticide identified in column heading is not compatible with treatment subcategory.

**Prices are calculated on a per pound of pesticide basis.

Table 5-21

Summary of PSNS Treatment Costs on Price of Pesticides

Sub-category	Annual Production (1,000 lbs.)	Annualized Treatment Cost Per Pound ($)		Treatment Cost as Percent of Pesticide Price (%)**					
				Fungicides		Herbicides		Insecticides	
		High[1]	Low[1]	High[1]	Low[1]	High[1]	Low[1]	High[1]	Low[1]
1	6,897	0.09	0.03	3 to 7	1 to 2	2 to 3	0 to 1	3 to 12	1 to 4
2	7,491	0.115	0.036	4 to 26	1 to 8	3 to 4	0 to 1	4 to 10	1 to 3
3	8,844	0.49	0.10	18 to 41	4 to 8	*	*	*	*
4	2,554	0.428	0.23	16 to 36	8 to 19	11 to 15	6 to 8	14 to 37	7 to 20
5	8,448	0.244	0.068	9 to 28	2 to 8	6 to 9	1 to 2	8 to 20	2 to 6
6	4,191	0.024	0.010	1 to 2	0.4 to 0.8	*	*	*	*
7	1,436	0.681	0.355	25 to 57	13 to 30	*	*	22 to 58	11 to 30
8	25,377	0.037	0.011	*	*	0 to 1	0 to .05	1 to 3	.5 to 1
9	12,969	0.086	0.032	3 to 7	1 to 2	2 to 10	1 to 4	3 to 7	1 to 3
10	16,500	0.145	0.071	5 to 12	3 to 6	4 to 5	2 to 3	5 to 12	2 to 6
11	-	-	-	-	-	-	-	-	-
12	1,650	0.003	0.003	.03 to .2	.03 to .2	.03 to .2	.03 to .2	.03 to .2	.03 to .2
13	1,650	0.003	0.003	.1 to .2	.1 to .2	.1 to .2	.1 to .2	.1 to .2	.1 to .2

[1]High and low estimates are attributable to different pesticides that are included in a subcategory.

*Pesticide identified in column heading is not compatible with treatment subcategory.

**Prices and treatment cost are on a per pound of pesticide basis.

Prospects for Additional Plant Capacity

Projections of pesticide consumption compared to industry capacity suggest that there will be little, if any, need for additional capacity by 1985. The pesticides industry overall operated at a capacity utilization rate of 80 percent in 1979. Thus, while 1,429 million pounds of pesticide chemicals were produced in 1979, capacity was available to produce almost 1,800 million pounds. The components of the industry (fungicides, insecticides, herbicides) varied in their utilization of available capacity and Table 5-22 lists production capacity and capacity utilization for the industry.

Table 5-22 shows that the 1979 capacity was 184 million pounds for fungicides, 888 million pounds for herbicides and 726 million pounds for insecticides. The high point for pesticides production in the past decade occurred in 1974 when combined production of 1610 million pounds exceeded 1979 output; in 1974, about 160 million pounds of fungicide were produced, 660 million pounds of insecticides and 790 million pounds of herbicides.

Table 5-22

Pesticide Production and Capacity Utilization, 1979

Type of Pesticide	Production (million lbs.)	Capacity Utilization	Capacity (million lbs.)
Fungicides	155	.84	184
Herbicides	657	.74	888
Insecticides	617	.85	726
All pesticides	1,429	.80	1,786

Source: U.S. Pesticide Market, Frost & Sullivan (capacity values calculated by Meta Systems, Inc).

Projections by Arthur D. Little, Inc. forecasted insecticide production to be 625 million pounds, herbicide production to be 820 million pounds and fungicide production to be 155 million pounds by 1985. For each of these three major pesticide types, production data for the last several years demonstrate that the industry is capable of meeting the projected production requirements with current capacity.

