FINAL REPORT

VOLUME I: SIMULATION AND ANALYSIS

# THE OAP REGIONAL ECONOMIC MODEL UTILIZATION PHASE I

*Prepared for:*

Environmental Protection Agency
Office of Air Programs
Research Triangle Park
North Carolina

January 7, 1972

CONSAD Research Corporation

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Prepared for:

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Any opinions comprised in this report are those of CONSAD and do not necessarily reflect the views of the individuals cited above.

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# CHAPTER 1: INTRODUCTION AND SUMMARY

CONSAD Research Corporation has developed and demonstrated a Regional Economic Model for the assessment of the effects of air pollution abatement. * This model is operational and policy oriented and attempts to describe the economic system-wide effects of specific air pollution strategies in 91 major metropolitan areas in the United States.

Essentially, the model is a cross-sectional Keynesian-type regional macro model that describes in considerable detail, the two-digit SIC manufacturing industries, viewed as leading regional economic growth. The Keynesian system and economic base theory are integrated in the regional income determination block of the model that describes regional personal income, consumption expenditures and local government expenditures and revenues. In addition, there is a regional labor market block, that specifies the employment, unemployment and labor force equations. Finally,

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* CONSAD Research Corporation, An Economic Model System for the Assessment of Effects of Air Pollution Abatement, Development and Demonstration Phase, prepared for the Office of Air Pollution, Environmental Protection Agency, May 15, 1971.

the model describes the regional electricity and fuel demand patterns by the two-digit SIC industries. The regional model is hooked up to a National Input-Output Model (1963) via a Regional Share (location quotient) matrix. The I-O system is intended to serve as an external market for the regional economy and to measure the structural change in the national economy attendant on air pollution control in the regions.

The regional model was estimated using 1967 data for the 91 largest Standard Metropolitan Statistical Areas, using ordinary least squares except for the income block for which two stage least squares was used.

The operationality of this model was demonstrated in the effort described in May 1971, report. In that demonstration, the economic effects of the control costs associated with the reductions in emissions required by Section 305(a) of the Clean Air Act of 1967 on the 91 SMSAs were simulated. Specifically, three strategies reflecting the same control costs but different in their incidence of these costs among industries, consumers and government were simulated.

These simulation results suggested the need for further model utilization experiments that would lead to a more thorough utilization of the model than was possible in the development and demonstration phase. The resulting model utilization effort, termed Phase I, is the theme of this report.

The Phase I model utilization effort has been structured into a set of tasks.

The first task was addressed to a specification of air pollution control implementation strategies that introduce a greater realism to the model utilization and can lead to a more thorough exercise of the model than was possible in the demonstration phase.

Realism is introduced in a variety of ways. First, the standards and costs used in the strategies are the preliminary estimates corresponding to the control implied by Clean Air Amendment of 1970, provided by EPA. These estimates are termed as EPA cost estimates in the rest of the report.

Second, since control implementation would take place over a period extending to 1975 or 1977, the simulation includes the regional economies for the corresponding future years and the incidence of control costs over time is assumed to be a "step up" function (with the greatest proportion of the investments occurring closer to 1975 or 1977) rather than a uniform annual expenditure over the period, as assumed in the demonstration simulation (May 15, 1971). Since the EPA administrator can extend the period of implementation by two years under certain circumstances, strategies can also differ by implementation periods. Further, the economies of the AQCRs (Air Quality Control Regions) are likely to be larger in 1973-1975 than in 1967, and with a more realistic time scheme of cost incidence as proposed here, the proposed strategies are likely to be more realistic.

Third, a greater variety of schemes are tried in the strategies. According to Wilson and Minnotte,* several existing federal and state provisions act to reduce the cost to industry of air pollution. Included here are the Federal Corporate Tax, depreciation allowances, investment credit and State and local tax laws. These provisions give government assistance to industry amounting to as much as 59% of cost, under certain assumptions. The OAP model parameters estimated in 1967 will reflect the assistance provided the firms in all industries actively instituted control at that time. Thus, when a strategy calls for financial assistance, it implies additional cost sharing.

Fourth, alternative levels of "net" benefits of air pollution control are assumed. The institution of air control will result in increases of productivity, property values, control device production and decreases in health expenditures, housing maintenance, etc. The

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* Richard D. Wilson and David W. Minnotte, "Government Industry Cost Sharing of Air Pollution Control," Journal of Air Pollution Control Association, October, 1969, pp. 761-766.

level of increment of national final demand resulting from such changes is termed here as "net" benefits. Estimates of "net" benefits are hard to come by and two levels are assumed for the simulation.

Six strategies are developed in the light of the above dimensions -- time period of implementation, cost sharing and level of net benefits -- for simulation with the OAP model. A seventh strategy, termed as the "mixed" strategy evolves out of the simulation and implementation of the above six and is best described later.

The second task was essentially a quantification of the strategies and updating of economic data in a manner to simulate strategies such as those developed in this study. Since the strategies assume the implementation of Clean Air Amendments of 1970, the control costs used are the EPA preliminary estimates reflecting the emission reduction levels deemed appropriate to meet Clean Air Amendments air quality standards.

To facilitate the use of the model over the implementation period, a number of future cross-sections of the regional economies were developed for the 91 AQCRs using the OBE regional forecasts. *

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* U. S. Department of Commerce, Office of Business Economics, Economic Projections for Air Quality Control Regions, June, 1970.

The simulation procedures of the OAP Model were adopted to accommodate the overtime and cumulation effects of the strategies in Phase I.

The third task of the Phase I effect was to apply the model to simulate and assess the economic consequences of the three strategies.

As air pollution control requirements are instituted in the nation, the consequent effects are incident differentially in the various AQCRs. The primary purpose of regional economic modeling is to provide quantitative estimates of such differences among the AQCRs in any particular treatment (strategy) and among different treatments.

The second purpose of the model is to provide information on such differences among regions and among strategies that is useful to determine implementation strategies. For example, it is possible to argue that the "perfect" strategy is one in which each AQCR suffers the same degree of economic hardship. Exact measurement of such a condition is impossible, since there is no single measure of economic hardship. However, the use of this regional model permits useful estimation of the degree of differences in the treatment of AQCRs necessary to achieve some degree of uniformity in the effects of implementation of pollution control requirements.

Even, if spatial equity were not pursued as a major goal, the EPA administrator has the option of extending implementation period by two years under certain circumstances. Other forms of targeted assistance (differential cost sharing, etc.) are also possible. Consequently, the regional model can be used to design and assess such "mixed" implementation strategies (in which different AQCRs are treated differently) by trial and error, so that some guidance may be available to EPA officials to achieve some degree of equity among AQCRs in control implementation.

Thus, the effort to assess the economic effects air pollution control strategies is guided by these two objectives.

The aggregate, over time and geographic patterns of economic effects in the 91 AQCRs are explored in the six strategies. The reasons behind the geographic patterns of adverse economic effects such as the locational factors, industrial structure and economic history are explored in some depth. The resulting insights are utilized in the design of a "mixed" strategy that reduces the degree of economic adversity of control (to an arbitrary level of 0.5% unemployment increase) for all AQCRs. The search for a mixed strategy is then an effort towards equity among AQCRs in the economic effects of implementation.

The fourth task is addressed to an exploration of the potential for and the modifications necessary for the extension of the OAP model to other media -- water and land -- of pollution. These extensions are suggested in the light of the similarities and differences among air quality, water quality and solid waste practices and available data. The modifications and extensions of the model are outlined in some detail.

The fifth task identifies the potential areas for model refinement and extension prior to further application. These areas include elaboration of the public sector in the model and reestimation of the investment equations.

# CHAPTER 2: IMPLEMENTATION STRATEGIES: APPROACH AND SPECIFICATION

This chapter is directed to an identification of a set of air pollution control implementation strategies, which are plausible in the current legislative and administrative context, and whose economic effects can be assessed by the OAP Regional Economic Model. The implementation strategies will be designed to encompass the range of regulatory and advisory responsibilities of EPA,* and be plausible under the constraints of administration, timing of implementation, finance, manner of attainment, etc.

The specification of an air pollution control implementation strategy can be viewed usefully in three sequential steps:

- The identification of the range of variables defining the regulatory and advisory responsibilities of EPA in implementing air pollution control,

- The grouping of the above variables into a few key concepts that define major dimensions of implementation strategies, and

- The design of a number of implementation strategies by assigning values to these dimensions in terms of interest to EPA staff and specifiable with the data available.

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*The legislative and administrative context of these responsibilities are derived from the Clean Air Amendments of 1970 and EPA, "Requirements for Preparation, Adoption, and Submittals of Implementation Plans," Federal Register, August 14, 1971.

The chapter opens with an identification of the range of strategic variables that define the responsibilities of EPA air pollution control. It proceeds to a recognition of the key dimensions of implementation strategies that encompass the strategic variables. Next, each of these dimensions is explored in some depth. Finally, it presents a set of implementation strategies designed in the light of the previous discussion and data available for specifying strategies.

## A. Legislative-Administrative Context of Air Pollution Control

The legislative and administrative context of air pollution control is largely dictated by the Clean Air Amendments of 1970. They require the Administrator to adopt a strategy which provides for:

- adoption and implementation of national primary ambient air quality standards,
- adoption and implementation of secondary ambient air quality standards,
- adoption and implementation of performance standards for new sources,
- adoption and implementation of emission standards for hazardous pollutants,
- standards for vehicular emissions,
- adoption and implementation of standards for aircraft emissions,

- regulation of motor fuels and additives,
- support and conduct research and development activities,
- regulations for certification of eligibility for rapid write-off under Tax Reform Law of 1969,
- grants to state and local governments, and
- regulation of fuels.

In addition to these generic strategic variables for which EPA is directly responsible, EPA retains an important advisory capacity in many other matters:

- advising Treasury, Commerce, CEA, and CEQ on matters pertaining to the economics of the environment,
- advising FPC on natural gas and electric power policy,
- advising AEC on nuclear power policy,
- advising Interior on coal and oil policy, and
- advising Corps of Engineers on effects of permits to dump under the Refuse Act of 1899.

In particular, the National Ambient Air Quality Standards were established within one month of enactment of the Clean Air Amendments of 1970 for pollutants for which criteria had previously been issued and are to be established simultaneously with issuance of criteria documents in the future. Under this proviso, standards have already been established for sulfur oxides, particulates, carbon monoxides, hydrocarbons, and photochemical oxidants. For each pollutant for which standards are established, there will be a primary ambient air quality standard, set at a level of air quality adequate to protect public health, and a secondary ambient air quality standard to eliminate adverse effects on welfare.

Each state must submit to EPA for approval an implementation plan which provides for attainment of primary standards within three years of the data of approval of the plan. Plans must also provide for attaining the generally more restrictive secondary standards within a reasonable time period. State plans must provide for emissions limitations on all sources together with timetables for compliance, and provision for continuing monitoring and enforcement.

If at the time of plan approval, it is deemed impossible to bring specific sources into compliance within three years, the Governors of affected states may request an extension of the deadline of up to two years. If the Administrator is satisfied that the request is warranted and that all available interim measures will be taken, such requests may be granted. Governors may also request deadline extensions if, as the deadline approaches, it is impossible for plan requirements to be implemented and continued non-compliance is deemed to be in the higher national security or public health and welfare interest.*

* Clean Air Amendment of 1970, Sec. 109, Sec 112.

Timing specified by law for standards promulgation and implementation planning specifies that final standards shall be designated 90 days after proposal, that states shall have nine months for implementation planning from the data of such final adoption, and that EPA shall have four months from date of receipt to pass on a state's plan.

Given the complexity and the variety of strategic variables, it is clear that the key concepts to group these variables are required before implementation strategies can be developed. The development of four such organizing concepts or dimensions of implementation strategies is the theme of the next section.

B. Dimensions of an Implementation Strategy

Four dimensions are recognized here as key to specification of a strategy for simulation through the OAP Regional Economic Model. They are:

- Time scheme of implementation
- Cost -- air quality standard relations
- Abatement incentive schemes
- Treatment of benefits

1. Time Scheme of Implementation

It is clear that the three simulation runs in the Development and Demonstration Phase* provided valuable insight into the spatial aspects

* CONSAD Research Corporation, op. cit., Volume I, May 15, 1971.

of economic impacts of air pollution control strategies. For example, under Strategy I ("Industry Pays"), while the unemployment increase aggregated over 91 AQCRs was 0.43, seven AQCRs exhibited more than two percent increase and one as high as eight percent.

However, these strategies provided no clue to over-time implementation impacts of these strategies. The Clean Air Amendments of 1970 provide for a flexibility in the implementation of the national ambient air quality standards. Specifically, a two-year extension the deadline can be approved by the EPA upon application by a governor.

EPA can either adapt a "straight implementation" strategy which requires all AQCRs to meet the standards by 1975, or an "extended implementation" strategy which gives a two-year extension.

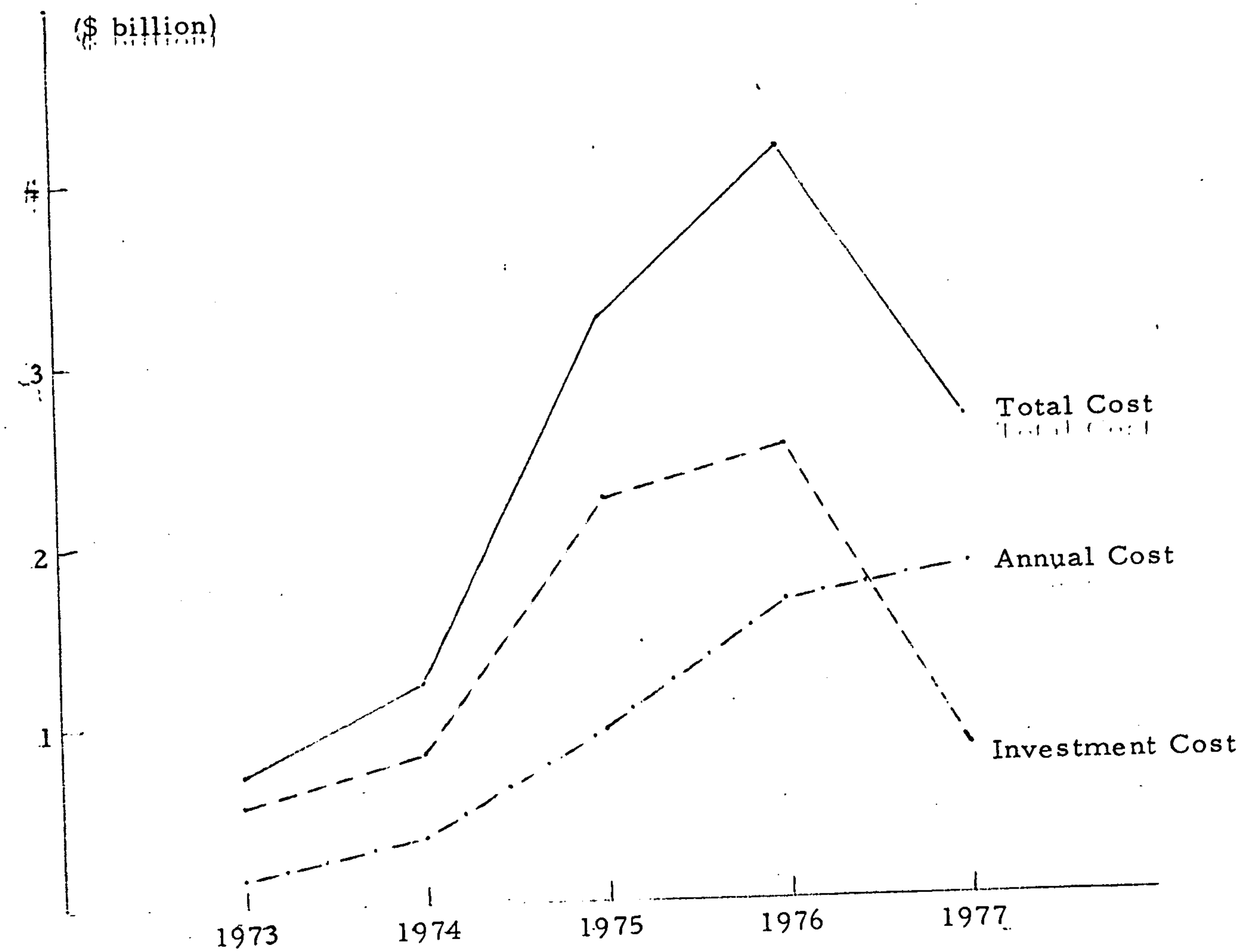
Thus, in assessing implementation strategies, over time impacts are of as much interest as geographic impacts. One criterion that may be used to grant extension of two years may be the degree of economic adversity likely to result from implementation. To facilitate the assessment of such cases, it may be useful to consider a set of "mixed implementation" strategies. Such strategies would give the AQCRs that were seriously adversely affected extended implementation and other AQCRs straight or modified implementation time schemes.

## 2. Cost-Standards Relations

One of the basic problems in specification of strategies is the lack of information on the technical relations between standards and corresponding estimates of costs to attain these standards. A survey of available cost data shows that there are two major sources of control cost estimates: one is the 1970 305(a) Report which gives control costs by AQCR by year from 1971 to 1975. This would permit a year-by-year simulation based on the standards and cost estimates provided in that report (a five-year average cost was used in the three trial simulations reported in the May 15, 1971, report). The second source will be the preliminary control cost estimates provided by EPA. The cost estimates reported in this document reflect the standards implied by the Clean Air Amendments of 1970 by major high emission industries at the national level.

Those total control costs consist of (1) investment cost, and (2) annual cost. The former includes upgrading existing facilities and installation of equipment for new sources, while the latter is the sum of operating and maintenance costs, interest expenditures and depreciation. For example, the over-time expenditure for the manufacturing industry is given in Figure 2.1. In general, there will be considerable investment expenditures in the second and third year of implementation

Figure 2.1
Control Costs for the Manufacturing Industry



given a three-year implementation period (1973-1975). Thus, if the "extended implementation" strategy were to be considered (1973-1977), the expenditures in the second and third year may be "stretched" for selected industries for those AQCRs which show the most serious negative effects of implementation.

3. Abatement Incentive Schemes

After the specification of cost-standard relations, and the time scheme of implementation, a major domain of strategy definition is the scheme of incentives to encourage abatement activities. The incentives fall under two broad categories:

- Cost sharing incentives, and
- Economic or profit motive incentives.*

Cost sharing incentives are provisions at the Federal, state, and local level that subsidize industry's cost of controlling pollution.

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*These incentives have been explored at length in a number of articles, books, and reports. Some useful recent work is the following: (a) Gerhardt, Paul H., "Incentives to Air Pollution Control," Law and Contemporary Problems, Vol. 33, No. 2, 1968; (b) Wilson, Richard D., and Minnotte, David W., "Government Industry Cost Sharing for Air Pollution Control," Journal of Air Pollution Control Association, Vol. 19, October, 1969; (c) Institute of Public Administration, Government Approaches to Air Pollution Control, prepared for OAP, EPA, July 15, 1971; and (d) ABT Associates, "Incentives to Industry for Water Pollution Control," A report to FWPCA, Washington, D.C., 1967.

Economic incentives are financial measures that provide decisive inducements for at least some firms to apply techniques for the control of air pollution. For these firms, pollution control should be at least as profitable as other possible investments. Both types of incentives can be and often are used in conjunction.

a. Cost-Sharing Incentives

The defining characteristic of cost-sharing schemes is that high emission industries share the cost of pollution control partly with other sectors. Examples are:

- Rapid write-offs
- Investment tax credits
- Tax exemptions
- Loans and loan guarantees
- Grants

Rapid write-offs, also known as accelerated depreciation, are permitted by the Internal Revenue to recover the cost of capital. When firms use accelerated rather than straightline depreciation for tax purposes, the difference in tax liability acts as an interest-free loan to the firm installing control equipment. Rapid write-offs are available at the Federal and state level. In general, this scheme favors larger and more profitable firms, though the associated paper and administrative work is quite considerable.

Investment tax credits are offered to offset the expenditures on control equipment. These can be subtracted from either taxes or gross revenues. Tax credit laws have been changed more frequently than depreciation (e.g., 7 percent tax credit for investment available up to October, 1966, repealed, reinstated in 1967 and repealed again in 1969 and being reinstated in 1971). Tax credits, consequently, typically provide only temporary incentives to the extent that repeal of tax credits is foreseen. They act as an incentive to make expenditures earlier than would otherwise be the case.

Exemptions are available for equipment from personal income taxes, property taxes, sales and excise taxes, or some combination therefore are available for pollution control equipment. However, the extent to which the overall effect of these provisions would reduce the cost of pollution equipment appears to be quite limited.*

Government loans and loan guarantees make funds available at subsidized interest rates and borrowing easier by providing funds to firms that do not have any easy access to commercial lending sources. This will appeal more to the marginal firm than to a firm with a good financial situation. To the government, costs are largely administrative and risk insurance.

Grants are available for planning and demonstration purposes to localities and governments.

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* See Institute of Public Adminstration, op. cit.