Appendix A

Plant and Firm Data Ordered by Firm Employment and Firm Sales

Table A-1

SORT BY FIRM SALES ECONOMIC - OPTION 1

?LANT	PLANT PROD (OOOLBS)	FIRMSALES ($MILLION)	FIRMEMP	FIRM COST ($000)	%COST/ SALES	CUMCOST ($000)	%CUMCOST/ TOTCOST	CUMSALES ($MILLION)	%CUMSALES TOTSALE	CUMPROD (OOOLBS)	%CUMPROD/ TOTPROD	CUMEMP	%CUMEMP/ TOTALEMP
	3450.60	1329.00	18800	1342.00	16.6	19335.0	63.9	681.5	23.6	428005	23.5	13173	18.1
	1000.00	1420.00	16500	0.00	0.0	19335.0	63.9	683.7	23.7	429005	23.6	13323	18.3
	1950.00	1470.00	9940	0.00	0.0	19335.0	63.9	688.0	23.9	430955	23.7	13343	18.3
	116022.00	1526.00	12300	0.00	0.0	19335.0	63.9	935.9	32.5	546977	30.0	14545	20.0
	30702.70	1590.00	13000	3029.00	231	22364.0	73.9	966.8	33.5	577680	31.7	17545	24.1
	3785.70	1778.00	23000	0.00	0.0	22364.0	73.9	975.2	33.8	581465	31.9	17584	24.1
	2200.00	1925.00	15000	0.00	0.0	22364.0	73.9	977.7	33.9	583665	32.1	17604	24.2
	184.80	2000.00	17978	0.00	0.0	22364.0	73.9	978.1	33.9	583850	32.1	20104	27.6
	2206.00	2061.00	30200	0.00	0.0	22364.0	73.9	983.0	34.1	586056	32.2	20125	27.6
	42090.00	2206.00	26500	0.00	0.0	22364.0	73.9	1076.5	37.3	628146	34.5	20564	28.2
	23202.00	2350.00	24000	219.00	2.9	22583.0	74.7	1088.5	37.7	651348	35.8	21534	29.5
	32222.22	2357.00	12441	0.00	0.0	22583.0	74.7	1160.0	40.2	683570	37.5	21684	29.8
	37044.50	2360.00	43000	401.00	2.4	22984.0	76.0	1234.8	42.8	720615	39.6	22379	30.7
	2309.47	2385.00	30900	15.00	0.3	22999.0	76.0	1239.8	43.0	722924	39.7	22453	30.8
	17000.00	2683.00	10800	402.00	2.6	23401.0	77.4	1255.4	43.5	739924	40.6	22630	31.0
	4883.00	2736.00	49421	0.00	0.0	23401.0	77.4	1264.1	43.8	744807	40.9	24162	33.2
	54218.00	2746.00	43963	86.00	2.5	23487.0	77.6	1288.2	44.7	799025	43.9	26214	36.0
	200.00	2746.00	41000	0.00	0.0	23487.0	77.6	1288.7	44.7	799225	43.9	26289	36.1
	18901.00	3307.00	46212	213.00	4.3	23700.0	78.4	1330.3	46.1	818126	44.9	26486	36.3
	116.73	3699.00	41000	108.00	1.4	23808.0	78.7	1337.8	46.4	818243	44.9	26521	36.4
	248722.00	6195.00	63926	2281.00	3.0	26089.0	86.3	1614.0	56.0	1066965	58.6	31443	43.1
	22.10	6250.00	33200	0.00	0.0	26089.0	86.3	1614.1	56.0	1066987	58.6	31563	43.3
	47758.00	7013.00	123700	0.00	0.0	26089.0	86.3	1720.1	59.6	1114745	61.2	52673	72.3
	51461.00	9177.00	115763	0.00	0.0	25089.0	86.3	1834.3	63.6	1166206	64.0	54173	74.3
	392047.00	9255.00	55900	463.10	4.0	26552.1	87.8	2279.3	79.0	1558253	85.6	66879	91.8
	5276.00	10207	179000	441.79	14.7	26993.9	89.2	2282.3	79.1	1563529	85.9	66934	91.8
	7540.00	10207	179000	411.00	3.7	27404.9	90.6	2293.5	79.5	1571069	86.3	67013	91.9
	973.80	10207	179000	0.00	0.0	27404.9	90.6	2304.9	79.9	1572043	86.3	67024	92.0
	37716.00	12572	134000	2843.00	3.6	30247.9	100	2460.7	85.3	1609759	88.4	69324	95.1
	114219.00	15000	36384	0.00	0.0	30247.9	100	2693.7	93.4	1723978	94.7	71487	98.1
	800.00	19500	58300	0.00	0.0	30247.9	100	2695.4	93.5	1724778	94.7	71495	98.1
	15731.00	30527	75800	0.00	0.0	30247.9	100	2730.4	94.7	1740509	95.8	71660	98.3