All of the above cost sharing methods tend to have the following faults and advantages in common. The major emphasis is on capital expansion for pollution abatement, when, in many cases, changes in operations or basic production processes would greatly decrease the quantity of emissions and therefore costs incurred by the firms. In essence, without carefully controlled research, these types of incentives would jeopardize an efficient allocation of control resources. Also, these incentives do not encourage cooperation among various firms in the same air shed area, which could lead to economies of scale in certain control areas and an increase in knowledge about control techniques. Lastly, all of these policies have hidden government revenue losses. Since most control equipment will not bring about future income for the firms, the government will not be able to recuperate losses by taxing the revenues from the investments. However, the government will be able to tax the profits of the Air Pollution Control Equipment Industry.

There are, however, two major advantages of cost sharing incentives. First, the administration of all the policies can be handled through existing structures, thereby greatly decreasing administrative costs and allowing more of the funds to filter down to the firms. Secondly, this method allows for differential levels of incentives for different firms and/or incentives. Cost sharing incentives could be used to encourage spreading the costs of control over broader time periods by encouraging control in one industry or area at a time. For instance, heavy polluters might be encouraged very rapidly to invest in control methods while lighter polluters would not be encouraged until closer to the deadline in 1977. Hopefully, this would keep prices of control inputs down by allowing resources to be channeled to the development of specific types of control technology.

b. Economic or Profit Motive Incentives

Economic incentives provide the necessary profit motive in influencing the actions of industry. Unlike cost sharing schemes, there is no need for supplemental inducements.

Economic incentives can be classified into two broad categories:*

- Those based on surrogates for pollution, e.g., a tax on sulfur content of power plant fuels serving as a substitute for a tax on pollution itself. Other examples: subsidies, tax on lead, tax on electricity, etc.

- Those based on emissions per se, e.g., a system of emission charges.

Emission reduction subsidies are an example of surrogate type and are payments made to polluters who have decreased the amount of

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* See IPA, op. cit., p. 7-4.

emissions from their firms, according to the actual amount of the decrease. Such a policy is expensive and allows the total cost of cleaning the air to fall on the public.

Taxes on sulfur content of power plant fuels are considered to be relatively easier to administer than charges based on emissions. Such taxes require taxes to be based on inputs whose sulfur content levels are easier to measure than emission level measurement required in the previous case. *

An excellent example of the emission category of incentives is the emission charges or the pollution tax. The process involves a firm being fined or taxed on the amount of pollutant it emits. In theory, the firm will reduce pollution to the point where marginal abatement costs are equal to or less than the marginal emission tax rate.

The emissions charge consists of ascertaining the pollution potential for a firm (maximum), and then, by determining the actual levels of emissions from the operations of the firm, and calculating actual emissions based on the level of operations of the firm. Once this is accomplished, a charge can be levied against the firm. To clarify this idea, suppose there exists a tax on sulfur emissions. Studies could ascertain the amount of potential sulfur emissions from

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* For a detailed discussion of these points, see, Robert M. Solow, "The Economist's Approach to Pollution and Its Control," Science, Volume 173, August 6, 1971.

a fuel used in the production process. At the end of a stated period of time, the amount of fuel consumed could be recorded and the amount of sulfur emissions by the firm determined, and the appropriate fine carried out. If, however, there exists some form of pollution control, the efficiency of the device could be measured and, again, based on this and the amount of fuel used, the quantity of sulfur emitted could be estimated.

A specific incentive strategy may include some combination of emission charges, tax credit or rapid write-offs for control devices. Each such combination will suggest a particular cost sharing scheme or distribution of incidence among consumers, producers and the public sector. Any given cost sharing scheme will greatly affect the pattern of economic impacts among different AQCRs.

Whatever cannot be passed on must be shared between those industries and government. It has been estimated that the government assistance to the industries through accelerated depreciation investment, tax credits, government loans, direct and in the form of grants and technical assistance, etc., amounts to as much as 59 percent of the cost of air pollution. *

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* Wilson, Richard D., and David W. Minnotte, op. cit., reported that 59 percent percent of the control cost was shared by different levels of the government.

Wilson and Minnotte indicate that existing federal and state provisions act to share the cost of air pollution control to industry. These include federal corporate income tax, depreciation allowances, investment credits, Small Business Administration loans, Economic Development Administration, and state tax laws. Maximally, these provisions share as much as 59 percent of the cost. These estimates include 53.6 percent as a result of reduced tax liabilities associated with cash expenses, depreciation allowances, and investment credits, five percent of state income taxes and exemptions. The 59 percent sharing of pollution costs with government is available to profitable firms, while marginal firms do not enjoy the benefit. Further, the cost sharing is available only to firms that control pollution.

The OAP regional model was estimated using 1967 data. The model parameters would reflect this level of cost sharing provided the firms in all industries actively instituted control at that time. Thus it is possible to state that when control is instituted (say under strategy 1 below) as much as 59 percent cost sharing is available to industries. However, in view of the caveats in the Wilson-Minnotte paper, this level may overstate the level of government assistance.

When a simulation strategy calls for government financial assistance, that would be viewed as additional cost sharing.

4. Treatment of Benefits

In any region, air pollution damages will be considerably reduced with a corresponding improvement of air quality. These "benefits" from air pollution control are somewhat harder to quantify, compared to the costs of control.

In general, the damages of air pollution are external to market transaction and, thus, have no "prices" that can be identified in the market system of a given economy. Therefore, most of the damage estimates must be based on some statistical relations between the level of pollution and changes in property values, health expenditures, and the like. Some types of benefits (such as the quality of life) are clearly beyond the scope of proper measurement at this time.

With such difficulties, some reliable estimates of benefits are very limited. In particular, the technical relations between the level of air quality, and the corresponding changes of damages are almost non-existent. This is an area crying out for further empirical studies. A long-term health cost study is currently underway on Community Health Environment Surveillance System (CHESS) which uses survey methods to relate socio-economic variables to the estimated health costs in selected communities over the nation.* In some limited AQCRs, changes

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* Estimating Health Costs Attributed to Air Pollution, Department of Health, Education and Welfare, Mimeo, 1971.

of property values related to air quality have been reported. However, such estimates are unavailable for most of the AQCRs. Besides health expenditures and property values, other types of damages, such as extra buildings and household maintenance costs, productivity losses, damages to plants and animals, inefficiency in the economy caused by delays, accidents, etc., need to be estimated.

A Status Report by Barrett and Waddell* covers the estimates of damages on health, material, vegetation, soil, animals, aesthetics, property values, etc. A total of $16.1 billion was reported for the United States by a survey of 36 studies related to the air pollution damages.

Two points need to be made about the Barrett-Waddell report. First, the relations between "standards" and "damages" estimated still remains unclear. These estimates by each AQCR are non-existent.

Second, it must be stressed that some types of expenditures carried out when air quality was lower will not take place after improvement in air quality. For example, reduced expenditures on laundry result in an effective increase in income to the consumer, but reduce income to the laundry industry. In order to model these phenomena detailed estimates of consumer behavior patterns would be required.

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* Barrett, Larry B., and Thomas E. Waddell, The Cost of Air Pollution Damages: A Status Report, Environmental Protection Agency, July, 1970.

At the present stage, it is possible to use only "net" benefits, which may be thought of as the increment in national final demand due to air pollution control. The different levels of "net" benefits assumed here are different levels of increment in national final demand.

C. The Alternative Strategies

Given the general discussion of the dimensions described for each specific strategy in the previous section, a list of alternative strategies can be designed as follows.

1. Straight Implementation 1973-75, Without Additional Government Financial Assistance

This strategy requires implementation of the standards specified by the Clean Air Amendments of 1970 by 1975. It is assumed that the actual period of implementation will be 1973-1975. This is because states are expected to get their implementation approval and regulation in force only by the end of fiscal year 1972. No additional governmental financial assistance than what is implicit in the existing tax structure is provided.

2. Extended Implementation 1973-1977,
Without Government Financial Assistance

This strategy is the same as strategy 1 except that it allows all AQCRs to extend the target year to 1977, as the maximum extension permitted by the law, without any financial assistance from the government.

3. Straight Implementation 1973-1975, With
59% of Government Financial Assistance

This strategy has a fixed target of 1975. However, 59 percent additional of control costs will be borne by the government.

4. Extended Implementation 1973-1977, with
59% of Government Financial Assistance

This is the same as strategy 2 except that the government will share an additional 59 percent part of the control costs.

In the above four alternative strategies, a $10 billion net benefit over the entire implementation period is assumed. In order to test a different level of benefits, two additional strategies were included with a $15 net billion benefit.

5. Straight Implementation 1973-1975,
Without Government Financial Assistance
and Benefit = $15 Billion

This strategy is equivalent to strategy 1, except that the level of net benefits has been changed from $10 billion to 15 billion.

6. Extended Implementation 1973-1977, With 59% of Additional Government Financial Assistance and Benefit = $15 billion

This strategy is equivalent to Strategy 4, except that the level of net benefits has been changed from $10 billion to 15 billion.

7. "Mixed" Implementation Strategy

For a selective number of AQCRs, a two-year extension will be permitted, although other AQCRs will be required to meet the standards by 1975, and this strategy can be specified with or without government financial assistance. This strategy will be specified* after analysis of the simulation results of previous strategies in order to identify a set of selected AQCRs with different implementation requirements.

The above listed strategies can be identified through the use of the following table.

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* See Chapter 4.

Table 2.

A Summary Table of Seven Alternative Strategies

| Alternative Strategies | Target Year | | Level of Benefits | | Level of Add. Govern. Financial Asst. (% of Control Cost) | | |
|---|---|---|---|---|---|---|---|
| | 1975 | 1977 | $10 billion | $15 billion | Without | 59% | 75% |
| Strategy 1 | x | | x | | x | | |
| Strategy 2 | | x | x | | x | | |
| Strategy 3 | x | | x | | | x | |
| Strategy 4 | | x | x | | | x | |
| Strategy 5 | x | | | x | x | | |
| Strategy 6 | | x | | x | | x | |
| Strategy 7* | (mixed) | | x | | (mixed) | | |

*As the result of simulation analysis, 58 AQCRs will be under Strategy 1. A total of 13 AQCRs will be permitted to have two-year extensions and, in addition, 14 AQCRs will receive 59 percent additional government financial assistance, 4 AQCRs will be permitted to have both two-year extensions and 59% of additional government financial assistance, and finally, 2 AQCRs will receive 75 percent of government cost sharing of the control costs (detailed in Chapter 4).

# CHAPTER 3: CONTROL COSTS AND ECONOMIC PROJECTIONS

This chapter is addressed to the assembly of data on control costs corresponding to the Clean Air Amendments of 1970 and regional economies in 91 AQCRs in a manner that would permit the simulation over time of the seven strategies specified in the last chapter.

## A. Control Cost Estimates

The preliminary cost estimates provided by EPA reflect that the national ambient air quality standards are equivalent to the emission reductions as shown in Table 3. 1. This table shows percentage reduction of emissions by major source categories, while Table 3. 2 gives emission reduction by major industries. Five major pollutants; particulates, oxides of sulfur, carbon monoxide, hydrocarbons, and oxides of nitrogen, are included

Control cost estimates, as shown in Table 3. 3, summarize costs of control for major sources. The total investment costs are the necessary investment requirement through the implementation years under the assumption that the standards established under the Clean Air Amendment of 1970 Act will be fully implemented. Annual costs are the sum

Table 3.1: National Emission Reductions by Major Source Categories which Reflect the National Ambient Air Quality Standards of Clean Air Amendments of 1970

| Pollutant | Source Category | Emission Decrease (%) |
|---|---|---|
| Particulates | solid waste<br>stationary combustion<br>industrial process | 97.6<br>94.6<br>91.1 |
| Sulfur oxides | stationary combustion<br>industrial process | 88.4<br>90.7 |
| Hydrocarbons | solid waste<br>industrial process | 90.7<br>97.4 |
| Carbon monoxide | solid waste<br>industrial process | 95.0<br>98.0 |
| Nitrogen oxides | industrial process | 89.1 |

Source: Estimates of control costs provided by EPA.

Table 3.2: National Percentage Reduction of Industrial Process Emission by Industry by Pollutant

| SIC | Industry | Part. | $SO_x$ | HC | CO | $NO_x$ |
|---|---|---|---|---|---|---|
| | Asphalt batching | 85.8 | | | | |
| | Cement | 92.8 | | | | |
| | Coal Cleaning | 97.3 | | | | |
| | Grain | 93.2 | | | | |
| | Handling | 93.1 | | | | |
| | Milling | 93.9 | | | | |
| | Gray Iron | 88.5 | | | 93.9 | |
| | Iron and Steel | 96.1 | | | | |
| | Kraft Pulp | 87.3 | | | | |
| | Lime | 94.7 | | | | |
| | Nitric Acid | | | | | 89.1 |
| | Petroleum | 74.2 | 96.5 | 97.4 | 99.5 | |
| | Products & Storage | | | 55.8 | | |
| | Refining | 74.2 | 96.5 | 97.5 | 99.5 | |
| | Phosphate | 53.7 | | | | |
| | Primary Copper | | 88.0 | | | |
| | Primary Lead | | 86.3 | | | |
| | Primary Zinc | 33.3 | 73.6 | | | |
| | Primary Aluminum | 81.4 | | | | |
| | Secondary Non-ferrous | 82.9 | | | | |
| | Sulfuric acid | 87.4 | 81.4 | | | |
| | All Industries | 91.1 | 90.7 | 97.4 | 98.0 | 89.1 |

Source: Estimates of control costs provided by EPA.

Table 3.3: Estimates of Control Costs Provided by EPA

| Source Categories<br>Industries: | SIC | Total Investment Requirement ($ mil.) | Annual Cost with 100% of capitalization ($ mil.) |
|---|---|---|---|
| Grain Milling and Handling | 2042 | 414 | 87 |
| Kraft Pulp | 2611 | 38.3 | 14.7 |
| Nitric Acid | | 50 | 11 |
| Sulfuric Acid | 2819 | 147 | 34.6 |
| Phosphate | 2871 | 31 | 15 |
| Petroleum Refining and Storage | 2911 | 478 | 44 |
| Asphalt Batching | 2951 | 154 | 33 |
| Portland Cement | 3241 | 89 | 24 |
| Lime | 3274 | 28.7 | 7.2 |
| Gray Iron Foundries | 3321 | 282 | 85 |
| Steel | 3323 | 829 | 353 |
| Primary Copper | 3331 | 266.4 | 77.4 |
| Primary Lead | 3332 | 65 | 15.6 |
| Primary Zinc | 3333 | 40.7 | 17.7 |
| Primary Aluminum | 3334 | 223.3 | 75.8 |
| Secondary Non-ferrous metals | 3341 | 31.6 | 9.3 |
| Stational combusion: | | | |
| Electric Power | | 3960 | 960 |
| Other | | 897 | 1145 |
| Solid Waste | | 309 | 196 |

of operating and maintenance costs, interest expenditures, and depreciation for the year, assuming 100% of capitalization of control equipment.

Given a specified time scheme of implementation, the total investment requirement is likely to be distributed over time. Given a three-year implementation from 1973-75, it is likely that annual investment expenditures on control equipment will be a "step-up" function. That is, to say, a greater proportion of the investment will take place in year 1975. For any given straight implementation strategy, it is assumed that time scheme of investments will be distributed as follows.

| | | | |
|---|---|---|---|
| Implementation Year | 1973 | 1974 | 1975 |
| % of Total Investment | 15 | 35 | 50 |

With installations of control facilities, the annual operational cost is assumed to be parallel to the accumulation of the investment. If for the target year, 1975, annual operational cost is 100, then the index of annual operating cost during the implementation period will be:

| | | | |
|---|---|---|---|
| Implementation Year | 1973 | 1974 | 1975 |
| Index of Annual Cost | 15 | 50 | 100 |

On the other hand, for the two-year extended implementation of five years from 1973 to 1977, it is assumed that the weight of investment will be shifted to the later years, as follows:

| | | | | | |
|---|---|---|---|---|---|
| Implementation Year | 1973 | 1974 | 1975 | 1976 | 1977 |
| % of Total Investment | 5 | 10 | 35 | 40 | 10 |

and the corresponding annual operating cost index can be given as:

| | | | | | |
|---|---|---|---|---|---|
| Implementation Year | 1973 | 1974 | 1975 | 1976 | 1977 |
| Index of Annual Cost | 5 | 15 | 50 | 90 | 100 |

Given the above time scheme of the control cost distribution, the year-by-year cost estimates for both straight implementation by 1975 and two-year extended implementation by 1977 were obtained.

Furthermore, control cost by AQCR by industry was obtained by a step-by-step estimation of production capacity of each industry in each AQCR, electricity used by industry and consumption by AQCR. *

Tables 3.4 and 3.5 show the estimated cost for straight implementation (1973-75) and extended implementation (1973-77) by major categories.

B. Benefit Estimates

As part of the strategy specification, benefits levels of $10 billion and $15 billion were used to measure overall damages recovered from a cleaner air after the implementation of a given strategy.

---

* Industry control costs by AQCR were estimated by use of 2 to 4 digit SIC categories. A detailed list of cost estimates are included in the Program RMS with users manual (See Volume II: Revised User's Manual).

Table 3.4: Control Cost Estimates of 91 AQCR's Under Straight Implementation by 1975 ($ millions)

| Year | Industry | | Annual Cost | Other Stationary Combustion | | Annual Cost |
|---|---|---|---|---|---|---|
| | Investment Cost | Annual Cost | Electric Power | Investment Cost | Annual Cost | Solid Waste |
| 1973 | 277.1 | 81.1 | 64.9 | 78.9 | 100.7 | 20.1 |
| 1974 | 646.5 | 270.3 | 212.1 | 184.0 | 335.5 | 66.9 |
| 1975 | 923.6 | 540.6 | 415.9 | 262.8 | 671.0 | 133.8 |

Table 3.5: Control Cost Estimates of 91 AQCR's Under Two-Year Extended Implementation by 1977 ($ millions)

| Year | Industry | | Annual Cost | Other Stationary Combustion | | Annual Cost |
|---|---|---|---|---|---|---|
| | Investment Cost | Annual Cost | Electric Power | Investment Cost | Annual Cost | Solid Waste |
| 1973 | 92.4 | 27.0 | 21.6 | 26.8 | 33.5 | 6.7 |
| 1974 | 184.7 | 81.1 | 63.6 | 52.6 | 100.6 | 20.1 |
| 1975 | 646.5 | 270.3 | 208.2 | 184.0 | 335.5 | 66.9 |
| 1976 | 738.9 | 486.5 | 366.5 | 210.3 | 603.9 | 120.4 |
| 1977 | 184.7 | 540.6 | 397.6 | 52.6 | 671.0 | 133.8 |

It is argued that time scheme of annual benefits is likely to be linked to the schedule of control implementation and some time lags do exist between the stage of control and receipt of benefit.

For the current simulation study, annual benefit has been introduced parallel to the accumulation of control facilities with one-year time lag as shown in Figure 3.1.

For straight implementation the following index was used to distribute total benefit during the implementation period.

| Implementation Year | 1973 | 1974 | 1975 |
|---|---|---|---|
| Index of annual benefits | 0 | 15 | 50 |

For two-year extended implementation the index is:

| Implementation Year | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|
| Index of annual benefits | 0 | 5 | 15 | 50 | 90 |

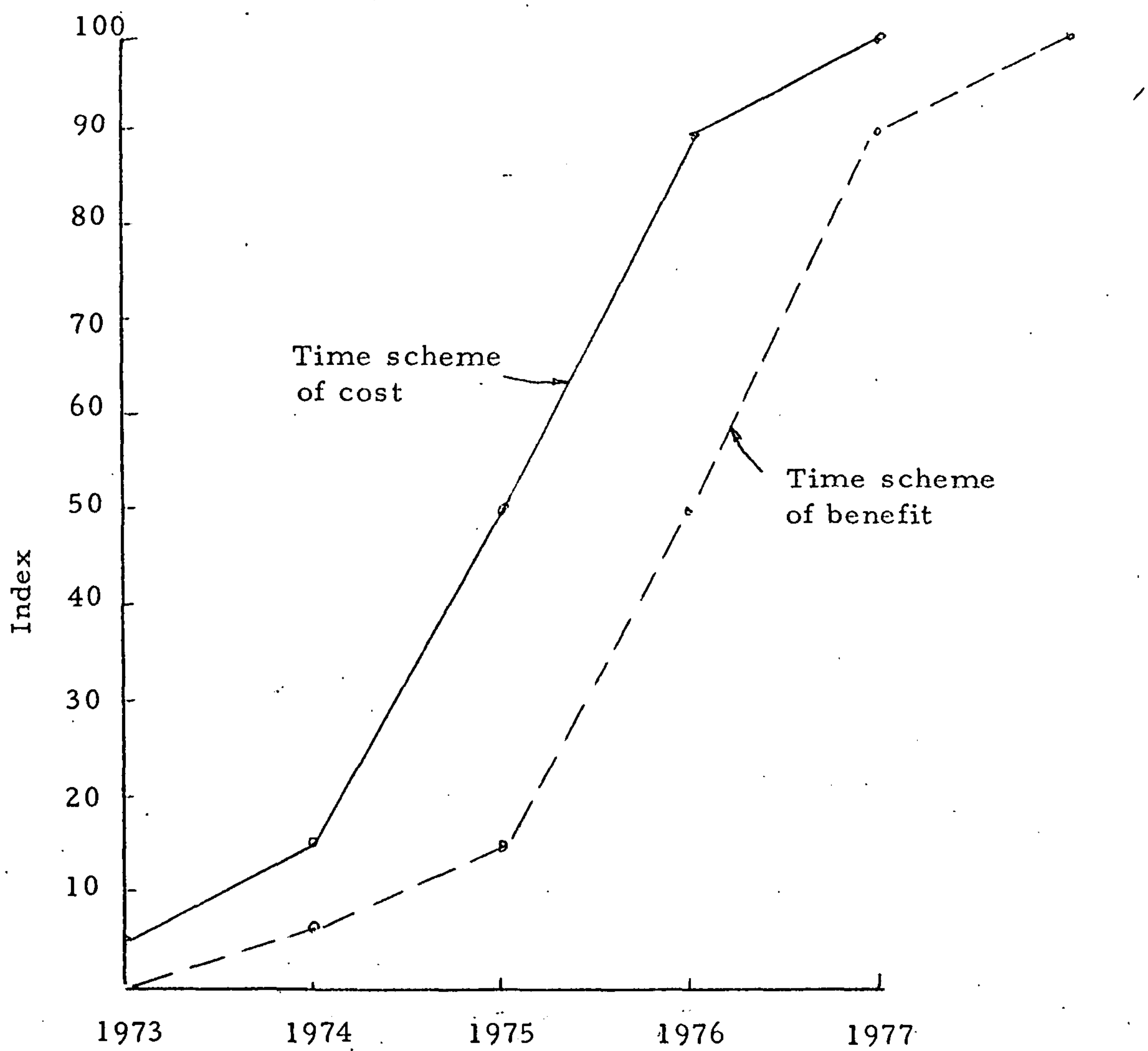
Both $10 billion and $15 billion of benefits were distributed using the above index for corresponding strategies.