Table A-1

SORT BY FIRM SALES ECONOMIC - OPTION 1

PLANT	PLANT PROD (000LBS)	FIRMSALES ($MILLION)	FIRMEMP	FIRM COST ($000)	%COST/ SALES	CUMCOST ($000)	%CUMCOST/ TOTCOST	CUMSALES ($MILLION)	%CUMSALES TOTSALE	CUMPROD (000LBS)	%CUMPROD/ TOTPROD	CUMEMP	%CUMEMP/ TOTALEMP
	.	.	.	0.00	.	0.0	0.0	0.0	0.0	0	0.0	0	0.0
	170.00	.	140	266.00	75.6	266.0	0.9	0.4	0.0	170	0.0	60	0.1
	444.00	1.00	7	0.00	0.0	266.0	0.9	1.3	0.0	614	0.0	67	0.1
	645.70	1.45	7	0.00	0.0	266.0	0.9	2.8	0.1	1260	0.1	74	0.1
	799.00	2.00	35	0.00	0.0	266.0	0.9	4.5	0.2	2059	0.1	109	0.1
	0.45	2.00	30	0.00	0.0	266.0	0.9	4.5	0.2	2059	0.1	139	0.2
	1900.00	2.50	13	0.00	0.0	266.0	0.9	7.0	0.2	3959	0.2	152	0.2
	1100.00	2.50	11	211.00	2.4	477.0	1.6	15.8	0.5	5059	0.3	163	0.2
	483.00	2.60	18	0.00	0.0	477.0	1.6	16.4	0.6	5542	0.3	181	0.2
	1519.50	3.42	16	0.00	0.0	477.0	1.6	19.8	0.7	7062	0.4	197	0.3
	225.00	4.00	30	0.00	0.0	477.0	1.6	20.7	0.7	7287	0.4	227	0.3
	1822.10	4.10	19	0.00	0.0	477.0	1.6	24.7	0.9	9109	0.5	246	0.3
	2000.00	4.50	21	0.00	0.0	477.0	1.6	27.2	0.9	11109	0.6	267	0.4
	0.26	7.00	32	0.00	0.0	477.0	1.6	27.2	0.9	11109	0.6	299	0.4
	45.02	7.00	32	0.00	0.0	477.0	1.6	27.3	0.9	11154	0.6	331	0.5
	34530.00	7.50	360	58.00	0.8	535.0	1.8	34.8	1.2	45684	2.5	691	0.9
	146.00	8.20	30	0.00	0.0	535.0	1.8	35.1	1.2	45830	2.5	721	1.0
	4000.00	9.00	100	0.00	0.0	535.0	1.8	44.0	1.5	49830	2.7	821	1.1
	4540.00	10.22	48	0.00	0.0	535.0	1.8	54.1	1.9	54370	3.0	869	1.2
	1613.00	13.00	130	0.00	0.0	535.0	1.8	57.7	2.0	55983	3.1	999	1.4
	600.00	13.00	70	0.00	0.0	535.0	1.8	58.7	2.0	56583	3.1	1007	1.4
	38.00	14.50	51	0.00	0.0	535.0	1.8	58.8	2.0	56621	3.1	1058	1.5
	1423.00	15.00	60	0.00	0.0	535.0	1.8	62.0	2.1	58044	3.2	1083	1.5
	855.00	15.00	10	0.00	0.0	535.0	1.8	63.9	2.2	58899	3.2	1093	1.5
	5878.00	18.00	70	465.00	14.2	1000.0	3.3	67.2	2.3	64777	3.6	1163	1.6
	3896.30	33.00	450	30.00	0.4	1030.0	3.4	75.0	2.6	68673	3.8	1204	1.7
	42189.00	57.00	1830	0.00	0.0	1030.0	3.4	168.7	5.8	110862	6.1	1354	1.9
	370.00	70.00	.	0.00	0.0	1030.0	3.4	169.5	5.9	111232	6.1	1384	1.9
	724.00	103.00	630	0.00	0.0	1030.0	3.4	171.1	5.9	111956	6.1	1392	1.9
	71000.00	123.00	950	0.00	0.0	1030.0	3.4	328.7	11.4	182956	10.0	2132	2.9
	40.00	127.80	588	0.00	0.0	1030.0	3.4	328.8	11.4	182996	10.1	2720	3.7
	12864.00	200.00	1500	271.00	1.8	1301.0	4.3	343.8	11.9	195860	10.8	2854	3.9
	1471.00	200.00	1600	0.00	0.0	1301.0	4.3	347.1	12.0	197331	10.8	3210	4.4
	41.00	258.30	10760	0.00	0.0	1301.0	4.3	347.2	12.0	197372	10.8	3211	4.4
	6988.00	350.00	2600	1379.00	20.1	2680.0	8.9	354.0	12.3	204360	11.2	3284	4.5
	265.00	399.00	2000	0.00	0.0	2680.0	8.9	354.6	12.3	204625	11.2	3287	4.5
	2206.50	500.00	9200	166.00	6.6	2846.0	9.4	357.1	12.4	206832	11.4	4037	5.5
	133.00	579.00	4139	7.00	11.7	2853.0	9.4	357.2	12.4	206965	11.4	4187	5.7
	2329.00	594.30	78	0.00	0.0	2853.0	9.4	362.3	12.6	209294	11.5	4265	5.9
	690.20	700.00	6500	51.00	2.0	2904.0	9.6	364.8	12.7	209984	11.5	4365	6.0
	15846.00	748.00	6300	0.00	0.0	2904.0	9.6	400.0	13.9	225830	12.4	4715	6.5
	13764.00	753.00	6500	0.00	0.0	2904.0	9.6	430.6	14.9	239594	13.2	4815	6.6
	62.00	967.00	6250	0.00	0.0	2904.0	9.6	430.7	14.9	239656	13.2	4816	6.6
	22146.20	975.00	5417	0.00	0.0	2904.0	9.6	476.3	16.5	261802	14.4	7816	10.7
	14104.00	1000.00	4000	0.00	0.0	2904.0	9.6	507.6	17.6	275906	15.2	8416	11.5
	657.00	1079.00	13970	0.00	0.0	2904.0	9.6	509.1	17.7	276563	15.2	8986	12.3
	1800.00	1103.00	9000	0.00	0.0	2904.0	9.6	513.1	17.8	278363	15.3	10486	14.4
	[illegible]	[illegible]	[illegible]	0.00	0.0	2904.0	9.6	521.1	18.1	281963	15.5	10836	14.9
									[illegible]	[illegible]	[illegible]	[illegible]	18.0