C. Economic Projections

Given the nature of a cross-sectional estimation of the current model, projections of economic data in the future years are as important as control inputs preparation.

The OAP Regional Economic Model was estimated from 1967 economic data. For the present simulation study of the economic impact of alternative strategies for year 1973 through 1977, the Economic

Figure 3.1: Cost and Benefit Distribution Over Implementation Period 1973-1977



Projections for Air Quality Control Regions was used to provide the projection of economic data for each AQCR in the future years.*

This OBE projection was provided through the use of the trend projection similar to the Kuznets study.**

For each AQCR, 1967 data were used as base year data, which is consistent with data base of the OAP model. Then the growth rates by industry by AQCR were provided for years 1970, 1975 and 1980. Economic data between the above projection years were estimated with linear interpolation methods as shown in Figure 3.2.***

---

* U. S. Department of Commerce, Office of Business Economics, Regional Economics Division, Economic Projections for Air Quality Control Regions, a report to the National Air Pollution Administration, June, 1970.

** Simon Kuznets, "Concepts and Assumptions in Long-Term Projections of National Products," Studies in Income and Wealth, Volume 16, 1954.

*** Let:

$y_o$ = base year (1967) data
$y_t$ = economic projection of year t
$a_1$ = growth rate at year 1970
$a_2$ = growth rate at year 1975
$a_3$ = growth rate at year 1980
t = 1971, . . . , 1980

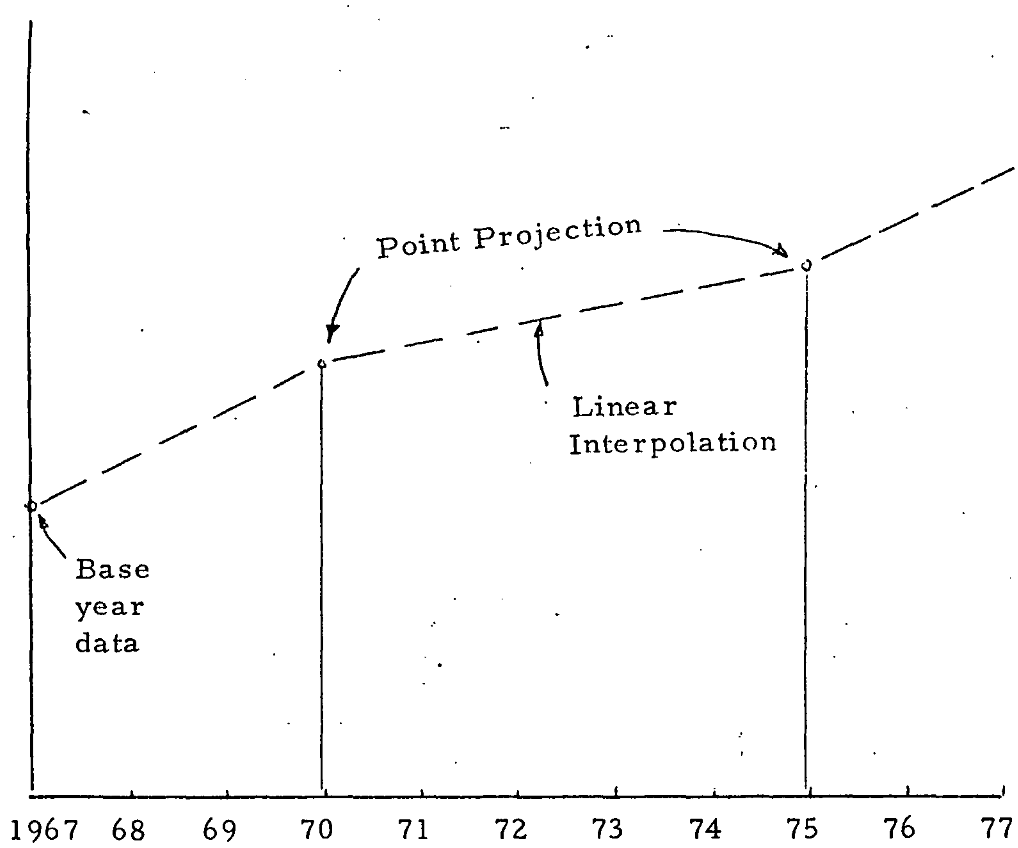
Then the economic projection for year 1971 to 1975 will be:

$$y_t = y_o (1 + a_1) \left[\frac{a_2 - a_1}{5} (t - 70)\right] \qquad t = 71, \ldots, 75$$

For year 1976 and 1977 will be,

$$y_t = y_o (1 + a_1) \left[\left(1 + (a_2 - a_1)\right)\left(1 + \frac{(a_3 - a_2)}{5} (t-75)\right)\right] \qquad t = 76, 77$$

Figure 3.2: Example of Economic Projection with OBE Estimates



However, the OBE economic projection only covered 53 AQCRs of the 91 AQCRs under study. Therefore, for the remaining 38 AQCRs, the United States growth rate by industry provided in the same OBE report were applied to the 1967 data.

## D. Note on Simulation of Strategies*

Every economic model represents a simplification of economic phenomena as dictated by the requirements of the users. When the model is later used for policy simulation, it is important to explore carefully the theoretical implications of a given policy to be simulated with this model. **

This section describes the manner of introduction of a control strategy into the model and the theoretical rationale for doing so.

### 1. Overall Impacts of Air Pollution Control

Essentially, implementation of air pollution control strategies will result in a resource allocations between different economic sectors and hence a geographic redistribution of the economic activities across the nation.

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* This section is an elaboration of the discussion provided by CONSAD's May 15, 1971, report.

** An example of policy simulation with large scale econometric model see Fromm, G. and P. Taubman, Policy Simulations with an Econometric Model, the Brookings Institute, 1968.

Part of labor and capital must be devoted to the improvement of air quality without any output to show for it. The additional expenditures for control equipment and corresponding increased operational costs to the high emission industries will, in general, result in increases in the prices of such products. In such cases, substitutional effects may result in reduced consumption of the products of high emission industries and increased consumption of products of low emission industries.

Meanwhile, the demand for control equipment will generate a series of new demands in the national economy. It may be also argued that there will be a significant shift of the health and service expenditures related to air pollution damages to other consumption sectors as suggested in many damage studies. *

This change in the demand for different goods and services will alter the national production of each industry. Since the geographic concentration of industries influences the distribution of cities and the industrial belt of the United States, structure changes of the national economy will, if large, have a profound effect on the regional economies across the nation. **

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* Barrett, Larry, B. and Thomas E. Waddell, op. cit.

** New York Times, December 14, 1971, page 35, "In Gary, Clean Air Means No Job," points out that Gary faces a 41% unemployment rate owing to the cutback of steel production.

2. Interregional Effects

The OAP Economic Model System consists of two major components, one with a national input-output model tied with a regional market share matrix, and one with a cross-sectional regional model of 91 AQCRs.

The link provided between the regional model and the national I-O model is best explained in the following manner: since the regional model is a cross-sectional model with manufacturing industries as export-oriented industries, demands for manufacturing products remains to be determined at the national markets. At this stage, in the absence of a time series national model with manufacturing industries specified in detail, the I-O model and the regional share matrix serve to link the regions with the nation.

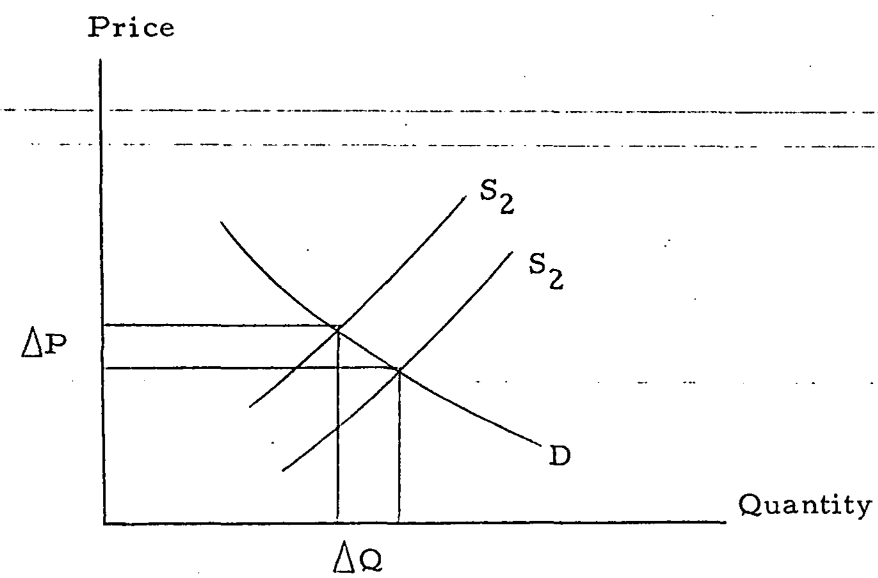
Some data on air pollution control impact are obtainable only at the national level. For example, rough estimates on "net" benefits accruable from air pollution control are available only at the national level. These estimates can be treated at the national level by the I-O model and distributed through the regional share matrix to the regions. Assuming an equilibrium economy, air pollution control costs will shift up supply curves of high emission industries (which are manufacturing industries) and cut down the production levels of such industries in each AQCR.* Since manufacturing industries are export-oriented, changes in regional manufacturing production will generate a sequence of interregional effects and feedbacks from other regions, including the 91 AQCRs under study and the rest of the United States. The use of national I-O model and regional market share matrix as proposed here provides a reasonable simulation of these interregional effects.**

---

* Price changes of high emission industries due to the increase in production costs due to air pollution control were provided exogenously. See Comprehensive Study of Specified Air Pollution Sources to Assess the Economic Effects of Air Quality Standards, Research Triangle Institute, December, 1970.

** Another way to estimate such effects will be an aggregation of changes in production by AQCRs as the estimates of changes in demand at national level and then feedback to each AQCR through I-O model and regional market share matrix. However, such an operation faced some difficulty as experienced in the simulation reported in May 15, 1971. First, aggregation of 91 AQCRs includes only 60 percent of national manufacturing products. Second, industrial data disclosure problems in a number of AQCRs will pose a problem to such aggregation.

Given exogeneous information of percentage price change due to the air pollution control, it is impossible to estimate how demand will respond to the price changes without a full disclosure of demand and supply relations at the national market, as shown in the following figure.




Let:

$$e = \frac{\Delta Q}{Q} / \frac{\Delta P}{P}$$

where:

e is price elasticity of demand

$\frac{\Delta P}{P}$ is percentage change of price

$\frac{\Delta Q}{Q}$ is percentage change of demand response to the price change

Since it is not possible to estimate a set of price elasticities on regional cross-sectional data, unit price elasticity was assumed for the simulation study. This is to say 1 percent of price change will result in 1 percent change of demand (an acceptable assumption for automobiles, but one that requires caution for other industries).

### 3. Control Costs and Manufacturing Sector in the Regional Model

Control costs, both investment expenditure on control equipment, and annual operational cost, are usually considered as non-productive expenditures in addition to conventional productive cost expenditures.

In general, "gross profit" is defined as the difference between total sales (which is value of shipments) minus cost of intermediate and raw materials and wage bill.

$$\Pi = X - \sum_i M_i - WB$$

where:

$\Pi$ is gross profit

X is total product (values of shipment)

$M_i$'s are raw materials and intermediate goods (Input)

WB is wage bill

Under air pollution control, additional operational costs to control air pollution on production process will result in a further reduction of the gross-profit.

$$\Pi^* = X - \sum_i M_i - WB - C_o$$
$$= \Pi - C_o$$

where:

$\Pi^*$ is gross profit with air pollution control*

$C_o$ is additional operational cost due to air pollution control

Co includes operational costs of control on industrial processes, operation costs of industrial stationary combustion, and price increases in the electricity due to a price increase in the electricity (under an assumption that power industry is a monopoly in the region). Other costs such as charges in industrial solid waste may also add to the cost increase in the production due to an air pollution control.

In addition to operational costs which contribute to the changes in the "flow" of gross profit, investment expenditures on air pollution control will alter the investment on the productive capital stock accordingly. Moreover, changes in the gross-profit due to the additional cost of production affects the investment behavior as well.

---

* All variables with an * in this section are estimates of endogenous variables after control.

$$I = f(\Pi)$$

$$I^* = f(\Pi^*) - C_I$$

where:

I is investment on the productive capital stock

I* is investment on the productive capital stock with air pollution control

$C_I$ is investment cost of air pollution control-equipment

Changes in the productive investment will lead to a change in productive capital stock.

$$K_t = K_{t-1} + I_t - dK_t$$

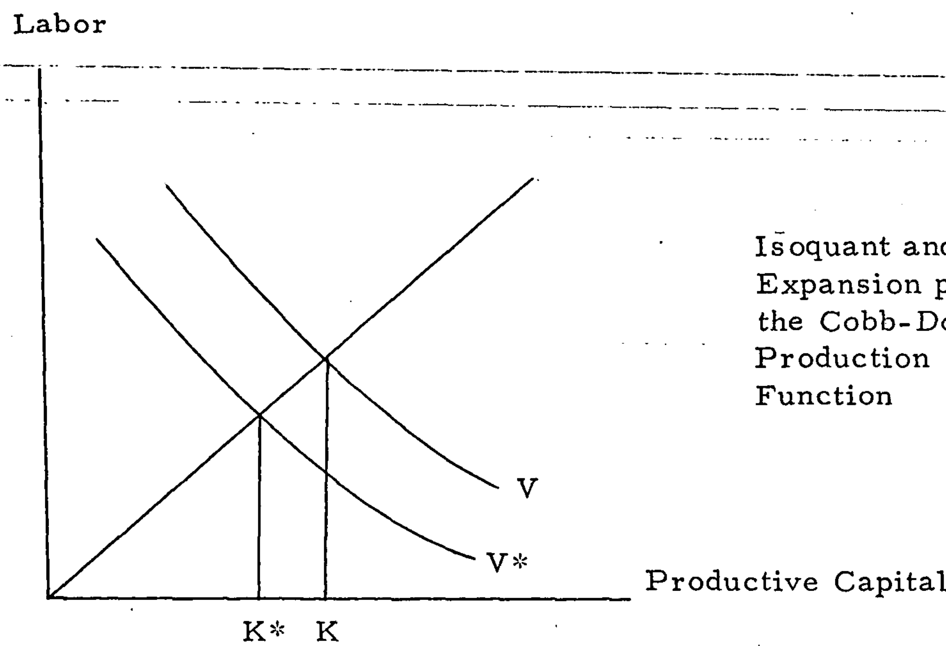
$$K_t^* = K_{t-1} + I_t^* - dK_t^*$$

where:

$K_t$ is total productive capital stock

$K_t^*$ is total productive capital stock after air pollution control

The Cobb-Douglas production function in the model assumes constant returns to scale.* Outputs will change proportionally to the production capital stock assuming that ratio between wage and price of capital to be constant.**




Isoquant and Expansion path of the Cobb-Douglas Production Function

* Mathematically it is homogeneous function of degree one; in other words, output will change proportionally to change in the inputs.

**It seems to be reasonable to assume that wage and price of capital are constants in a cross-sectional model (at a given time t).

$$V^* = V \cdot \left(\frac{K^*}{K}\right)$$

where:

V is the output measured by value added

$V^*$ is the output after air pollution control

Finally, changes in production level will lead to a change in employment. With a Cobb-Douglas production function, wage bill, by definition, is a fixed share of value added, then:

$$WB = \beta V$$

$$WB^* = \beta V^*$$

$$N^* = \frac{WB^*}{W}$$

where:

WB is wage bill of production worker

$\beta$ is a labor share coefficient from a Cobb-Douglas production function

N is number of production workers

W is wage rate

* implies the corresponding variables after air pollution control

Some overall assumptions need further remarks. The capital and labor inputs for air pollution control were separated from productive capacity in the model so that the estimated structure of production functions remained the same. Furthermore, increases in operational costs due to air pollution were not merely additional labor and capital but include additional cost increase from its purchase (for e.g., price increases in electricity and other fuels are typical components of control costs).

4. Regional Income Block

In the regional income determination block, a simple Keynesian model gives:

$$Y = f(V^*, C, G)$$

$$C = f(Y)$$

$$G = f(T)$$

where:

Y is regional personal income

V* is manufacturing production (value added) with air pollution control

C is regional consumption

G is regional government expenditure

T is regional government revenue

Besides, a decrease in manufacturing production of control costs will have an impact on regional personal income. A price increase in electricity due to pollution control will cause a reduction in real disposable income.

Suppose:

$$-\Delta y = \Delta q \, Q_c$$

where:

$\Delta q$ is price change in residential use of electricity due to air pollution control

$Q_c$ is total kilowatt-hours of residential use of electricity

$\Delta y$ is total reduction of real disposable income

This change in real income also affects other variables in the regional income determination. Further, it is plausible that changes in regional income may also affect regional government revenue, that:

$$T^* = f(Y^*)$$

At the current stage of model development, T is considered to be exogenous in the model. Therefore, changes of local government revenue (T*) due to changes in regional personal income (Y*) are merely a side calculation in the simulation study (when required as in Chapter 4). It is suggested in Chapter 6 that local government revenue should be endogenous.

5. Labor Market Block

Regional employment in the sector other than manufacturing industries ($\overline{N}$) is a simple function of difference between regional personal income and a value added of manufacturing industries.

$$\overline{N}^* = f(Y^* - \sum_i V^*)$$

And total regional employment is

$$N^* = \overline{N}^* + \sum_i N^*$$

In the original estimation of the model based on 1967 data labor force supply function and regional unemployment were given as:

$$L = f(N \quad U)$$

$$U = \frac{L-N}{L} \times 100$$

where L is regional labor force

U is regional unemployment rate

However, since OBE trend projections of regional economic data are used for future years 1973 through 1977. The OBE assumptions of 4% fixed regional unemployment rate are used for the future years. Thus:

$$\bar{U} = 4.00$$

$$L^* = f(N^*, \bar{U})$$

6. Electric Power Demand Block

In this simulation study it has been assumed that electric power industry is able to pass on the entire cost increase due to pollution control as price increase to the users.

In return, changes in production and consumption due to pollution control strategy in the region will alter the demand for the electricity.

$$Q_i^* = f(V_i^*)$$

$$Q_c^* = f(C^*)$$

$$\bar{Q}^* = f(Y^* - V^*)$$

$$Q^* = \sum_i Q_i^* + Q_c^* + \bar{Q}^*$$

where:

$Q_i^*$ is electricity demand of manufacturing industry, i with pollution control

$Q_c^*$ is residential demand of electricity with pollution control

$\bar{Q}^*$ is electricity demand of industries other than manufacturing industries with pollution control

$Q^*$ is total regional demand of electricity

# CHAPTER 4: ECONOMIC EFFECTS OF SELECTED STRATEGIES

As air pollution control requirements are instituted in the nation, the consequent effects are incident differentially in the various AQCRs. The primary purpose of regional economic modelling is to provide quantitative estimates of such differences among the AQCRs in any particular treatment (strategy) and among different treatments.

The second purpose of the model is to provide information on such differences among regions and among strategies that is useful to determine implementation strategies. For example, it is possible to argue that the "perfect" strategy is one in which each AQCR suffers the same degree of economic hardship. Exact measurement of such a condition is impossible, since there is no single measure of economic hardship. However, the use of this regional model permits useful estimation of the degree of differences in the treatment of AQCRs necessary to achieve some degree of uniformity in the effects of implementation of pollution control requirements. Even, if spatial equity were not pursued as a major goal the EPA administrator has the option of extending implementation period by two years under certain circumstances. Other forms of targeted assistance (differential cost sharing, etc.) are also possible. Consequently, the regional model can be used to design and assess such "mixed" implementation strategies (in which different AQCRs are treated differently) by trial and error, so that some guidance may be available to EPA officials to achieve some degree of equity among AQCRs in control implementation.

This chapter is addressed to a description of the effort directed to both of the above purposes of the OAP Regional Economic Model. First it opens with a brief description of the framework of analyses of economic impacts and the rationale for the measures of impact of control used in this chapter. It proceeds to a comparative description of the economic effects over time aggregated over 91 AQCRs under the alternative strategies. Next it provides a comparison of strategies in terms of the geographic pattern of incidence of economic effects, specifically, the geographic distribution of economic hardships. Next, it relates the geographic patterns of economic effects to the scale and industrial composition, the locational factors and the economic history of the regions. Finally, in the light of these analyses, mixed strategies of implementation that provide some equity among regions in terms of economic hardship are designed and assessed.

## A. Measures of Economic Effects of Implementation Strategies

All the strategies simulated assume the preliminary EPA estimates and have, therefore, the same aggregate costs for 91 AQCRs over the implementation periods. However, they differ from one another in the length of the implementation period, level of government cost sharing with industry, and the level of benefits. Thus, the geographic and time incidence of control costs vary among AQCRs (apart from their differences in terms of industrial composition). These varying levels of control costs lead, in turn, through the operation of the complex interrelationships of regional economies (as captured by the OAP model) to a range of effects on high emission industries, consumers, employment, tax payers, local government, and regional growth.

The simulation of the strategies through the OAP model provides a large number of measures of these economic effects (Figure 4.1). Figure 4.1 gives a sample output for Pittsburgh AQCR in the year 1975 under strategy 1. There is a list of variables and four columns of outputs. The first column--"without control"--shows OBE economic projections without any air pollution control. The second column--"with (T-1)" --provides the projection of the variable in column 1 with air pollution control to year T-1 (which is 1974) but before control is applied in 1975.

Figure 4.1

THREE YEAR STRAIGHT IMPLEMENTATION 1973 - 1975
WITHOUT GOVERNMENT FINANCIAL ASSISTANCE
BENEFIT = $10.0 BILLION

TOTAL NET EFFECT OF ALL CONTROL STRATEGIES PURSUED IN THIS RUN

AQCR 8 PITTSBURGH, PA.

| | FOR 1975 | | | |
|---|---|---|---|---|
| | WITHOUT CONTROL | WITH (T-1) | NET CHANGE | PERCENT CHANGE |
| MANUFACTURING INDUSTRIES | | | | |
| VALUE ADDED (MILLIONS) | 4676.738 | 4560.667 | -149.256 | -3.2583 |
| PROFIT (MILLIONS) | 1782.225 | 1713.343 | -117.058 | -6.8322 |
| INVESTMENT (MILLIONS) | 438.380 | 349.670 | -98.295 | -28.1108 |
| CAPITAL STOCK (MILLIONS) | 3679.000 | 3595.172 | -92.899 | -2.5840 |
| EMPLOYMENT (1000 S) | 309.880 | 303.187 | -10.355 | -3.4153 |
| OTHER INDUSTRIES | | | | |
| EMPLOYMENT (1000 S) | 749.84 | 748.23 | -1.523 | -0.2035 |
| TOTAL PERSONAL INCOME FOR THE REGION (MILLIONS) | 10604.867 | 10492.488 | -164.031 | -1.5633 |
| REGIONAL CONSUMPTION (MILLIONS) | 6323.473 | 6246.145 | -108.663 | -1.7429 |
| TOTAL REGIONAL EMPLOYMENT (1000 S) | 1059.724 | 1051.412 | -11.959 | -1.1374 |
| REGIONAL UNEMPLOYMENT (PERCENT) | 4.000 | 4.616 | 1.0885 | 23.5790 |
| TOTAL LABOR FORCE (1000 S) | 1103.879 | 1102.298 | -12.429 | -1.1275 |
| GOVERNMENT REVENUE FROM THE REGION (MILLIONS) | 733.778 | 722.488 | -16.480 | -2.2809 |
| ELECTRIC POWER DEMAND | | | | |
| TOTAL ELECTRIC CONSUMPTION FOR THE REGION (10 M KWS) | 1476.773 | 1452.784 | -36.035 | -2.4804 |
| ELECTRICITY USED BY MANUFACTURING INDUSTRIES (10 M KWH) | 710.333 | 691.240 | -29.724 | -4.3002 |
| ELECTRICITY USED BY OTHER INDUSTRIES (10 M KWH) | 360.964 | 359.717 | -1.174 | -0.3264 |
| RESIDENTIAL CONSUMPTION IN THE REGION (10 M KWH) | 405.476 | 401.628 | -5.136 | -1.2782 |

It shows the cumulative effects of control through 1974 before control of 1975. The third column shows "net change" of control in year 1975 and the last column shows percentage change of control in year 1975. An assessment of these effects is best organized by identifying from among this long list a few indicators of strategic importance to the purpose at hand. The purpose at hand is:

- To compare alternative strategies in terms of effects aggregated over 91 AQCRs,
- To compare the alternative strategies in terms of the degree of adverse effects in different AQCRs,
- To explore the geographic patterns of impacts in terms of industries, regions, government and communities, and
- To describe the geographic patterns of these effects in terms of the locational factors, industrial structure and economic histories of these AQCRs. The objective of this speculation is to identify to some degree the transitional adjustment problems in severely affected AQCRs.
- To design and assess mixed strategies that provide some degree of equity among regions.

The measures that appear to be relevant from these criteria for each of the three major sectors in the regional economy are shown on the following page.

| Sector | Measure |
|---|---|
| Manufacturing industries | 1. Manufacturing production (Value-added) |
| | 2. Manufacturing investments (for production) |
| Regional economy | 3. Regional personal income |
| | 4. Unemployment rate |
| Government | 5. Government revenue |

The rest of this chapter interprets the results of the simulation of the various strategies in terms of these five measures.

B. Total Net Effects of Alternative Strategies

The 91 AQCRs included in the current study are the major metropolitan areas of the United States. They account for 64 percent of the regional personal income, 56 percent of total labor force, and 60 percent of the total manufacturing industries in the United States.* In general, these AQCRs have a lower than national average of agriculture and mining production but a higher than average of manufacturing, transportation, wholesale-retail trade, finance and service sectors.

This section presents the effects of the four major strategies aggregated over all these 91 AQCRs. A caveat is in order before these

* Personal income projections of the United States and regional aggregation for the year 1967 and manufacturing production percentages in 91 AQCRs is estimated from Census of Manufactures, 1967.

effects are described and interpreted. The OAP model is a cross-sectional regional model; its strength lies in description of geographical patterns; however, aggregate changes are less reliable.

Tables 4.1 to 4.6 provide the economic effects aggregated over 91 AQCRs under six strategies described in Chapter 2.

Several points are fairly evident when these tables are examined.

- The economic effects under the different strategies are sufficiently different to suggest that the regional economies are sensitive to the differences in the strategies. The different economic indicators move in the same consistent direction among the strategies.

- Expectedly, the economic indicators of manufacturing sector (high emission) show the greatest range of difference on a percentage scale among the strategies. The regional economy and government indicators show a narrower range of variations.

- Extension of the implementation period from three to five years in each case reduces the aggregate adverse economic effects. This is to be expected in view of the spread of control costs over a longer period. Further, the regional economies of 1977 are larger than those of 1975 and the control costs form a smaller percentage of the aggregate regional economies.

- Strategies involving levels of cost sharing with high emission industry that are higher than available under existing legislation (i.e., over 59%) provide additional relief.

- Economic adversity as measured by unemployment rates is lessened in strategies assuming higher levels of benefit.

Table 4.[illegible]

Aggregate Economic Effects on 91 AQCR's Measured by Five Key Variables Under Strategy 1

Three-Year Straight Implementation, 1973-75, Without Government Financial Assistance, Benefit = $15.0 Billion

| | | 1973 | 1974 | 1975 |
|---|---|---|---|---|
| Manufacturing Production (value added, in $ million) | Without control | 189257.8 | 196005.0 | 202753.9 |
| | With control | 188863.8 | 194607.5 | 199730.1 |
| | Percentage change* | -0.21 | -0.51 | -0.78 |
| Manufacturing Investment (in $ million) | Without control | 14031.2 | 14535.6 | 15041.4 |
| | With control | 13637.2 | 13150.0 | 12099.4 |
| | Percentage change | -2.81 | -6.92 | -11.08 |
| Regional Personal Income (in $ millions) | Without control | 564383.5 | 591054.6 | 618190.5 |
| | With control | 563891.9 | 589317.8 | 614413.1 |
| | Percentage change | -0.09 | -0.21 | -0.32 |
| Unemployment Rate | Without control | 4.0 | 4.0 | 4.0 |
| | With control | 4.084 | 4.281 | 4.509 |
| | Net change | +0.08 | +0.28 | +0.51 |
| Government Revenue (in $ millions) | Without control | 80273.6 | 50718.9 | 53038.7 |
| | With control | 48389.0 | 50544.5 | 52659.3 |
| | Percentage change | -0.10 | -0.24 | -0.37 |

* In Tables 4.1 to 4.6, this entry is the annual percent change. The cumulative percent change for a year can be obtained by adding the given figures up to that year. For example, the cumulative change in manufacturing production for 1975 is (0.21 + 0.51 + 0.78) = -1.50.

Table 4.2
Aggregate Economic Effects on 9 AQCR's Measured by Five Key Variables Under Strategy 2

Five-Year Extended Implementation Without Government Assistance
1973-1977, Benefit = $10.0 Billion

| | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|
| Manufacturing Production (value added in $ millions) | | | | | |
| Without control | 189257.8 | 196004.8 | 202751.8 | 211124.1 | 219497.5 |
| With control | 189128.8 | 195584.6 | 201332.6 | 208372.4 | 215948.3 |
| Percentage change | 0.07 | 0.15 | 0.49 | 0.61 | 0.32 |
| Manufacturing Investment (in $ millions) | | | | | |
| Without control | 14031.2 | 14535.3 | 15039.6 | 15667.4 | 16296.5 |
| With control | 13900.0 | 14119.3 | 13638.4 | 12985.6 | 12934.1 |
| Percentage change | 0.94 | 1.94 | 6.65 | 8.60 | 4.24 |
| Regional Personal Income (in $ millions) | | | | | |
| Without control | 564383.5 | 591054.6 | 618187.2 | 650558.6 | 683462.2 |
| With control | 564218.1 | 590524.0 | 616409.8 | 647101.6 | 678854.0 |
| Percentage change | 0.03 | 0.06 | 0.20 | 0.24 | 0.14 |
| Unemployment Rate | | | | | |
| Without control | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| With control | 4.027 | 4.088 | 4.250 | 4.427 | 4.395 |
| Net change | 0.027 | 0.088 | 0.250 | 0.427 | 0.395 |
| Government Revenue (in $ millions) | | | | | |
| Without control | 48438.4 | 50718.9 | 53038.4 | 55804.3 | 58615.1 |
| With control | 48421.8 | 50665.6 | 52859.9 | 55457.1 | 58152.3 |
| Percentage change | 0.03 | 0.07 | 0.23 | 0.29 | 0.17 |

Table 4.3
Aggregate Economic Effects on 9 AQCR's Measured by Five Key Variables Under Strategy 3

Three-Year Straight Implementation, 1973-75, With Government Financial Assistance, Benefit = $10.0 Billion

| | | 1973 | 1974 | 1975 |
|---|---|---|---|---|
| Manufacturing Production (value added, in $ million) | Without control | 189257.8 | 196005.3 | 202752.4 |
| | With control | 189099.3 | 195434.1 | 201505.6 |
| | Percentage change | -0.084 | -0.208 | -0.325 |
| Manufacturing Investment (in $ million) | Without control | 14031.2 | 14535.3 | 15040.0 |
| | With control | 13869.9 | 13966.5 | 13829.4 |
| | Percentage change | -1.151 | -2.796 | -4.304 |
| Regional Personal Income (in $ millions) | Without control | 564383.5 | 591054.6 | 618188.6 |
| | With control | 564184.8 | 590334.6 | 616622.9 |
| | Percentage change | -0.035 | -0.089 | -0.132 |
| Unemployment Rate | Without control | 4.000 | 4.000 | 4.000 |
| | With control | 4.032 | 4.114 | 4.215 |
| | Net change | +0.032 | +0.114 | +0.215 |
| Government Revenue (in $ millions) | Without control | 48438.4 | 50718.9 | 53038.5 |
| | With control | 48418.5 | 50646.6 | 52881.3 |
| | Percentage change | -0.041 | -0.101 | -0.154 |

Table 4.4

Aggregate Economic Effects on 91 AQCR's Measured by Five Key Variables Under Strategy 4

Five-Year Extended Implementation With Government Assistance
1973-1977, Benefit = $10.0 Billion

| | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|
| Manufacturing Production (value added in $ millions) | | | | | |
| Without control | 189257.8 | 196004.6 | 202751.6 | 211123.3 | 219495.2 |
| With control | 189206.5 | 195833.4 | 202169.9 | 209984.9 | 218024.1 |
| Percentage change | -0.027 | -0.060 | -0.200 | -0.253 | -0.132 |
| Manufacturing Investment (in $ millions) | | | | | |
| Without control | 14031.2 | 14535.2 | 15039.3 | 15666.3 | 16293.8 |
| With control | 13977.6 | 14364.5 | 14464.1 | 14563.5 | 14908.2 |
| Percentage change | -0.383 | -0.795 | -2.682 | -3.343 | -1.576 |
| Regional Personal Income (in $ millions) | | | | | |
| Without control | 564383.5 | 591054.0 | 618187.2 | 650557.1 | 683456.4 |
| With control | 564374.3 | 590819.6 | 617435.5 | 649122.4 | 681517.7 |
| Percentage change | -0.011 | -0.028 | -0.082 | -0.099 | -0.055 |
| Unemployment Rate | | | | | |
| Without control | 4.000 | 4.000 | 4.000 | 4.000 | 4.000 |
| With control | 4.009 | 4.037 | 4.107 | 4.179 | 4.163 |
| Net change | +0.009 | +0.037 | +0.107 | +0.179 | +0.163 |
| Government Revenue (in $ millions) | | | | | |
| Without control | 48438.4 | 50718.9 | 53038.4 | 55804.2 | 58614.6 |
| With control | 48432.0 | 50695.3 | 52963.0 | 55660.1 | 58425.3 |
| Percentage change | -0.013 | -0.033 | -0.096 | -0.116 | -0.065 |

Table 4.5

Aggregate Economic Effects on 91 AQCR's Measured by Five Key Variables Under Strategy 5

Three-Year Straight Implementation, 1973-75, Without Government Financial Assistance, Benefit = $15.0 Billion

| | | 1973 | 1974 | 1975 |
|---|---|---|---|---|
| Manufacturing Production (value added, in $ million) | Without control | 189257.8 | 196005.0 | 202753.8 |
| | With control | 188863.8 | 194751.5 | 200360.9 |
| | Percentage change | -.21 | -.43 | -.54 |
| Manufacturing Investment (in $ million) | Without control | 14031.2 | 14535.6 | 15041.4 |
| | With control | 13637.2 | 13159.8 | 12142.4 |
| | Percentage change | -2.81 | -6.85 | -10.83 |
| Regional Personal Income (in $ millions) | Without control | 564383.5 | 591054.6 | 618190.3 |
| | With control | 563892.0 | 589471.7 | 615048.5 |
| | Percentage change | -.09 | -.18 | -.24 |
| Unemployment Rate | Without control | 4.00 | 4.00 | 4.00 |
| | With control | 4.08 | 4.18 | 4.28 |
| | Net change | .08 | .18 | .28 |
| Government Revenue (in $ millions) | Without control | 48438.4 | 50718.9 | 53038.7 |
| | With control | 48389.0 | 50559.9 | 52723.1 |
| | Percentage change | -.10 | -.21 | -.28 |

Table 4.6
Aggregate Economic Effects on 91 AQCR's Measured by Five Key Variables Under Strategy 6

Five-Year Extended Implementation With Government Assistance
1973-1977, Benefit = $15.0 Billion

| | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|
| Manufacturing Production (value added in $ millions) | | | | | |
| Without control | 189257.8 | 196004.6 | 202751.9 | 211123.2 | 219495.4 |
| With control | 189206.5 | 195844.7 | 202211.2 | 210148.2 | 218399.2 |
| Percentage change | -0.27 | -0.05 | -0.19 | -0.20 | -0.04 |
| Manufacturing Investment (in $ millions) | | | | | |
| Without control | 14031.2 | 14535.2 | 15039.3 | 15666.3 | 16293.9 |
| With control | 13977.6 | 14365.2 | 14466.6 | 14573.7 | 14931.7 |
| Percentage change | -0.38 | -0.79 | -2.67 | -3.29 | -1.49 |
| Regional Personal Income (in $ millions) | | | | | |
| Without control | 564383.5 | 591054.0 | 618187.3 | 650556.7 | 683455.8 |
| With control | 564319.3 | 590836.0 | 617492.7 | 649299.3 | 681943.8 |
| Percentage change | -0.01 | -0.03 | -0.08 | -0.08 | -0.03 |
| Unemployment Rate | | | | | |
| Without control | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| With control | 4.01 | 4.03 | 4.08 | 4.09 | 4.05 |
| Net change | .01 | .03 | .08 | .09 | .05 |
| Government Revenue (in $ millions) | | | | | |
| Without control | 48438.4 | 50718.9 | 53038.4 | 55804.1 | 58614.6 |
| With control | 48432.0 | 50697.0 | 52968.6 | 55677.9 | 58462.7 |
| Percentage change | -0.01 | -0.03 | -0.09 | -0.09 | -0.03 |

More specifically, Table 4.1 shows that with straight implementation by 1975 and without government financial assistance under strategy 1, manufacturing production (measured by value-added) in these AQCRs will decrease 1.50 percent by 1975. Further, investment in manufacturing industries (for production capacity) will drop from $15 billion to 12.1 billion which is about a 21 percent drop. Personal income and local government revenues are expected to decrease 0.6 percent and 0.7 percent, respectively, while unemployment rate will increase by 0.9 percent. This indicates that the manufacturing sector, bearing the brunt of the control costs will be more sensitive to the air pollution control compared with regional income, unemployment rate, and local government revenue.

The effects of a strategy (Strategy 2) that has a two-year extension to the year 1977 without government financial assistance are displayed in Table 4.2. This adverse economic effect for the year 1975 will be quite similar to that for the year 1975 in Table 4.3 where government financial assistance is given instead of extension of time. However, a more appropriate year for comparison in Table 4.2 is the year 1976 when the incidence of control costs in Strategy 2 is closer than that of 1975 in Strategy 1, and the regional economy is more comparable in size. Consequently, when comparing the 1973-1975 strategies with 1973-1977 strategies, it will be instructive to compare four economic indicators for the year 1975 in the former group with those of the year 1976 in the latter group. From such a comparison of strategies 1 and 2, it is clear that extension of the time of implementation is likely to help.

Table 4.3 shows that at a level of 59 percent of government cost-sharing with the industries, at the end of year 1975, manufacturing production will drop only 0.62 percent, which is about $1.5 billion of production measured by value-added. At the same time, investment expenditures for manufacturing production capacity decreased by 8.3 percent compared with 21 percent without financial assistance. All the other three variables show a consistent pattern of diminution of the adverse impacts.

Table 4.4 showing the effects of an extended time period 59 percent cost-sharing and a benefit level of $10 billion indicates very modest drops in economic activity.

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* See Federal Register, August 14, 1971, and Wilson and Minnotte, op. cit.

The pattern of over-time distribution of both costs and benefits in the strategies by itself may lead to differences in the economic impacts from year to year. As indicated in the previous section, without a two-year extension, 50 percent of the investment costs and 100 percent of the operational cost will be incurred in the year 1975; therefore, the impact will be much heavier in the year 1975. For example, in Table 4.1, manufacturing production will drop only 0.21 percent in 1973, 0.51 percent in 1974 and finally decrease by 0.78 percent in 1975. The same pattern is true of the variables in Table 4.2. In strategies 3 and 4 shown in Tables 4.2 and 4.4, the year 1976 incurs 40 percent of investment costs and 90 percent of operational costs of a given control strategy. For example, year by year changes of manufacturing investment as shown in Table 4.4 are 0.38 percent in 1973, 0.80 percent in 1974, 2.68 percent in 1975, 3.34 percent in 1976 and 1.58 percent in 1977.

Tables 4.5 and 4.6 display the aggregate effects associated with the two simulations assuming a $15 billion level of benefits. Unemployment rates in strategy 5 are lower than in strategy 1 which assumes a $10 billion level of benefits. The same observation is valid in comparing strategies 4 and 6 which differ in the level of benefits. Unemployment rates are lower in strategy 6 which uses a higher level of benefit.