Table A-2

SORT BY FIRM EMPLOYEES ECONOMICS - OPTION 1

PLANT	PLANT PROD (OOOLBS)	FIRMSALES ($MILLION)	FIRMEMP	FIRM COST ($000)	%COST/ SALES	CUMCOST ($000)	%CUMCOST/ TOTCOST	CUMSALES ($MILLION)	%CUMSALES TOTSALE	CUMPROD (OOOLBS)	%CUMPROD/ TOTPROD	CUMEMP	%CUMEMP/ TOTALEMP
	.	.	.	0.00	.	0.0	0.0	0.0	0.0	0	0.0	0	0.0
	370.00	70.00	.	0.00	0.0	0.0	0.0	0.8	0.0	370	0.0	30	0.0
	444.00	1.00	7	0.00	0.0	0.0	0.0	1.8	0.1	814	0.0	37	0.1
	645.70	1.45	7	0.00	0.0	0.0	0.0	3.2	0.1	1460	0.1	44	0.1
	855.00	15.00	10	0.00	0.0	0.0	0.0	5.1	0.2	2315	0.1	54	0.1
	1100.00	2.50	11	211.00	2.4	211.0	0.7	13.9	0.5	3415	0.2	65	0.1
	1900.00	2.50	13	0.00	0.0	211.0	0.7	16.4	0.6	5315	0.3	78	0.1
	1519.50	3.42	16	0.00	0.0	211.0	0.7	19.8	0.7	6834	0.4	94	0.1
	483.00	2.60	18	0.00	0.0	211.0	0.7	20.4	0.7	7317	0.4	112	0.2
	1822.10	4.10	19	0.00	0.0	211.0	0.7	24.4	0.8	9139	0.5	131	0.2
	2000.00	4.50	21	0.00	0.0	211.0	0.7	26.9	0.9	11139	0.6	152	0.2
	0.45	2.00	30	0.00	0.0	211.0	0.7	26.9	0.9	11140	0.6	182	0.2
	146.00	8.20	30	0.00	0.0	211.0	0.7	27.3	0.9	11286	0.6	212	0.3
	225.00	4.00	30	0.00	0.0	211.0	0.7	28.1	1.0	11511	0.6	242	0.3
	0.26	7.00	32	0.00	0.0	211.0	0.7	28.1	1.0	11511	0.6	274	0.4
	45.02	7.00	32	0.00	0.0	211.0	0.7	28.2	1.0	11556	0.6	306	0.4
	799.00	2.00	35	0.00	0.0	211.0	0.7	30.0	1.0	12355	0.7	341	0.5
	4540.00	10.22	48	0.00	0.0	211.0	0.7	40.1	1.4	16895	0.9	389	0.5
	38.00	14.50	51	0.00	0.0	211.0	0.7	40.2	1.4	16933	0.9	440	0.6
	1423.00	15.00	60	0.00	0.0	211.0	0.7	43.3	1.5	18356	1.0	465	0.6
	600.00	13.00	70	0.00	0.0	211.0	0.7	44.4	1.5	18956	1.0	473	0.6
	5878.00	18.00	70	465.00	14.2	676.0	2.2	47.7	1.7	24834	1.4	543	0.7
	2329.00	594.30	78	0.00	0.0	676.0	2.2	52.8	1.8	27163	1.5	621	0.9
	4000.00	9.00	100	0.00	0.0	676.0	2.2	61.7	2.1	31163	1.7	721	1.0
	1613.00	13.00	130	0.00	0.0	676.0	2.2	65.3	2.3	32776	1.8	851	1.2
	170.00	.	140	266.00	75.6	942.0	3.1	65.7	2.3	32946	1.8	911	1.2
	34530.00	7.50	360	58.00	0.8	1000.0	3.3	73.2	2.5	67476	3.7	1271	1.7
	3896.30	33.00	450	30.00	0.4	1030.0	3.4	81.0	2.8	71372	3.9	1312	1.8
	40.00	127.80	588	0.00	0.0	1030.0	3.4	81.1	2.8	71412	3.9	1900	2.6
	724.00	103.00	630	0.00	0.0	1030.0	3.4	82.7	2.9	72136	4.0	1908	2.6
	71000.00	123.00	950	0.00	0.0	1030.0	3.4	240.3	8.3	143136	7.9	2648	3.6
	12864.00	200.00	1500	271.00	1.8	1301.0	4.3	255.3	8.9	156000	8.6	2782	3.8
	1471.00	200.00	1600	0.00	0.0	1301.0	4.3	258.6	9.0	157471	8.6	3138	4.3
	42189.00	57.00	1830	0.00	0.0	1301.0	4.3	352.2	12.2	199660	11.0	3288	4.5
	265.00	399.00	2000	0.00	0.0	1301.0	4.3	352.8	12.2	199925	11.0	3291	4.5
	6988.00	350.00	2600	1379.00	20.1	2680.0	8.9	359.7	12.5	206913	11.4	3364	4.6
	14104.00	1000.00	4000	0.00	0.0	2680.0	8.9	391.0	13.6	221017	12.1	3964	5.4
	133.00	579.00	4139	7.00	11.7	2687.0	8.9	391.1	13.6	221150	12.1	4114	5.6
	22146.20	975.00	5417	0.00	0.0	2687.0	8.9	436.7	15.1	243297	13.4	7114	9.8
	62.00	967.00	6250	0.00	0.0	2687.0	8.9	436.8	15.1	243359	13.4	7115	9.8
	15846.00	748.00	6300	0.00	0.0	2687.0	8.9	472.0	16.4	259205	14.2	7465	10.2
	13764.00	753.00	6500	0.00	0.0	2687.0	8.9	502.5	17.4	272969	15.0	7565	10.4
	690.20	700.00	6500	51.00	2.0	2738.0	9.1	505.0	17.5	273659	15.0	7665	10.5
	1800.00	1103.00	9000	0.00	0.0	2738.0	9.1	509.0	17.7	275459	15.1	9165	12.6
	2206.50	500.00	9200	166.00	6.6	2904.0	9.6	511.5	17.7	277665	15.2	9915	13.6
	1950.00	1470.00	9940	0.00	-0.0	2904.0	9.6	515.9	17.9	279615	15.4	9935	13.6
	41.00	258.30	10760	0.00	0.0	2904.0	9.6	516.0	17.9	279656	15.4	9936	13.6
	[illegible]	2683.00	10800	402.00	2.6	3306.0	10.9	531.6	18.4	296656	16.3	10113	13.9
					[illegible]	[illegible]	[illegible]	683.9	23.7	439247	24.1	12413	17.0