## C. Comparative Analysis of the Alternative Strategies

The previous section dealt with only the over-time aggregate effects of 91 AQCRs during the implementation periods of each given strategy. However, behind these aggregate patterns lie a wide variation in economic effects among the different AQCRs. Within any one control strategy there is a considerable regional difference of economic impact. For example, under Strategy 1 (three-year straight implementation from 1973-1975 without government financial assistance), the annual level of manufacturing production (value-added) in 1975 will drop 1.78 percent. However, as shown in Table 4.7 for the same strategy in 1975, there will be 29 out of 91 AQCRs which have 0.50 percent or more reduction in the manufacturing production. More precisely, 25 AQCRs will be in the range of 0.5 to 1.0 percent and four AQCRs will be in the category of 1 to 1.5 percent.

Table 4.7 presents the frequency distribution of the five economic indicators for the AQCRs under strategies 1 through 4. For each economic variable, a number of classes as recognized and the number of AQCRs in each class in each strategy identified.

Table 4.7
Frequency Distribution of Major Variables for AQCRs (Strategies through 4)

| | Strategy 1 Three Year Straight Without Assistance | | | Strategy 2 Extended Without Assistance | | | | | Strategy 3 Three Year Straight With Assistance | | | Strategy 4 Extended With Assistance | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1973 | 1974 | 1975 | 1973 | 1974 | 1975 | 1976 | 1977 | 1973 | 1974 | 1975 | 1973 | 1974 | 1975 | 1976 | 1977 |
| A. Unemployment Rate | | | | | | | | | | | | | | | | |
| Annual Change | | | | | | | | | | | | | | | | |
| Decr. (better off) | | 2 | 3 | 7 | 4 | 4 | 4 | 5 | 2 | 2 | 5 | 13 | 9 | 4 | 5 | 10 |
| .01% to .49% | 87 | 75 | 56 | 84 | 87 | 78 | 67 | 79 | 88 | 88 | 80 | 77 | 82 | 86 | 84 | 80 |
| .50% to .99% | 4 | 11 | 25 | | | 6 | 16 | 6 | 1 | 0 | 6 | 1 | | 1 | 2 | 1 |
| 1.00% to 1.49% | | 3 | 4 | | | 3 | 3 | 1 | | 0 | | | | | | |
| 1.50% and over | | | 3 | | | | 1 | | | 1 | | | | | | |
| Total | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |
| B. Manufacturing Production (value added) | | | | | | | | | | | | | | | | |
| Annual change of Manufacturing Production | | | | | | | | | | | | | | | | |
| Increase | | | 1 | | | | | 9 | | | 2 | 1 | 2 | | 2 | 9 |
| -.01% to -.99% | 87 | 76 | 52 | 90 | 88 | 73 | 64 | 73 | 91 | 86 | 82 | 90 | 89 | 88 | 84 | 78 |
| -1.00% to -1.99% | 4 | 10 | 27 | 1 | 3 | 14 | 21 | 5 | | 3 | 4 | | | 2 | 3 | 2 |
| -2.00% to -2.99% | | 2 | 5 | | | 1 | 3 | 1 | | 2 | 1 | | | 1 | 2 | 2 |
| -3.00% to -3.99% | | 1 | 2 | | | 1 | 0 | 1 | | | 2 | | | | | |
| -4.00% and over | | 2 | 4 | | | 2 | 3 | 2 | | | | | | | | |
| Total | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |

| | Strategy 1 Three Year Straight Without Assistance | | | Strategy 2 Extended Without Assistance | | | | | Strategy 3 Three Year Straight With Assistance | | | Strategy 4 Extended With Assistance | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1973 | 1974 | 1975 | 1973 | 1974 | 1975 | 1976 | 1977 | 1973 | 1974 | 1975 | 1973 | 1974 | 1975 | 1976 | 1977 |
| C. Manufacturing Investment (for production) Annual Percent Change | | | | | | | | | | | | | | | | |
| -4.9% or less | 79 | 37 | 17 | 88 | 84 | 33 | 23 | 50 | 90 | 78 | 58 | 91 | 90 | 74 | 64 | 83 |
| -5.0% to -9.9% | 9 | 32 | 31 | 3 | 6 | 30 | 30 | 25 | 1 | 10 | 24 | | 1 | 14 | 21 | 6 |
| -10.0% to -14.9% | 2 | 13 | 15 | | 1 | 19 | 16 | 8 | | 2 | 6 | | | 2 | 3 | 1 |
| -15.0% to -19.9% | 1 | 5 | 13 | | | 4 | 9 | 3 | | 1 | 1 | | | 1 | 2 | 1 |
| -20.0% and over | | 4 | 15 | | | 5 | 13 | 5 | | | 2 | | | | 1 | |
| Total | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |
| D. Regional Personal Income Annual Percent Change | | | | | | | | | | | | | | | | |
| Increase | 3 | 1 | 3 | 1 | | | 2 | 7 | 1 | 2 | 3 | 10 | 9 | 1 | 5 | 11 |
| 0 to -0.49% | 86 | 73 | 57 | 90 | 89 | 78 | 68 | 76 | 87 | 86 | 81 | 80 | 82 | 87 | 83 | 78 |
| -.50% to 0.99% | 0 | 13 | 23 | | 1 | 10 | 15 | 4 | 3 | 1 | 5 | 1 | | 1 | 2 | 1 |
| -1.00% to -1.49% | 1 | 1 | 3 | | 1 | 1 | 5 | 2 | | 1 | 0 | | | 2 | 0 | 0 |
| -1.50% to -1.99% | 1 | 0 | 2 | | | | | 1 | | 1 | 1 | | | | 0 | 1 |
| -2.00% and over | 0 | 3 | 3 | | | 2 | 1 | 1 | | | 1 | | | | 1 | |
| Total | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |

| | Strategy 1 Three Year Straight Without Assistance | | | Strategy 2 Extended Without Assistance | | | | | Strategy 3 Three Year Straight With Assistance | | | Strategy 4 Extended With Assistance | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1973 | 1974 | 1975 | 1973 | 1974 | 1975 | 1976 | 1977 | 1973 | 1974 | 1975 | 1973 | 1974 | 1975 | 1976 | 1977 |
| E. Government Revenue Annual Change | | | | | | | | | | | | | | | | |
| Increase | 3 | 1 | 2 | 1 | | | 2 | 7 | 1 | 2 | 3 | 10 | 9 | 1 | 5 | 11 |
| 0 to -0.49% | 84 | 67 | 51 | 89 | 89 | 68 | 59 | 70 | 87 | 83 | 74 | 80 | 82 | 85 | 78 | 76 |
| -0.50% to -0.99% | 2 | 15 | 24 | 1 | 2 | 16 | 19 | 7 | 2 | 3 | 5 | | | 3 | 7 | 3 |
| -1.00% to -1.49% | 2 | 5 | 6 | | | 4 | 4 | 3 | 1 | 3 | 2 | 1 | | 2 | | |
| -1.50% to -1.99% | | 1 | 2 | | | 1 | 5 | 3 | | | 1 | | | | 1 | 1 |
| -2.00% and over | 1 | 2 | 6 | | | 2 | 2 | 1 | | | 1 | | | | | |
| Total | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |

An inspection of tables 4.7 and 4.8 shows a consistent pattern of over-time impacts as described in the previous section. For example, under strategy 1 (3 years, no additional cost sharing), changes in regional unemployment rates indicated in Table 4.7 in the year 1973 show only four AQCRs having a 0.5 percent or more increase in unemployment rate. In 1974, 14 AQCRs will experience more than 0.5 percent increase in the regional unemployment rate. In 1975, the number of AQCR's in the same category (over one percent) jumps to 29 AQCRs.

Under strategy 2, which differs from strategy 1, in having a two year longer period of implementation, the number of AQCRs having 0.5 percent or more unemployment rate are 9, 20 and 7, for 1975, 1976 and 1977, respectively. This suggests that a two year extension reduces the number of AQCRs adversely affected (with more than 0.5 percent unemployment rate change). The simulation of strategy 3 which implies a 59 percent cost sharing additional to that implied in strategy 1 indicates that the number of AQCRs in the 0.5% unemployment rate increase group is 1, 1, and 6, for 1973, 1974 and 1975, respectively. Thus, the additional cost sharing in strategy 3 removes most of the AQCRs from the group of moderately adversely affected group. Strategy 4, which extends the time period to five years from the three years used is strategy 3, is the most propitious strategy.

Table 4.8
Frequency Distribution of Major Variables for AQCRS
(Strategies 5 and 6)

| | Strategy 5 Three Year Straight Without Assistance | | | Strategy 6 Extended With Assistance | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1973 | 1974 | 1975 | 1973 | 1974 | 1975 | 1976 | 1977 |
| **A. Annual Change of Unemployment Rate (%) in AQCRs** | | | | | | | | |
| Decr. (better off) | | 10 | 4 | 13 | 12 | 5 | 7 | 17 |
| .01% to .49% | 87 | 74 | 55 | 77 | 79 | 86 | 81 | 73 |
| .50% to .99% | 4 | 10 | 25 | 1 | | | 3 | 1 |
| 1.00% to 1.49% | 0 | 3 | 4 | | | | | |
| 1.50% and over | 0 | | 3 | | | | | |
| Total | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |
| **B. Annual percent change of Manufacturing Production in AQCRs** | | | | | | | | |
| Increase | | 2 | 15 | 1 | 4 | 1 | 6 | 38 |
| -.01% to -.99% | 87 | 75 | 48 | 90 | 87 | 87 | 80 | 50 |
| -1.00% to -1.99% | 4 | 9 | 19 | | | 2 | 3 | 2 |
| -2.00% to -2.99% | | 3 | 3 | | | 1 | 2 | 1 |
| -3.00% to -3.99% | | 0 | 2 | | | | 0 | |
| -4.00% and over | | 2 | 4 | | | | | |
| Total | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |
| **C. Annual Percent change of Manufacturing Investments in AQCRs** | | | | | | | | |
| -4.9% or less | 79 | 37 | 19 | 91 | 90 | 74 | 64 | 84 |
| -5.0% to -9.9% | 9 | 32 | 30 | | 1 | 14 | 21 | 5 |
| -10.0% to -14.9% | 2 | 13 | 15 | | | 2 | 3 | 1 |
| -15.0% to -19.9% | | 6 | 12 | | | 1 | 2 | 1 |
| -20.0% and over | | 3 | 15 | | | | 1 | |
| Total | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |
| **D. Annual Percent Change of Personal Income** | | | | | | | | |
| Increase | 3 | 4 | 10 | 10 | 10 | 2 | 7 | 35 |
| 0 to -0.49% | 86 | 75 | 55 | 80 | 81 | 87 | 81 | 54 |
| -.50% to 0.99% | 0 | 9 | 18 | 1 | | 0 | 2 | 1 |
| -1.00% to 1.49% | 1 | 1 | 4 | | | 2 | 0 | 0 |
| -1.50% to 1.99% | 1 | 0 | 2 | | | | 0 | 1 |
| -2.00% and over | 0 | 2 | 2 | | | | 1 | 0 |
| Total | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |

| | Strategy 5 Three Year Straight Without Assistance | | | Strategy 6 Extended With Assistance | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1973 | 1974 | 1975 | 1973 | 1974 | 1975 | 1976 | 1977 |
| E. Annual Change in Government Revenue | | | | | | | | |
| Increase | 3 | 4 | 10 | 10 | 10 | 2 | 7 | 35 |
| 0 to -0.49% | 85 | 66 | 44 | 80 | 81 | 86 | 77 | 52 |
| -0.50% to -0.99% | 1 | 13 | 26 | | | 1 | 6 | 3 |
| -1.00% to -1.49% | 2 | 5 | 4 | 1 | | 2 | | 0 |
| -1.50% to -1.99% | | 1 | 1 | | | | | 1 |
| -2.00% and over | | 2 | 6 | | | | | |
| Total | 91 | 91 | 91 | 91 | 91 | 91 | 91 | 91 |

The other four economic indicators evidence the same pattern.

Figures 4.1, 4.2 and 4.3 compare strategies 1, 2, 3, and 4 in terms of changes in unemployment rate. Since the only difference between strategies 1 and 3 is the time of implementation, the two-year extension in strategy 3 improves a number of AQCRs. Attention, however, must be drawn to the fact that Figures 4.1 and 4.3 refer to 1975 while Figures 4.2 and 4.4 pertains to 1976. 1976 is used for strategies 2 and 4 because the time pattern of cost incidence is such that investment and operational costs peak in 1976 and the 1976 economy is closer in size to 1975 economy for comparison purposes.

It should be noted that the moderately and seriously affected AQCRs in strategies 1 and 2 are found in the Manufactures Belt described in the next sector.

D. Geographical Patterns of Economic Effects

Appendix B provides the five economic indicators for the four strategies for all the 91 AQCRs.--An examination of these tables suggests the following observations (some of which have been made):

- The individual AQCRs have the same pattern of differences among the strategies that were observed while analyzing aggregate effects in 91 AQCRs (see Section B).

Figure 4.1
Geographic Distribution of Economic Effects in 1975 Measured by Change of Unemployment Rate: Strategy 1. Three-Year <u>Straight</u> Implementation 1973-1975 <u>Without</u> Government Financial Assistance
Benefit = $10.0 Billion

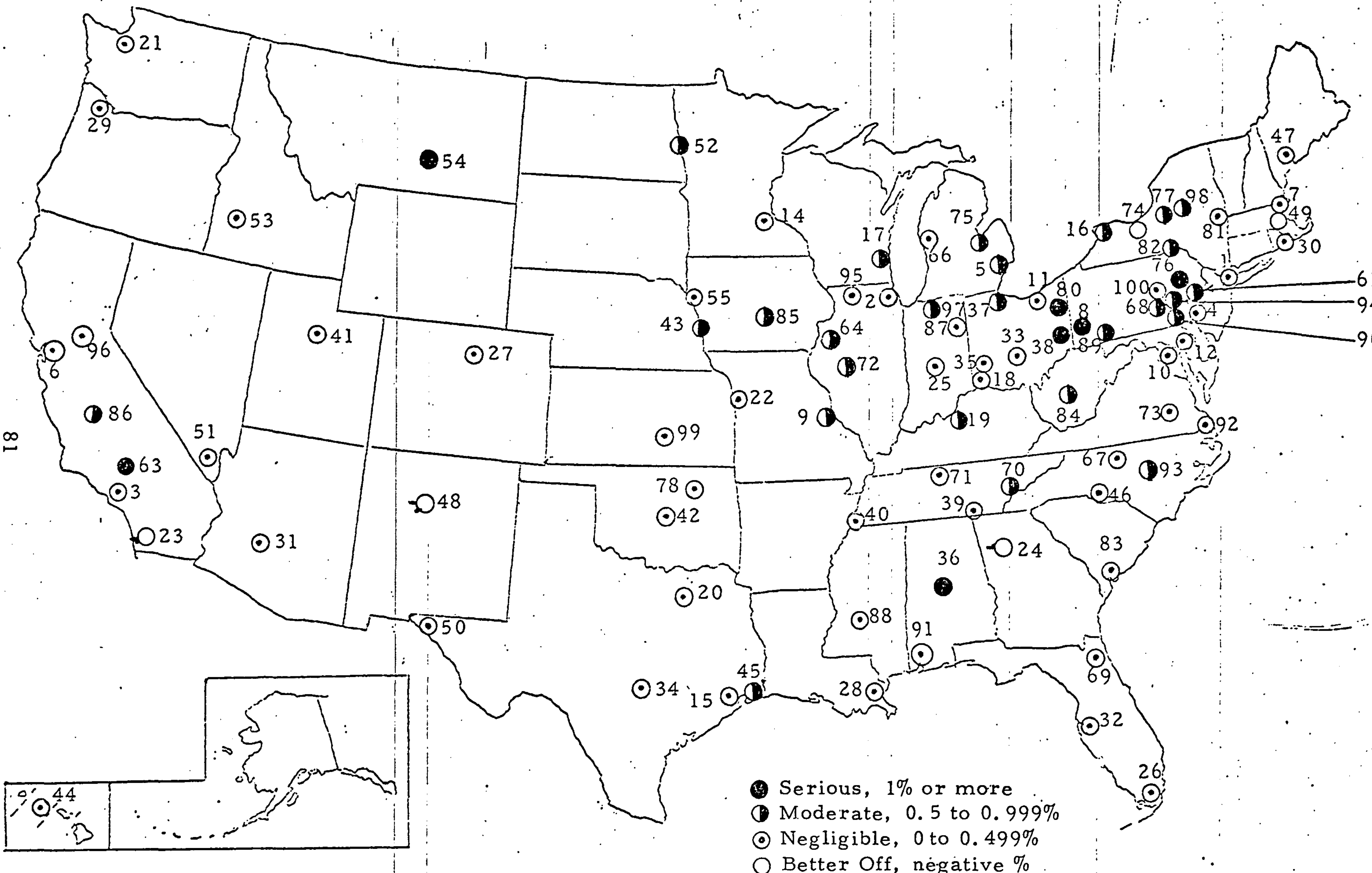


Figure 4.2
Geographic Distribution of Economic Effects in 1976 Measured by Change of Unemployment Rate:
Strategy 2: Five Year Extended Implementation 1973-77 Without Government Financial Assistance
Benefit = $10 Billion

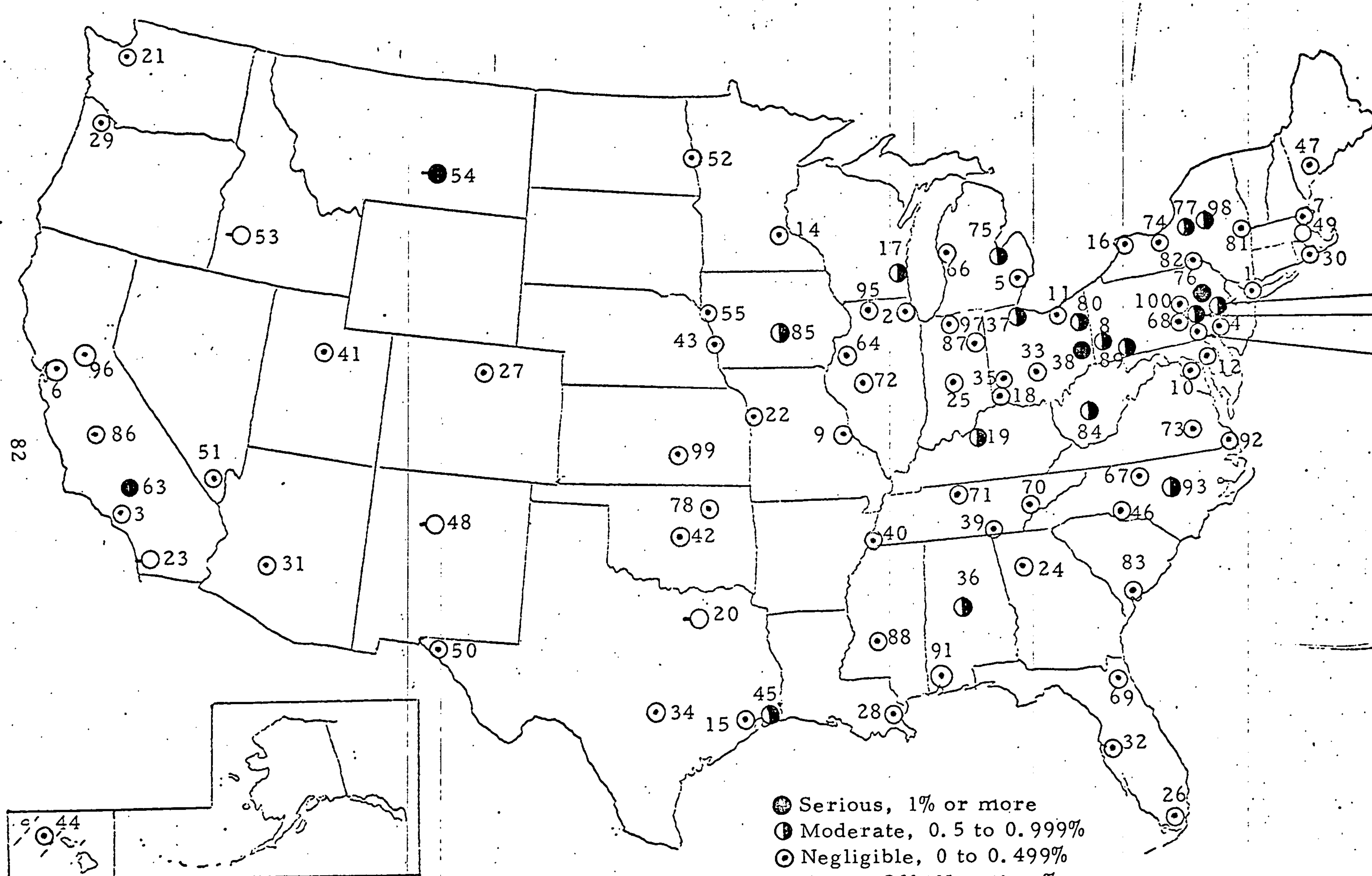


Figure 4.3
Geographic Distribution of Economic Effects in 1975 Measured by Change of Unemployment Rate:
Strategy 3: Three Year <u>Straight</u> Implementation 1973-1975 <u>with</u> Government Financial Assistance
Benefit = $10.0 Billion

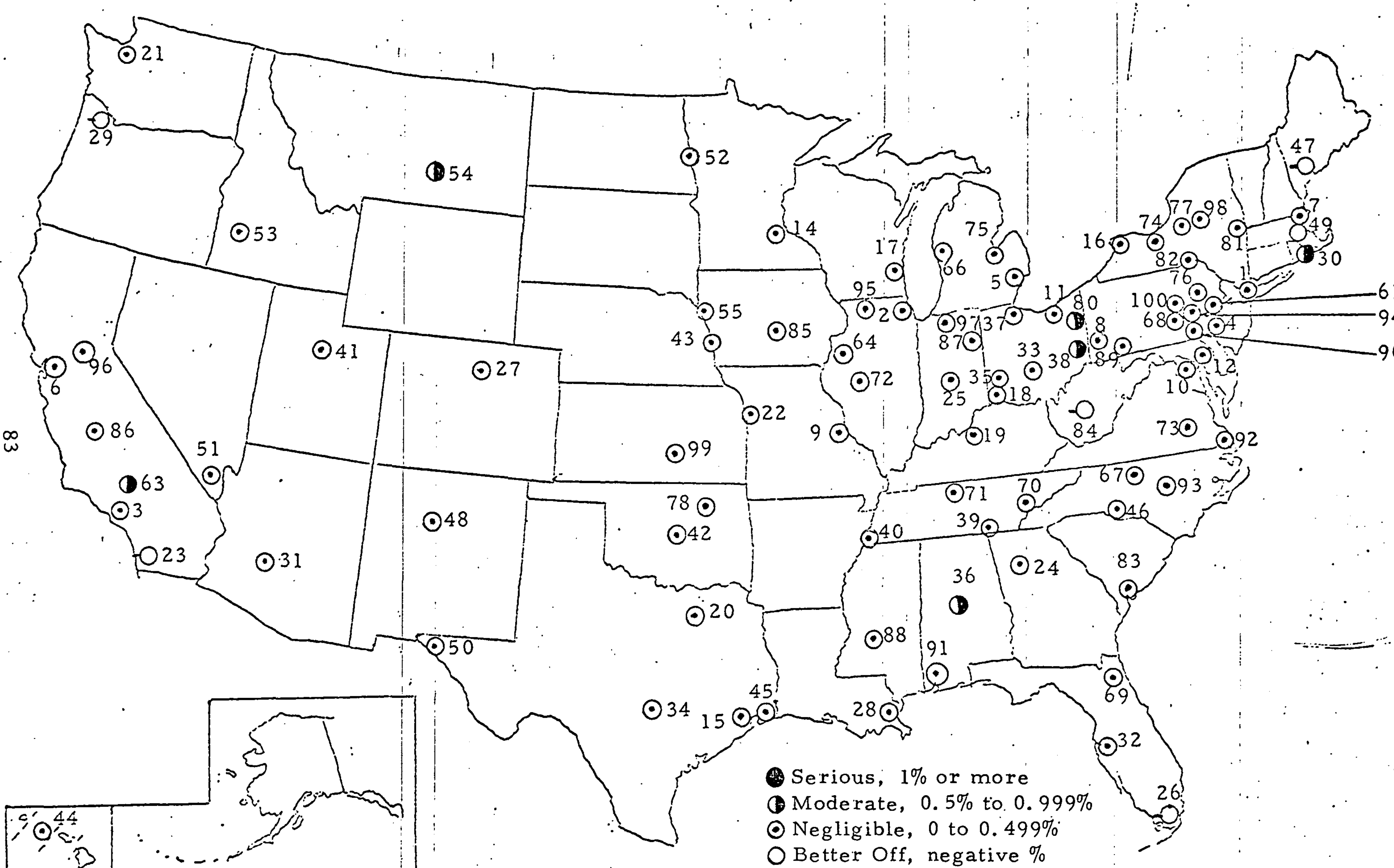
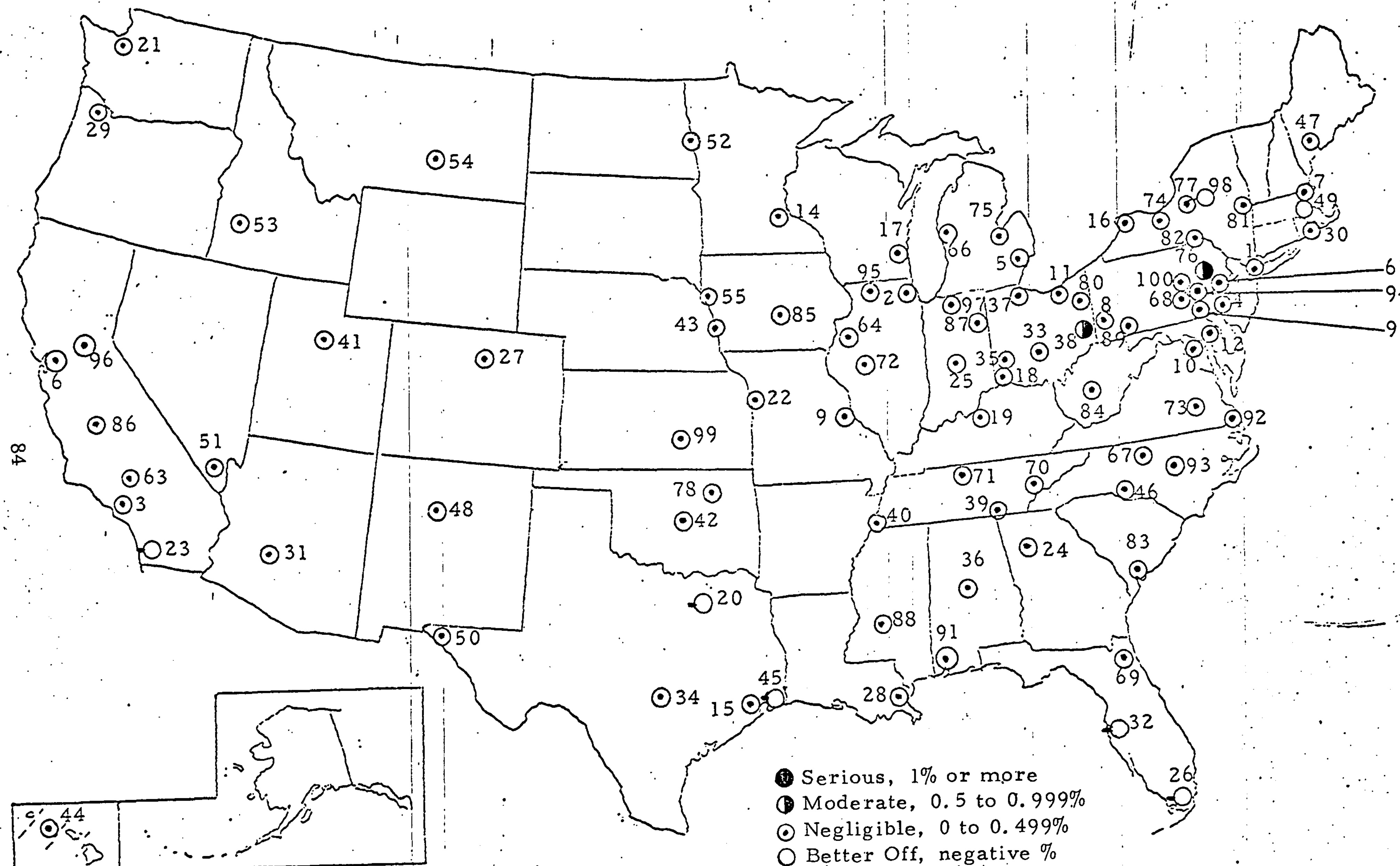


Figure 4.4
Geographic Distribution of Economic Effects in 1976 Measured by Change of Unemployment Rate:
Strategy 4: Five Year Extended Implementation 1973-1977 with Government Financial Assistance
Benefit = $10.0 Billion



- However, the individual AQCRs have widely varying effects in the same strategy. For example, some AQCRs such as San Diego are actually "better off" in unemployment and personal income changes in Strategy 1, while Steubenville and Scranton show more than 1.7 percent increase in unemployment.

- The direction of different economic indicators are consistent for an AQCR in a strategy. However, the magnitude of the effect may be different depending upon the size and industrial composition of the economy. For instance, under Strategy 1, Birmingham, Alabama, has an unemployment rate increase of 1.30 percent and regional personal income drop of 2.1 percent while Billings, Montana, had the same unemployment effect (1.73 percent) but only 0.98 percent decline in personal income. This difference is ascribable partly to the lower percent of personal income derived from manufacturing in Billings.

These are very broad and general observations. They tend to conceal the geographic patterns of adverse economic effects. If "mixed" strategies are to be designed to achieve some degree of equity among regions, the geographic patterns of adverse effects and the reasons behind these must be understood.

To develop this understanding of the geographic patterns, a number of AQCRs that experienced moderate and severe adverse economic effects are selected. Two criteria were used in this selection.

- Select all the AQCRs that experienced .5 to 1.0 percent or more unemployment rate increase and display these two groups of AQCRs under the following strategies (Table 4.9 - 4.13).

- For each of the four strategies (1 through 4), select and display the AQCRs that: (a) show 2% or more reduction in manufacturing production; (b) show 15% or more reduction in manufacturing investment; (c) show 1% or more reduction in personal income. Tables 4.14 through 4.16 display the AQCRs that meet this criterion.

Seven AQCRs experienced 1% or more and 26 others between 0.5 to 1% increase in unemployment rate. Other economic indicators (Tables 4.10 - 4.13) of the four implementation strategies are provided for these 33 AQCRs to provide a more balanced view of the economic effects of the four basic implementation strategies. In general, there is a consistent pattern of behavior of the various indicators within one strategy and among strategies.

Table 4.14 through Table 4.16 and Figures 4.7 through 4.9 tell the same story. They identify AQCRs that are moderately and severely affected in terms of manufacturing production, investment and personal income.

The single most important characteristic evident from these tables and figures is the persistence of a set of metropolitan areas enclosed by the so-called American "Heartland" Manufacturing Belt in every list.

Table 4.9
% Change in Unemployment of Selected AQCRs
Under Alternative Strategies

| Selected AQCRs | Strategy 1<br>No Ext. Without Govt. Asst.<br>1975 | Strategy 2<br>2-Yr. Ext. Without Govt. Asst.<br>1976 | Strategy 3<br>No Ext. With Govt. Asst.<br>1975 | Strategy 4<br>2-Yr. Ext. With Govt. Asst.<br>1976 |
|---|---|---|---|---|
| Group 1 | | | | |
| 8 Pittsburgh, Pa. | 1.089 | 0.739 | 0.450 | 0.305 |
| 36 Birmingham, Ala. | 1.296 | 0.826 | 0.570 | 0.364 |
| 38 Steuvenville, Ohio | 1.730 | 1.568 | 0.699 | 0.632 |
| 54 Billings, Montana | 1.310 | 1.441 | 0.746 | 0.465 |
| 63 Bakersfield, Calif | 1.500 | 1.159 | 0.614 | 0.462 |
| 76 Scranton, Pa. | 1.780 | 1.248 | 0.719 | 0.509 |
| 80 Youngstown, Ohio | 1.226 | 0.754 | 0.549 | 0.327 |
| Group 2 | | | | |
| 5 Detroit, Michigan | 0.529 | 0.468 | 0.239 | 0.192 |
| 9 St. Louis, Missouri | 0.614 | 0.476 | 0.243 | 0.222 |
| 16 Buffalo, New York | 0.751 | 0.44 | 0.321 | 0.116 |
| 17 Milwaukee, Wisconsin | 0.906 | 0.712 | 0.371 | 0.290 |
| 19 Louisville, Kentucky | 0.584 | 0.512 | 0.235 | 0.194 |
| 37 Toledo, Ohio | 0.616 | 0.539 | 0.253 | 0.212 |
| 43 Omaha, Nebraska | 0.547 | 0.398 | 0.198 | 0.148 |
| 45 Port Arthur, Texas | 0.899 | 0.672 | 0.367 | 0.439 |
| 52 Fargo, N. D. | 0.742 | 0.428 | 0.308 | 0.172 |
| 61 Allentown, Pa. | 0.860 | 0.541 | 0.350 | 0.228 |
| 64 Davenport, Iowa-Ill. | 0.552 | 0.322 | 0.228 | 0.137 |
| 68 Harrisburg, Pa. | 0.644 | 0.430 | 0.284 | 0.178 |
| 70 Knoxville, Tenn. | 0.553 | 0.371 | 0.224 | 0.144 |
| 72 Peoria, Illinois | 0.572 | 0.397 | 0.236 | 0.162 |
| 75 Saginaw Bay City, Mich. | 0.842 | 0.644 | 0.347 | 0.245 |
| 77 Syracuse, N. Y. | 0.754 | 0.506 | 0.298 | 0.207 |
| 82 Binghamton, N. Y. | 0.600 | 0.427 | 0.214 | 0.170 |
| 84 Charleston, W. Va. | 0.559 | 0.649 | 0.002 | 0.233 |
| 85 Des Moines, Iowa | 0.738 | 0.564 | 0.282 | 0.235 |
| 86 Fresno, California | 0.574 | 0.379 | 0.225 | 0.157 |
| 89 Johnstown, Pa. | 0.902 | 0.569 | 0.348 | 0.214 |
| 90 Lancaster, Pa. | 0.598 | 0.406 | 0.245 | 0.161 |
| 93 Raleigh/Durham, N. C. | 0.758 | 0.512 | 0.312 | 0.178 |
| 94 Reading, Pa. | 0.864 | 0.589 | 0.360 | 0.244 |
| 97 South Bend, Indiana | 0.696 | 0.469 | 0.264 | 0.191 |
| 98 Utica-Rome, N. Y. | 0.966 | 0.654 | 0.398 | 0.275 |

Table 4.10
% Change in Manufacturing Production (Value-Added) of Selected AQCRs Under Alternative Strategies

| Selected AQCRs | Strategy 1<br>No Ext. Without Govt. Asst.<br>1975 | Strategy 2<br>2-Yr. Ext. Without Govt. Asst.<br>1976 | Strategy 3<br>No Ext. With Govt. Asst.<br>1975 | Strategy 4<br>2-Yr. Ext. With Govt. Asst.<br>1976 |
|---|---|---|---|---|
| Group 1 | | | | |
| 8 Pittsburgh, Pa. | - 3.26 | - 1.94 | - 1.45 | - 0.87 |
| 36 Birmingham, Ala. | - 4.84 | - 2.71 | - 2.14 | - 1.21 |
| 38 Steuvenville, Ohio | - 8.76 | - 6.41 | - 3.52 | - 2.57 |
| 54 Billings, Montana | - 5.00 | - 4.74 | - 1.94 | - 1.85 |
| 63 Bakersfield, Calif | - 8.89 | - 7.45 | - 3.52 | - 2.95 |
| 76 Scranton, Pa. | - 2.21 | - 2.29 | - 0.90 | - 0.93 |
| 80 Youngstown, Ohio | - 2.95 | - 1.86 | - 1.33 | - 0.83 |
| Group 2 | | | | |
| 5 Detroit, Michigan | - 0.84 | - 0.56 | - 0.36 | - 0.24 |
| 9 St. Louis, Missouri | - 1.19 | - 0.85 | - 0.49 | - 0.35 |
| 16 Buffalo, New York | - 1.61 | - 1.11 | - 0.70 | - 0.45 |
| 17 Milwaukee, Wisconsin | - 1.08 | - 0.84 | - 0.44 | - 0.35 |
| 19 Louisville, Kentucky | - 0.44 | - 0.32 | - 0.17 | - 0.12 |
| 37 Toledo, Ohio | - 1.26 | - 0.94 | - 0.51 | - 0.38 |
| 43 Omaha, Nebraska | - 0.41 | - 0.51 | - 0.13 | - 0.19 |
| 45 Port Arthur, Texas | - 3.50 | - 2.69 | - 1.41 | - 1.08 |
| 52 Fargo, N. D. | - 2.17 | - 1.93 | - 0.88 | - 0.78 |
| 61 Allentown, Pa. | - 1.83 | - 1.33 | - 0.79 | - 0.57 |
| 64 Davenport, Iowa-Ill. | - 1.04 | - 0.75 | - 0.46 | - 0.33 |
| 68 Harrisburg, Pa. | - 1.52 | - 1.44 | - 0.63 | - 0.59 |
| 70 Knoxville, Tenn. | - 0.95 | - 0.94 | - 0.39 | - 0.38 |
| 72 Peoria, Illinois | - 1.17 | - 0.99 | - 0.48 | - 0.41 |
| 75 Saginaw Bay City, Mich. | - 1.29 | - 1.10 | - 0.53 | - 0.44 |
| 77 Syracuse, N. Y. | - 1.20 | - 1.09 | - 0.49 | - 0.44 |
| 82 Binghamton, N. Y. | - 0.60 | - 0.63 | - 0.22 | - 0.25 |
| 84 Charleston, W. Va. | - 1.11 | - 0.92 | - 0.46 | - 0.38 |
| 85 Des Moines, Iowa | - 1.80 | - 1.51 | - 0.73 | - 0.61 |
| 86 Fresno, California | - 1.54 | - 1.32 | - 0.63 | - 0.53 |
| 89 Johnstown, Pa. | - 1.05 | - 1.12 | - 0.42 | - 0.46 |
| 90 Lancaster, Pa. | - 0.93 | - 0.90 | - 0.37 | - 0.37 |
| 93 Raleigh/Durham, N.C. | - 1.07 | - 1.04 | - 0.44 | - 0.41 |
| 94 Reading, Pa. | - 2.23 | - 1.74 | - 0.93 | - 0.72 |
| 97 South Bend, Indiana | - 0.65 | - 0.60 | - 0.26 | - 0.24 |
| 98 Utica-Rome, N. Y. | - 1.42 | - 1.10 | - 0.60 | - 0.46 |

Table 4.11
% Change in Manufacturing Investment of Selected AQCRs Under Alternative Strategies

| Selected AQCRs | Strategy 1<br>No Ext. Without Govt. Asst. | Strategy 2<br>2-Yr. Ext. Without Govt. Asst. | Strategy 3<br>No Ext. With Govt. Asst. | Strategy 4<br>2-Yr. Ext. With Govt. Asst. |
|---|---|---|---|---|
| Group 1 | 1975 | 1976 | 1975 | 1976 |
| 8 Pittsburgh, Pa. | -28.11 | -20.46 | -10.24 | - 7.49 |
| 36 Birmingham, Ala. | -58.81 | -38.75 | -18.66 | -12.78 |
| 38 Steuvenville, Ohio | -28.50 | -19.39 | -10.13 | - 7.06 |
| 5[illegible] Billings, Montana | -39.58 | -36.80 | -13.40 | -12.13 |
| 63 Bakersfield, Calif | -76.14 | -66.42 | -22.82 | -19.51 |
| 76 Scranton, Pa. | -35.07 | -49.01 | -12.38 | -15.15 |
| 80 Youngstown, Ohio | -33.29 | -28.13 | -12.11 | - 9.96 |
| Group 2 | | | | |
| 5 Detroit, Michigan | - 9.09 | - 6.43 | - 3.60 | - 2.56 |
| 9 St. Louis, Missouri | -19.34 | -13.26 | - 7.17 | - 4.98 |
| 16 Buffalo, New York | -16.42 | -13.11 | - 6.26 | - 4.95 |
| 17 Milwaukee, Wisconsin | -18.85 | -14.90 | - 7.02 | - 5.55 |
| 19 Louisville, Kentucky | - 7.70 | - 4.52 | - 3.01 | - 1.79 |
| 37 Toledo, Ohio | -16.08 | -11.77 | - 6.03 | - 4.45 |
| 43 Omaha, Nebraska | - 8.00 | - 8.35 | - 3.10 | - 3.20 |
| 45 Port Arthur, Texas | -18.61 | -14.24 | - 6.85 | - 5.26 |
| 52 Fargo, N. D. | -14.35 | -19.21 | - 5.47 | - 6.88 |
| 61 Allentown, Pa. | -10.25 | - 8.97 | - 4.07 | - 3.51 |
| 64 Davenport, Iowa-Ill. | - 4.98 | - 4.94 | - 2.05 | - 1.99 |
| 68 Harrisburg, Pa. | -21.71 | -24.03 | - 8.02 | - 8.44 |
| 70 Knoxville, Tenn. | -11.71 | -13.34 | - 4.55 | - 5.02 |
| 72 Peoria, Illinois | - 8.30 | - 7.40 | - 3.28 | - 2.90 |
| 75 Saginaw Bay City, Mich. | - 2.94 | - 2.53 | - 1.19 | - 1.02 |
| 77 Syracuse, N. Y. | -12.87 | -12.74 | - 4.98 | - 4.83 |
| 82 Binghamton, N. Y. | - 9.97 | -10.28 | - 3.88 | - 3.96 |
| 84 Charleston, W. Va. | - 8.31 | - 7.00 | - 3.27 | - 2.75 |
| 85 Des Moines, Iowa | -23.05 | -19.77 | - 8.50 | - 7.25 |
| 86 Fresno, California | -12.08 | -12.04 | - 4.66 | - 4.55 |
| 89 Johnstown, Pa. | - 5.52 | - 7.95 | - 2.20 | - 3.09 |
| 90 Lancaster, Pa. | -15.55 | -15.32 | - 5.91 | - 5.69 |
| 93 Raleigh/Durham, N.C. | - 7.67 | - 8.86 | - 3.04 | - 3.42 |
| 94 Reading, Pa. | -35.21 | -29.80 | -12.16 | -10.14 |
| 97 South Bend, Indiana | - 6.24 | - 6.66 | - 2.48 | - 2.62 |
| 98 Utica-Rome, N. Y. | -24.22 | -21.05 | - 8.91 | - 7.62 |