Table A-2

SORT BY FIRM EMPLOYEES ECONOMIC - OPTION 1

PLANT	PLANT PROD (000LBS)	FIRMSALES ($MILLION)	FIRMEMP	FIRM COST ($000)	%COST/ SALES	CUMCOST ($000)	%CUMCOST/ TOTCOST	CUMSALES ($MILLION)	%CUMSALES TOTSALE	CUMPROD (000LBS)	%CUMPROD/ TOTPROD	CUMEMP	%CUMEMP/ TOTALEMP
	114022.00	1526.00	12300	0.00	0.0	18395.0	60.8	931.8	32.3	553269	30.4	13615	16.7
	32222.22	2357.00	12441	0.00	0.0	18395.0	60.8	1003.3	34.8	585491	32.2	13765	18.9
	30702.70	1590.00	13000	3029.00	231	21424.0	70.8	1034.2	35.9	616194	33.8	16765	23.0
	657.00	1079.00	13970	0.00	0.0	21424.0	70.8	1035.6	35.9	616851	33.9	17335	23.8
	2200.00	1925.00	15000	0.00	0.0	21424.0	70.8	1038.1	36.0	619051	34.0	17355	23.8
	3600.00	1213.00	15268	0.00	0.0	21424.0	70.8	1046.1	36.3	622651	34.2	17705	24.3
	1000.00	1420.00	16500	0.00	0.0	21424.0	70.8	1048.3	36.3	623651	34.3	17855	24.5
	184.80	2000.00	17978	0.00	0.0	21424.0	70.8	1048.7	36.4	623836	34.3	20355	27.9
	3450.60	1329.00	18800	1342.00	16.6	22766.0	75.3	1056.8	36.6	627287	34.5	20392	28.0
	3785.70	1778.00	23000	0.00	0.0	22766.0	75.3	1065.3	36.9	631072	34.7	20431	28.0
	23202.00	2350.00	24000	219.00	2.9	22985.0	76.0	1077.3	37.4	654274	35.9	21401	29.4
	42090.00	2206.00	26500	0.00	0.0	22985.0	76.0	1170.7	40.6	696364	38.2	21839	30.0
	2206.00	2061.00	30200	0.00	0.0	22985.0	76.0	1175.6	40.8	698570	38.4	21861	30.0
	2309.47	2385.00	30900	15.00	0.3	23000.0	76.0	1180.7	40.9	700880	38.5	21935	30.1
	22.10	6250.00	33200	0.00	0.0	23000.0	76.0	1180.7	40.9	700902	38.5	22055	30.3
	114219.00	15000	36384	0.00	0.0	23000.0	76.0	1413.7	49.0	815121	44.8	24218	33.2
	200.00	2746.00	41000	0.00	0.0	23000.0	76.0	1414.2	49.0	815321	44.8	24293	33.3
	116.73	3699.00	41000	108.00	1.4	23108.0	76.4	1421.7	49.3	815438	44.8	24328	33.4
	37044.50	2360.00	43000	401.00	2.4	23509.0	77.7	1496.4	51.9	852482	46.8	25023	34.3
	54218.00	2746.00	43963	86.00	2.5	23595.0	78.0	1520.6	52.7	906700	49.8	27075	37.1
	18901.00	3307.00	46212	213.00	4.3	23808.0	78.7	1562.2	54.2	925601	50.8	27272	37.4
	4883.00	2736.00	49421	0.00	0.0	23808.0	78.7	1570.8	54.5	930484	51.1	28804	39.5
	392047.00	9255.00	55900	463.10	4.0	24271.1	80.2	2029.8	70.4	1322531	72.6	41510	57.0
	800.00	19500	58300	0.00	0.0	24271.1	80.2	2031.6	70.4	1323331	72.7	41518	57.0
	330540.00	6195.00	63926	2281.00	3.0	26552.1	87.8	2446.6	84.8	1653871	90.8	46964	64.4
	15731.00	30527	75800	0.00	0.0	26552.1	87.8	2481.5	86.0	1669602	91.7	47129	64.7
	51461.00	9177.00	115763	0.00	0.0	26552.1	87.8	2595.8	90.0	1721063	94.5	48629	66.7
	47758.00	7013.00	123700	0.00	0.0	26552.1	87.8	2701.8	93.7	1768821	97.1	69739	95.7
	38243.00	12572	134000	2843.00	3.6	29395.1	97.2	2857.5	99.1	1807064	99.2	72139	99.0
	5276.00	10207	179000	441.79	14.7	29836.9	98.6	2860.5	99.2	1812340	99.5	72194	99.1
	7540.00	10207	179000	411.00	3.7	30247.9	100	2871.7	99.6	1819880	99.9	72273	99.2
	973.80	10207	179000	0.00	0.0	30247.9	100	2883.1	100	1820854	100	72284	99.2

Appendix B

Derivation of Capital Recovery Factor

Appendix B

Derivation of Capital Recovery Factor