Table 4.12
% Change in Regional Personal Income of Selected AQCRs Under Alternative Strategies

| Selected AQCRs | Strategy 1<br>No Ext. Without Govt. Asst.<br>1975 | Strategy 2<br>2-Yr. Ext. Without Govt. Asst.<br>1976 | Strategy 3<br>No Ext. With Govt. Asst.<br>1975 | Strategy 4<br>2-Yr. Ext. With Govt. Asst.<br>1976 |
|---|---|---|---|---|
| **Group 1** | | | | |
| 8 Pittsburgh, Pa. | -1.56 | -0.97 | -0.68 | -0.41 |
| 36 Birmingham, Ala. | -2.09 | -1.21 | -0.93 | -0.54 |
| 38 Steuvenville, Ohio | -6.42 | -5.29 | -2.60 | -2.13 |
| 54 Billings, Montana | -0.98 | -1.43 | -0.62 | -0.45 |
| 63 Bakersfield, Calif | -0.82 | -0.66 | -0.34 | -0.26 |
| 76 Scranton, Pa. | -1.23 | -1.08 | -0.49 | -0.44 |
| 80 Youngstown, Ohio | -1.90 | -1.19 | -0.86 | -0.53 |
| **Group 2** | | | | |
| 5 Detroit, Michigan | -0.49 | -0.37 | -0.22 | -0.16 |
| 9 St. Louis, Missouri | -0.61 | -0.43 | -0.24 | -0.20 |
| 16 Buffalo, New York | -1.01 | -0.67 | -0.44 | -0.25 |
| 17 Milwaukee, Wisconsin | -0.83 | -0.66 | -0.34 | -0.27 |
| 19 Louisville, Kentucky | -0.47 | -0.38 | -0.18 | -0.14 |
| 37 Toledo, Ohio | -0.76 | -0.60 | -0.31 | -0.24 |
| 43 Omaha, Nebraska | -0.30 | -0.28 | -0.10 | -0.10 |
| 45 Port Arthur, Texas | -4.53 | -3.52 | -1.81 | +0.43 |
| 52 Fargo, N. D. | -0.42 | -0.27 | -0.18 | -0.11 |
| 61 Allentown, Pa. | -0.98 | -0.67 | -0.42 | -0.29 |
| 64 Davenport, Iowa-Ill. | -0.69 | -0.46 | -0.29 | -0.20 |
| 68 Harrisburg, Pa. | -0.60 | -0.49 | -0.26 | -0.20 |
| 70 Knoxville, Tenn. | -0.51 | -0.41 | -0.20 | -0.16 |
| 72 Peoria, Illinois | -0.70 | -0.55 | -0.29 | -0.23 |
| 75 Saginaw Bay City, Mich. | -0.77 | -0.62 | -0.32 | -0.24 |
| 77 Syracuse, N. Y. | -0.65 | -0.52 | -0.26 | -0.21 |
| 82 Binghamton, N. Y. | -0.44 | -0.39 | -0.16 | -0.15 |
| 84 Charleston, W. Va. | -0.90 | -1.03 | -0.04 | -0.37 |
| 85 Des Moines, Iowa | -0.78 | -0.63 | -0.30 | -0.26 |
| 86 Fresno, California | -0.35 | -0.26 | -0.13 | -0.12 |
| 89 Johnstown, Pa. | -0.61 | -0.52 | -0.24 | -0.19 |
| 90 Lancaster, Pa. | -0.69 | -0.60 | -0.28 | -0.22 |
| 93 Raleigh/Durham, N.C. | -0.35 | -0.29 | -0.14 | -0.11 |
| 94 Reading, Pa. | -1.14 | -0.85 | -0.48 | -0,36 |
| 97 South Bend, Indiana | -0.50 | -0.40 | -0.19 | -0.16 |
| 98 Utica-Rome, N. Y. | -0.90 | -0.67 | -0.38 | -0.28 |

Table 4.13
% Change in Local Government Revenue of Selected AQCRs Under Alternative Strategies

| Selected AQCRs | Strategy 1<br>No Ext. Without Govt. Asst. | Strategy 2<br>2-Yr. Ext. Without Govt. Asst. | Strategy 3<br>No Ext. With Govt. Asst. | Strategy 4<br>2-Yr. Ext. With Govt. Asst. |
|---|---|---|---|---|
| | 1975 | 1976 | 1975 | 1976 |
| Group 1 | | | | |
| 8 Pittsburgh, Pa. | -2.28 | -1.41 | -0.99 | -0.60 |
| 36 Birmingham, Ala. | -3.10 | -1.80 | -1.38 | -0.80 |
| 38 Steuvenville, Ohio | -5.74 | -4.74 | -2.33 | -1.91 |
| 54 Billings, Montana | -1.12 | -1.63 | -0.71 | -0.51 |
| 63 Bakersfield, Calif | -0.57 | -0.45 | -0.23 | -0.18 |
| 76 Scranton, Pa. | -2.20 | -1.93 | -0.88 | -0.78 |
| 80 Youngstown, Ohio | -2.94 | -1.84 | -1.33 | -0.81 |
| Group 2 | | | | |
| 5 Detroit, Michigan | -0.64 | -0.48 | -0.29 | -0.20 |
| 9 St. Louis, Missouri | -0.94 | -0.65 | -0.37 | -0.31 |
| 16 Buffalo, New York | -0.96 | -0.64 | -0.42 | -0.24 |
| 17 Milwaukee, Wisconsin | -0.83 | -0.66 | -0.34 | -0.27 |
| 19 Louisville, Kentucky | -0.67 | -0.53 | -0.25 | -0.19 |
| 37 Toledo, Ohio | -1.07 | -0.83 | -0.43 | -0.33 |
| 43 Omaha, Nebraska | -0.40 | -0.38 | -0.14 | -0.14 |
| 45 Port Arthur, Texas | -4.60 | -3.56 | -1.83 | +0.43 |
| 52 Fargo, N. D. | -0.40 | -0.25 | -0.17 | -0.10 |
| 61 Allentown, Pa. | -1.56 | -1.08 | -0.67 | -0.46 |
| 64 Davenport, Iowa-Ill. | -0.90 | -0.61 | -0.38 | -0.26 |
| 68 Harrisburg, Pa. | -0.85 | -0.70 | -0.38 | -0.29 |
| 70 Knoxville, Tenn. | -0.69 | -0.56 | -0.27 | -0.21 |
| 72 Peoria, Illinois | -1.07 | -0.85 | -0.44 | -0.35 |
| 75 Saginaw Bay City, Mich. | -0.97 | -0.74 | -0.40 | -0.31 |
| 77 Syracuse, N. Y. | -0.57 | -0.46 | -0.23 | -0.19 |
| 82 Binghamton, N. Y. | -0.36 | -0.31 | -0.13 | -0.12 |
| 84 Charleston, W. Va. | -1.38 | -1.58 | -0.06 | -0.57 |
| 85 Des Moines, Iowa | -1.00 | -0.80 | -0.38 | -0.33 |
| 86 Fresno, California | -0.18 | -0.14 | -0.07 | -0.06 |
| 89 Johnstown, Pa. | -0.80 | -0.68 | -0.32 | -0.25 |
| 90 Lancaster, Pa. | -1.16 | -1.00 | -0.47 | -0.37 |
| 93 Raleigh/Durham, N. C. | -0.46 | -0.39 | -0.19 | -0.14 |
| 94 Reading, Pa. | -1.86 | -1.39 | -0.78 | -0.58 |
| 97 South Bend, Indiana | -0.64 | -0.52 | -0.25 | -0.21 |
| 98 Utica-Rome, N. Y. | -0.85 | -0.62 | -0.35 | -0.26 |

Table 4. 14
Comparison of Regions with Manufacturing Production Decreased 2% or More in 1975 or 1976

| Selected AQCRs | 3 Yr. (Without) 1975 | 3 Yr (With) 1975 | 5 Yr. (Without) 1976 | 5 Yr. (With) 1976 |
|---|---|---|---|---|
| 8 Pittsburgh, Pa. | -3.26 | -1.45 | -1.94 | - .87 |
| 36 Birmingham, Alabama | -4.84 | -2.14 | -2.71 | -1.21 |
| 38 Steubenville-Weirton/ Wheeling, West Va. | -8.76 | -3.52 | -6.41 | -2.57 |
| 45 Beaumont-Port Arthur-Orange, Texas | -3.50 | -1.41 | -2.69 | -1.08 |
| 52 Fargo-Moorhead, N.D., Minnesota | -2.17 | -0.88 | -1.93 | - .78 |
| 54 Billings, Montana | -5.00 | -1.94 | -4.74 | -1.85 |
| 55 Sioux City, Iowa | -2.02 | -0.76 | -1.91 | - .73 |
| 63 Bakersfield, Calif. | -8.89 | -3.52 | -7.45 | -2.95 |
| 76 Scranton/Wilkes-Barre/ Hazelton, Pa. | -2.21 | -0.90 | -2.29 | - .93 |
| 80 Youngstown-Warren, Ohio | -2.95 | -1.33 | -1.86 | - .83 |
| 94 Reading, Pa | -2.23 | -0.93 | -1.74 | - .72 |

Table 4.15
Comparisons of Manufacturing Investment Showing a 15% or Greater Decrease in 1975 or 1976

| Selected AQCRs | 3 Yr. (Without) 1975 | 3 Yr (With) 1975 | 5 Yr. (Without) 1976 | 5 Yr. (With) 1976 |
|---|---|---|---|---|
| 6 San Francisco, Calif. | -23.88 | -8.59 | -18.23 | -6.59 |
| 8 Pittsburgh, Pa. | -28.11 | -10.24 | -20.46 | -7.49 |
| 9 St. Louis, Mis | -19.34 | -7.17 | -13.26 | -4.98 |
| 10 Washington, D.C. | -24.42 | -8.67 | -20.84 | -7.41 |
| 12 Baltimore, Maryland | -15.84 | -6.08 | -11.75 | -4.51 |
| 16 Buffalo, New York | -16.42 | -6.26 | -13.11 | -4.95 |
| 17 Milwaukee, Wisconsin | -18.85 | -7.02 | -14.90 | -5.55 |
| 25 Indianapolis, Ind. | -22.19 | -8.07 | -17.42 | -6.34 |
| 29 Portland, Oregon | -18.90 | -6.91 | -14.60 | -5.42 |
| 36 Birmingham, Alabama | -58.81 | -18.66 | -38.75 | -12.78 |
| 37 Toledo, Ohio | -16.08 | -6.03 | -11.77 | -4.45 |
| 38 Steubenville-Weirton Ohio/Wheeling, W. Va. | -28.50 | -10.13 | -19.39 | -7.06 |
| 45 Beaumont-Port Arthur-Orange-Texas | -18.61 | -6.85 | -14.24 | -5.26 |
| 52 Fargo-Moorehead, N.D., Minnesota | -14.35 | -5.47 | -19.21 | -6.88 |
| 53 Boise, Idaho | -8.83 | -3.44 | -16.75 | -6.07 |
| 54 Billings, Montana | -39.58 | -13.40 | -36.80 | -12.13 |
| 55 Sioux City, Iowa | -133.60 | -30.39 | -118.36 | -25.66 |
| 63 Bakersfield, Calif. | -76.14 | -22.82 | -66.42 | -19.51 |
| 68 Harrisburg, Pa. | -21.71 | -8.02 | -24.03 | -8.44 |
| 69 Jacksonville, Florida | -15.53 | -5.91 | -14.66 | -5.49 |
| 76 Scranton, Wilkes Barre-Hazelton, Pa. | -35.07 | -12.38 | -49.01 | -15.15 |
| 78 Tulsa, Oklahoma | -18.40 | -6.88 | -20.29 | -7.29 |
| 80 Youngstown-Warren, Ohio | -33.29 | -12.11 | -28.13 | -9.96 |
| 85 DesMoines, Iowa | -23.05 | -8.50 | -19.77 | -7.25 |
| 88 Jackson, Mississippi | -18.74 | -7.02 | -17.68 | -6.50 |
| 90 Lancaster, Pa. | -15.55 | -5.91 | -15.32 | -5.69 |
| 92 Norfolk Portsmouth/Newport News-Hampton, Va. | -16.86 | -6.41 | -17.25 | -6.35 |
| 94 Reading, Pa. | -35.21 | -12.16 | -29.80 | -10.14 |
| 98 Utica-Rome, N.Y. | -24.22 | -8.91 | -21.05 | -7.62 |

Table 4.16
Comparisons of Regions With Personal Income Decrease 1% or More in 1975 or 1976

| Selected AQCRs | 3 Yr. (Without) 1975 | 3 Yr. (With) 1975 | 5 Yr. (Without) 1976 | 5 Yr. (With) 1976 |
|---|---|---|---|---|
| 8 Pittsburgh, Pa. | - 1.56 | - 0.68 | - 0.97 | - 0.41 |
| 16 Buffalo, New York | - 1.01 | - 0.44 | - 0.67 | - 0.25 |
| 36 Birmingham, Alabama | - 2.09 | - 0.93 | - 1.21 | - 0.54 |
| 38 Steubenville-Weirton, Ohio/Wheeling, W. Va. | - 6.42 | - 2.60 | - 5.29 | - 2.13 |
| 45 Beaumont-Port Arthur, Orange, Texas | - 4.53 | - 1.81 | - 3.52 | + 0.43 |
| 54 Billings, Montana | - 0.98 | - 0.62 | - 1.43 | - 0.45 |
| 76 Scranton/Wilkes Barre-Hazelton, Pa. | - 1.23 | - 0.49 | - 1.08 | - 0.44 |
| 80 Youngstown-Warren, Ohio | - 1.90 | - 0.86 | - 1.19 | - 0.53 |
| 84 Charlestown, West Va. | - 0.90 | - 0.04 | - 1.03 | - 0.37 |
| 94 Reading, Pa. | - 1.14 | - 0.48 | - 0.85 | - 0.36 |

Figure 4.7
Regions with Manufacturing Production Decreased 2% or More in 1975 or 1976

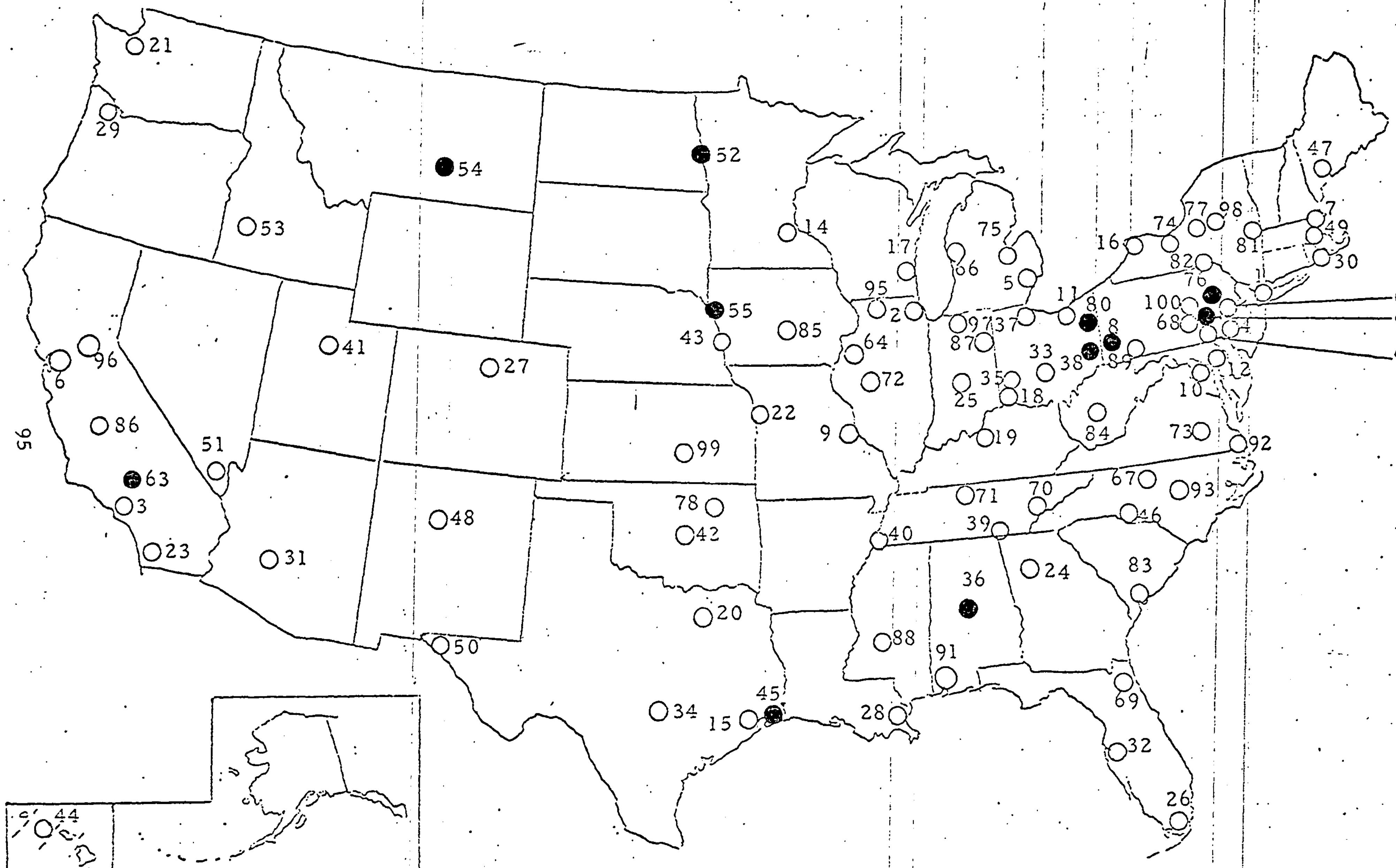


Figure 4.8
Regions with Manufacturing Investment Decreased 5% or More in 1975 or 1976