The capital recovery factor (CRF) measures the rate of return that an investment must achieve each year in order to cover the cost of the investment and maintain net earnings, including depreciation and taxes. Stated another way, the capital recovery factor is the excess of revenues over variable costs, per dollar of invested capital, needed to cover the cost of borrowing, depreciation and net profit-related taxes, while preserving the market value of the firm's stock.

The formula for CRF used in previous analyses was:

$$CRF = \frac{A(N,K_f) - td}{1 - t} \qquad (B\text{-}1)$$

where:

N = lifetime of investment
K_f = average after-tax cost of capital
$A(N,K_f)$ = annuity whose present value is 1, given N and K_f $[K_f/(1-(1+K_f)^{-N})]$
d = depreciation rate
t = corporate income taxes

Changes in the tax code dealing with rapid depreciation and investment tax credits, require alterations in the formula for calculating the capital recovery factor. The revised formula is:

$$CRF = \frac{A(N,K_f)(.9-c)}{1 - t} \qquad (B\text{-}2)$$

where: $$c = \sum_{l=1}^{n} \frac{td'}{(1+K_f)^l}$$

where:

n = depreciation lifetime under tax code
d' = new depreciation rate

Other variables as above.

The derivation of these formulas are given in the back of this Appendix. The assumptions and data used to obtain values for the above variables are described below.

A single, industry-wide CRF equal to 21.8 percent has been used in our analysis. For a given investment, a firm's CRF will vary with their cost of capital and mix of financing. However, it was not possible to estimate a separate CRF for each establishment or firm.

Average Cost of Capital

The cost of capital, K_f, is the average percentage return that suppliers of debt and equity demand. For firms which have more than one type of capital, K_f is calculated as the average of the after-tax costs of debt and the costs of equity, weighted by the share of market value of each relative to the total market value of the firm. In equation form:

$$K_f^* = bi(1-t) + (1-b)r \qquad \text{(B-3)}$$

where:

K_f^* = average cost of capital after taxes
i = average of cost of debt
r = average cost of equity
t = corporate income tax rate
b = share of debt financing

The costs of debt and equity are measured by the current market value of outstanding debt and stock, rather than the original costs when the debt and equity were issued. The argument that projects should be evaluated using the weighted average cost of capital as the discount factor has been made elsewhere* and rests on several assumptions. Firms are assumed to have an optimal debt/equity ratio (or at least some preferred debt/equity ratio), to have already obtained that ratio, and to strive to maintain it over time. In addition, it is assumed that new projects do not alter the overall risk position of the firm. (A change in the risk level might result in a change in the debt/equity level.) Therefore, new projects, on average, will be financed with these same desired fractions of debt and equity.

Cost of Debt. Since firms often have more than one debt issue, it is necessary to calculate an average cost within a company as well as across companies. The following information on the debts of 40 chemical companies was obtained from Standard and Poor's Bond Guide (August 1979).**

1) yield to maturity
2) debt outstanding
3) closing price

First, the total market value of each bond issue is calculated as the bond price multiplied by the amount of debt outstanding. Second, the average cost of debt is calculated as a weighted average of the various

*See, for example, J. Fred Weston and Eugene F. Brigham, Managerial Finance (6th ed.), Dryden Press, 1978, Chapter 19.

**See: Draft Industry Description: Organic Chemical Industry, Vol. I, December 1979, pages 3-7 through 3-16, for a detailed presentation of the data.

values for yield to maturity, where the weights equal the ratio of the market value of each bond issue to the total value of debt. The average before-tax cost of debt for these companies is 9.89 percent.

Cost of Equity. A firm's cost of equity can be expressed in equation form as:

$$r = \frac{e}{P} + g \qquad \text{(B-4)}$$

where e is the annual dividend, P is the stock price, and g the expected growth rate of dividends.* To estimate the firms' cost of equity, the following data were obtained from Standard and Poor's Stock Guide (August 1979):

1) dividend yield;
2) closing price;
3) number of shares outstanding.

Information was collected for common stocks. The existence of preferred stocks complicates the calculations substantially, since a preferred stock is more nearly a stock-bond hybrid. Preferred stocks are ignored except where they represent more than 10 percent of the market value of all stocks. In those cases where preferred socks represent a signficiant portion of equity, the company was removed from the survey.

An estimate of the expected growth rate was obtained using data from the USITC Organic Chemicals (1977) and the DRI Chemical Review. A weighted average of annual growth rates for plastics, fibers, and elastomers sales was obtained for the entire industry:

$$g = \underset{\text{Plastics}}{.745(7.1)} + \underset{\text{Elastomers}}{.125(1.6)} + \underset{\text{Fibers}}{.130(3.8)} = 6.0$$

Depreciation

Depreciation is normally defined as the fraction of revenues set aside each year to cover the loss in value of the capital stock. Due to recent changes in the federal tax code, the economic life of a capital item is now considerably longer than the depreciation life for tax purposes. Based on earlier work the lifetime of capital stock for this industry is assumed to be about 10 years.* The depreciation rate for most personal property now is straight-line over five years (20). These values are used in the revised calculation of the capital recovery factor.

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*See, for example, J. Weston and F. Brigham, op.cit.

Tax Rate

The current federal corporate income tax rate is 20 percent on the first $25,000 of profits, 22 percent on the next $25,000, and 46 percent on all profits over $50,000. For this analysis, we assume that plants are paying an even 46 percent federal tax on all profits. A study by Lin and Leone** indicates that state and local income taxes also are a significant factor in pollution control investments. State corporate income tax rates may be as high as 9.5 percent. In their study, a weighted average of 7 steel-producing states yielded an average state corporate income tax rate of 7.55 percent. State income taxes, of course, are deductible expenses in computing corporate income tax. We assume a state corporate income tax rate of 8 percent. Deducting this figure before computing the federal income tax rate reduces the net effect of the 8 percent rate to about 4 percent. Thus, the overall effective income tax rate is approximately 50 percent.

Sensitivity Analysis

Table 1 presents various values for the capital recovery factor, assuming various weighted costs of capital (K_f) and different formulations allowing for changes in the federal tax code. Both the rapid depreciation and the investment tax credit serve to lower the capital recovery factor, thus reducing the return necessary to justify a given investment.

In previous work in both the pulp and paper industry and the organic chemical industry, we have estimated the weighted cost of capital based on the current costs as reflected in the current prices and yields of a sample of corporate stocks and bonds for that industry. In August of 1979, the weighted cost of capital for the organic chemical industry was estimated to be about 10 . There are two major assumptions in using this method. First that current prices and yields accurately reflect future costs of capital. However, interest rates have increased significantly since the summer of 1979. Second, that the current portfolio mix will remain constant over the next several years. Given changes in tax codes, and changes in the availability of certain sources of capital such as industrial revenue bonds, this is unlikely. Therefore we expect that the cost of capital will be higher than 10 percent. Given the mix of financing sources available, it is unlikely to be as high as 15 percent and we believe that 13 percent is a good estimate of the weighted cost of capital for the period covered by this study.

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*Draft Industry Description: Organic Chemical Industry, Vol. I, December 1979.

**An Loh-Lin and Robert A. Leone, "The Iron and Steel Industry," in Environmental Controls, (Robert A. Leone, ed.), Lexington, MA: Lexington Books (1976), p. 70.

Table B-1

Alternative Derivations of the Capital Recovery Factor

Variable	Values						
Weighted cost of capital (K_f)	.10	.15	.20	.10	.13	.15	.20
Life of asset (N)	10	10	10	10	10	10	10
A(N, K_f)	.163	.199	.239	.163	.185	.199	.239
Depreciation life (n)	10	10	10	5	5	5	5
Depreciation rate (d)	.10	.10	.10	.20	.20	.20	.20
Tax rate (t)	.50	.50	.50	.50	.50	.50	.50
c				.330	.310	.300	.275
CRF(1)	.226	.298	.378				
CRF(2)				.218	.255	.279	.347
CRF(3)				.185	.218	.239	.299

where: CRF(1) is original formula (2-1 in text)
CRF(2) allows for rapid depreciation but not investment tax credit
CRF(3) allow for both rapid depreciation and investment tax credit (2-2 in text)

Original Form

The capital recovery factor can be expressed analytically as follows. Let:

R	=	annual revenue
C	=	annual variable costs: labor, materials, energy, etc.
I	=	investment cost
π	=	capital recovery factor = (R-C)/I
d	=	depreciation rate
t	=	tax rate
K_f	=	weighted cost of capital (after-tax)
N	=	investment lifetime in years
$A(K_f,N)$	=	annuity whose present value equals 1, given discount rate K_f and lifetime N.

Given revenues and direct costs, average cost of capital, tax rates, depreciation rates, and investment lifetime, the problem is to find that gross return per dollar of invested capital which allows the firm to just cover its costs of capital, depreciation, and taxes and maintain the value of the firm. Equation (B-5) expresses the relationship that must hold for the firm to break even on its invested capital, I. In other words, the present discounted value of the net income flow (using the average cost of capital as the discount factor) just equals the cost of the firm's initial investment:

$$\sum_{j=1}^{N} \frac{(R-C) - t(R-C) + tdI}{(1 + K_f)^j} = I \qquad (5\text{-}5)$$

The numerator of the left-hand side of equation (B-5) shows net profits plus the tax subsidy on depreciation. Note that the tax subsidy on interest payments is not included because it is already taken into account by using the after-tax cost of debt in the average cost of capital. Dividing equation (B-5) by I and substituting π for (R-C)/I gives:

$$\sum_{j=1}^{N} \frac{\pi - t\pi + td}{(1 + K_f)^j} = 1 \qquad (B\text{-}6)$$

Note that if the numerator is assumed constant (i.e., constant R-C, depreciation and tax rates) over all periods, it represents the annuity whose present value is 1, given discount rate K_f and lifetime N, i.e., $A(K_f,N)$. We can then "solve" equation (B-6) for π using the tables for "Annuity whose Present Value is 1." Then π will be the "capital recovery factor," expressed as a percentage of initial investment, which must be added to direct operating costs to ensure the project return equals its cost of capital. The result is given below:

$$\pi - t\pi + td = A(K_f,N)$$

$$\pi = \frac{A(K_f,N) - td}{1 - t} \qquad \text{(B-7)}$$

<u>Alternative Form</u>

The 1981 tax reform act allows firms to depreciate capital stock for tax purposes at a rate faster than depreciation for economic purposes. Therefore d is no longer the inverse of N as above. In addition, a 10 tax credit is allowed on new investments, thus reducing the initial cost of the investment to 90 of its original cost. Therefore, equation (B-6) above becomes:

$$\sum_{j=1}^{N} \frac{\pi - t\pi}{(1+K_f)^j} + \sum_{l=1}^{n} \frac{td}{(1+K_f)^l} = .9 \qquad \text{(B-8)}$$

where:

n = depreciation lifetime under tax code
d' = new depreciation rate

Setting:

$$\sum_{l=1}^{n} \frac{td'}{(1+K_f)^l} = C$$

Then:

$$\sum_{j=1}^{N} \frac{\pi - t\pi}{(1 + K_f)^j} = .9\text{-}C \qquad \text{(B-9)}$$

$$\sum_{j=1}^{N} \frac{(\pi - t\pi) \, / \, (.9\text{-}C)}{(1 + K_f)^j} = 1$$

Assuming as before that the numerator is a constant over all periods, it represents the annuity whose present value is 1, given discount rate K_f and lifetime N.

Therefore:

$$\frac{\pi}{.9-C} - \frac{t\pi}{.9-C} = A(K_f, N) \qquad \text{(B-10)}$$

$$\pi\left(\frac{1-t}{.9-C}\right) = A(K_f, N) \qquad \text{(B-11)}$$

$$\pi = \frac{A(K_f, N)(.9-C)}{1-t} \qquad \text{(B-12)}$$

Appendix C

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