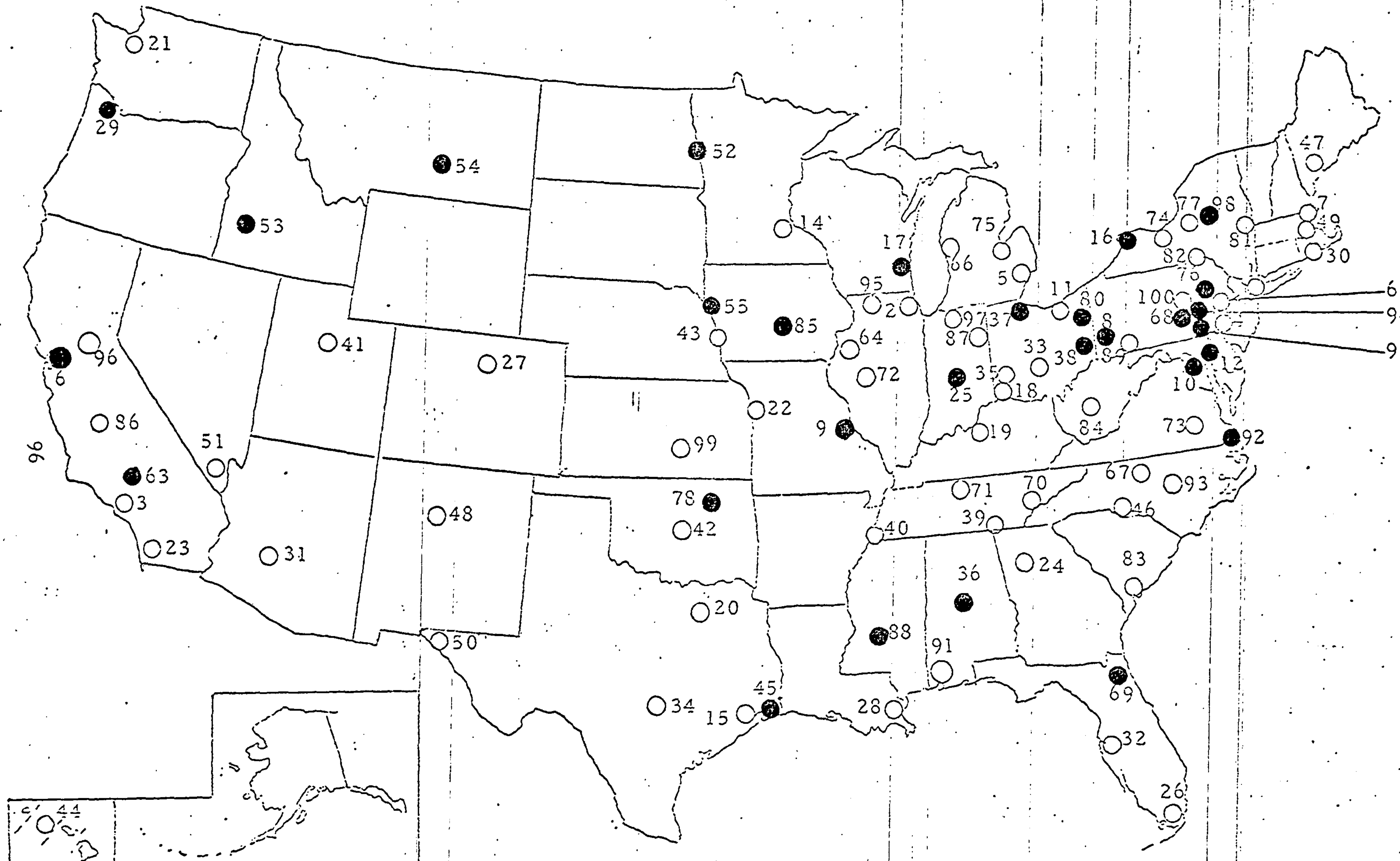
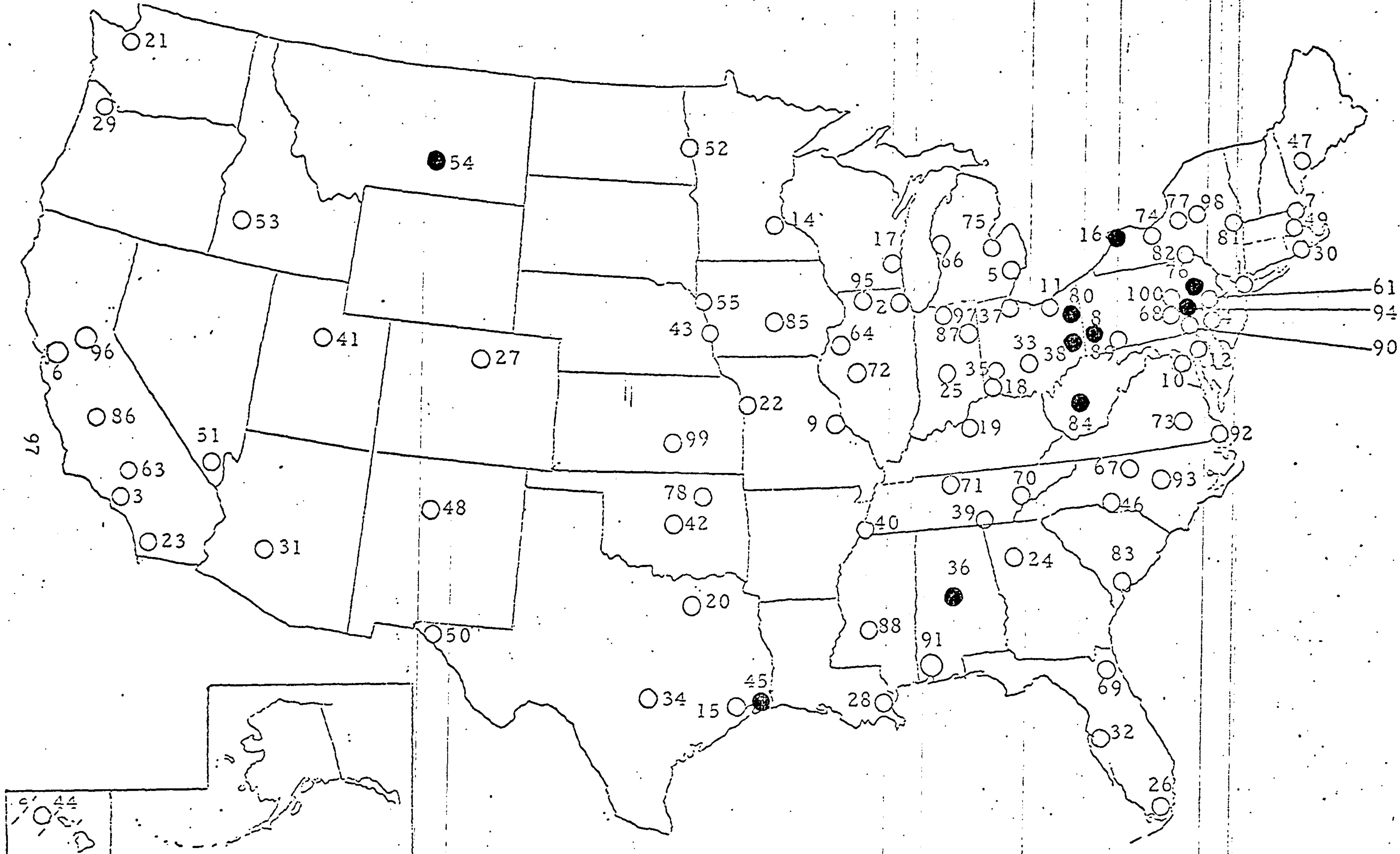


Figure 4.9
Regions with Personal Income Decreased 1% or More in 1975 or 1976



The Heartland Manufacturing Belt has been described by geographers and regional economists as the area that developed westwards from New York in the area bounded by Lake Superior iron ores, the Pennsylvania coalfields and the capital, entrepreneurial experience and engineering trades of the northeast United States.* In the phase of American growth associated with iron and steel, this area emerged as the heavy industrial center of the country, and has remained the center of national demand, determining patterns of market accessibility since 1870. Figures 4.10 and 4.11 show the urban centers of the manufacturing belt emerging in 1870 and continuing to be important in the national urban system to 1960 (the major difference being the emergence of Pacific and southwest by 1960). Since 1870, this area has grown into the urbanized center of the national market while subsequent metroplitan growth has been organized around this national core region. Continued spread of population to the west and modern higher-order industries (e.g., aerospace) suited to the local amenities have

*For a fuller discussion of this concept, see: (1) Pred, Allan, The Spatial Dynamics of U.S. Urban-Industrial Growth, 1800-1914, Cambridge, The MIT Press, 1966; (2) Perloff, Harvey S., Dunn, E.S., Lampard, E. E., and Muth, R. F., Regions, Resources and Economic Growth, Baltimore, Johns Hopkins Press, 1960; (3) Ullman, E. L., "Regional Development and the Geography of Concentration," Papers of the Regional Science Association, 1959; and (4) Berry, Brian J. L., and Neils, Elaine, Location, Size and Shape of Cities as Influenced by Environmental Factors, Chicago, University of Chicago, December, 1967.

Figure 4.10

The Emergence of Manufacturing Belt Urban Centers, 1870

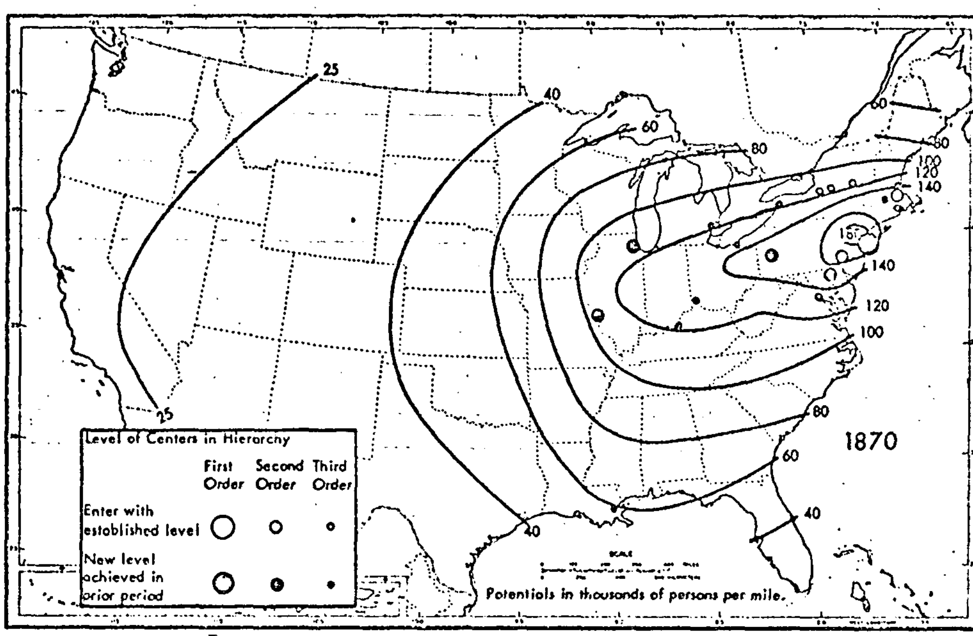
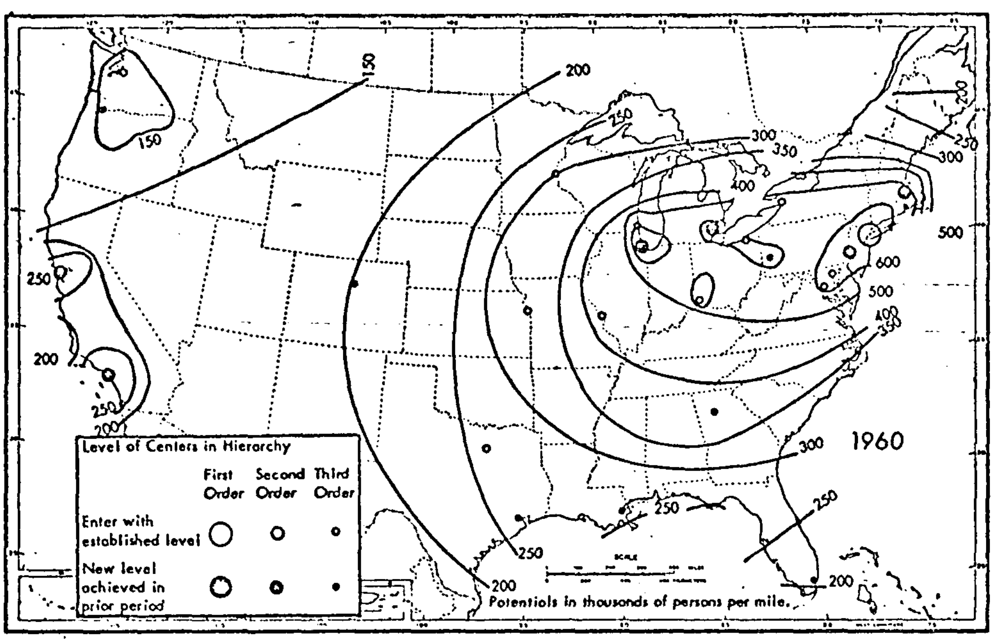



Figure 4.11

The Persistence of Manufacturing Belt Urban Centers, 1960




Source: Berry and Neils, op. cit.

led to processing, service and modern low-emission industries outside the heartland. The manufacturing belt has thus been "a great heartland nucleation of industry and the national market, the focus of large-scale national serving industry the seedbed of new industry responding to the dynamic structure of national demand and the center of high levels of per capita income."

The incidence of control costs on the AQCRs in the manufacturing belt is inevitable, given its industrial preeminence (see Appendix C ). However, given its persistent role as the lever of successive development of national regions, the adverse economic effects in the AQCRs inside the manufacturing belt (Figure 4.7 - 4.9) warrant some caution. The adverse effects on these AQCRs in the manufacturing belt may get impacted throughout a large part of the national economy. The design of the "mixed" strategy may help to alternate these AQCRs.

E. The "Mixed" Strategy

The mixed strategy is essentially a mixture of different treatments of different AQCRs in one strategy in the light of previous analysis of aggregate over time and geographic patterns of economic effects. It is intended to provide for a high degree of spatial equity in the incidence of adverse economic effects.

The mixed strategy chosen consists of:

a. 58 AQCRs simulated exactly as under strategy 1

b. 13 AQCRs as under strategy 2

c. 14 AQCRs as under strategy 3

d. 4 AQCRs as under strategy 4

e. 2 AQCRs with 75% additional government financial assistance and two-year extension

The identity of these AQCRs in each category is indicated in Table 4.17.

The performance of the AQCRs in the mixed strategy can be observed in the following manner:

- Appendix B indicates the performance of 58 AQCRs under strategy 1
- Tables 4.9 - 4.12 indicate the performance of the AQCRs in groups (b), (c) and (d), above
- Table 4.18 shows the performance of the two AQCRs -- Steubenville and Scranton

The mixed strategy brings the unemployment down for every AQCR under 0.5%. Economic hardship as judged by the criterion has been reduced to acceptable levels in all AQCRs, though this has meant 75% additional government financial assistance to two AQCRs.

TABLE 4.17

GROUPING OF AQCRs UNDER MIXED STRATEGY

a. 58 AQCRs Under Strategy 1

| | | | |
|---|---|---|---|
| 1 | New York, New York | 44 | Honolulu, Hawaii |
| 2 | Chicago, Illinois | 46 | Charlotte, North Carolina |
| 3 | Los Angeles, California | 47 | Portland, Maine |
| 4 | Philadelphia, Pa. | 48 | Albuquerque, New Mexico |
| 6 | San Francisco, California | 49 | Lawrence-Haverhill/Lowell, Massachusetts |
| 7 | Boston, Massachusetts | 50 | El Paso, Texas |
| 10 | Washington, D.C. | 51 | Las Vegas, Nevada |
| 11 | Cleveland, Ohio | 53 | Boise, Idaho |
| 12 | Baltimore, Maryland | 55 | Sioux City, South Dakota |
| 14 | Minneapolis-St. Paul Minnesota | 66 | Grand Rapids/Muskegon-Muskegon Hts., Michigan |
| 15 | Houston, Texas | 67 | Greensboro, North Carolina |
| 18 | Cincinnati, Ohio | 69 | Jacksonville, Florida |
| 20 | Dallas, Texas | 71 | Nashville, Tennessee |
| 21 | Seattle-Everett, Washington | 73 | Richmond, Virginia |
| 22 | Kansas City, Missouri | 74 | Rochester, New York |
| 23 | San Diego, California | 78 | Tulsa, Oklahoma |
| 24 | Atlanta, Georgia | 81 | Albany-Schenectady-Troy, New York |
| 25 | Indianapolis, Indiana | 83 | Charleston, South Carolina |
| 26 | Miami, Florida | 87 | Fort Wayne, Indiana |
| 27 | Denver, Colorado | 88 | Jackson, Mississippi |
| 28 | New Orleans, Louisiana | 91 | Mobile, Alabama |
| 29 | Portland, Oregon | 92 | Norfolk-Portsmouth/Newport News-Hampton, Va. |
| 30 | Providence-Pawtucket, Rhode Island | 95 | Rockford, Illinois |
| 31 | Phoenix, Arizona | 96 | Sacramento, California |
| 32 | Tampa, Florida | 99 | Wichita, Kansas |
| 33 | Columbus, Ohio | 100 | York, Pa. |
| 34 | San Antonio, Texas | | |
| 35 | Dayton, Ohio | | |
| 39 | Chattanooga, Tennessee | | |
| 40 | Memphis, Tennessee | | |
| 41 | Salt Lake City, Utah | | |
| 42 | Oklahoma City, Oklahoma | | |

TABLE 4. 17 (cont'd)

b. 13 AQCRs Under <u>Strategy 2</u>

| | |
|---|---|
| 5 | Detroit, Michigan |
| 9 | St. Louis, Missouri |
| 16 | Buffalo, New York |
| 43 | Omaha Nebraska |
| 52 | Fargo, North Dakota |
| 64 | Davenport, Iowa |
| 68 | Harrisburg, Pa. |
| 70 | Knoxville, Tennessee |
| 72 | Peoria, Illinois |
| 82 | Binghamton, New York |
| 86 | Fresno, California |
| 90 | Lancaster, Pa. |
| 97 | South Bend, Indiana |

c. 14 AQCRs Under <u>Strategy 3</u>

| | |
|---|---|
| 8 | Pittsburgh, Pa. |
| 17 | Milwaukee, Wisconsin |
| 19 | Louisville, Kentucky |
| 37 | Toledo, Ohio |
| 45 | Port Arthur, Texas |
| 61 | All ntown, Pa. |
| 75 | Saginaw Bay City, Michigan |
| 77 | Syracuse, New York |
| 84 | Charleston, West Virginia |
| 85 | Des Moines, Iowa |
| 89 | Johnstown, Pa. |
| 93 | Raleigh/Durham, North Carolina |
| 94 | Reading, Pa. |
| 98 | Utica-Rome, New York |

d. 4 AQCRs Under <u>Strategy 4</u>

| | |
|---|---|
| 36 | Birmingham, Alabama |
| 54 | Billings, Montana |
| 63 | Bakersfield, California |
| 80 | Youngstown, Ohio |

e. 2 AQCRs With <u>75% Gov't Assist</u>.

| | |
|---|---|
| 38 | Steubenville, Ohio |
| 76 | Scranton, Pa. |

Table 4.18
Economic Indicators Under "Mixed Strategy", 1976

| AQCR | Unemployment Rate | Mfg. Prod- % Change | Mfg. Invest. % Change | Reg. Pers. Inc. % Chg. | Govt. Rev. % Change |
|---|---|---|---|---|---|
| Steubenville | 0.38 | -1.56 | -4.18 | -1.28 | -1.15 |
| Scranton | 0.32 | -0.57 | -8.66 | -0.28 | -0.50 |

## F. Summing Up

The lengthy interpretation of regional economic impacts under alternative strategies can be summarized as:

- The regional economies of different AQCRs respond to alternative implementation strategies with considerable sensitivity as seen from the five variables selected for analysis, manufacturing production (value-added), manufacturing investment, regional personal income, regional unemployment ratio, and regional government revenue. For example, increment in unemployment aggregated over the 91 AQCRs varies from 0.51 percent to 0.18 percent (see Tables 4.1-4.4). In the case of individual AQCR, say Pittsburgh, it varies from 1.1 percent to 0.3 percent increment depending upon whether two-year extension for implementation and/or government financial assistance were available to each AQCR (see Appendix B and Tables 4.9-4.13).

- In general, implementation of the Clean Air Act of 1970 will have greater effect to the manufacturing industries than income and employment in a given region.

- Cost-sharing by the government is more effective than a two-year extension to the regional economy. For instance, the number of AQCRs which will face 0.5 percent or more increment in unemployment rate will drop from 32 to 20 AQCRs with two-year extensions from 1975 to 1977 while with 59 percent additional government financial assistance to the control cost the number will drop to 6 AQCRs (Table 4.7). Both aggregate effect for 91 AQCRs under study (Table 4.2 and 4.3) and individual AQCR data (Appendix B, Strategy 2 and 3) show a consistent pattern of changes for other variables.

- The geographic patterns of those seriously affected regions tend to consist with the heavy manufacturing belt. Moreover, among those highly polluted areas, those large cities such as Chicago, Pittsburgh, St. Louis, etc., with existence of a wide range of other industries, are able to take the adverse effects compared with small size cities such as Steubenville, Youngstown, etc.

- This time scheme of implementation also shows that in the case of a straight implementation by 1975, most of the impact will be concentrated in 1975. There are considerable time lags in the ordering, production, architecture and engineering and delivery of control equipment to industry, consequently, most of the impact is likely to be in 1975. With a two-year extension to 1977, the brunt of the cost is likely to be borne in 1976. The year of maximal impact is considered a critical comparative criterion when comparing the two implementation periods.

- With a detailed analysis of alternative strategy simulation, it is possible to identify AQCRs with five distinct groups (as shown in Table 4.7) such that economic hardship (say, measured by changes of unemployment rate) should not exceed a given criterion (.5 percent of unemployment rate increment). Such results can be achieved with different combinations of time schemes and percentage of government financial assistance as demonstrated.

# CHAPTER 5: APPLICATION TO WATER POLLUTION AND SOLID WASTE DISPOSAL

This chapter explores the potential for and the modifications necessary for the extension of OAP to other media -- water and land -- of pollution. It opens with a discussion of the similarities and differences among water and solid waste and air quality management. Next, it explores the applicability and modifications necessary for such extension of the OAP Regional Model to the other media in the light of their differences. Then, it proceeds to a brief review of external conceptual models for assessment of economic effects of water quality and solid waste management and the data available for operationalizing the conceptual models. Finally, a few remarks on potential approaches are presented.

## A. Salient Features of Water Quality and Solid Waste Management

The need for strategy evaluation regarding control of water pollution and solid waste disposal is no less important than for air pollution. The modelling approach developed here can be extended to provide estimates of certain effects of pollution control strategies in these areas. The general modelling approach developed here is conceptually appropriate for these evaluations, since the effect of control strategies will be to increase the costs of the various industrial sectors which produce solid wastes and water pollutants. Estimates of these cost increases can be used to estimate the effects in terms of output and employment for the various industrial sectors in various regions.

The problems of solid waste disposal and water pollution differ in some important dimensions from the problems of air pollution, and it would therefore be necessary to modify and extend the model. These differences include:

- The comparative ease of controlling the physical movement of liquid and solid wastes, thereby allowing more alternatives in terms of publicly and/or jointly operated waste disposal systems in contrast to gaseous or gas-borne pollutants which permit effective treatment only at the source.

- The extensive recycling and by-product possibilities which exist for liquid and solid wastes.

- The relatively greater importance of the final consumption and agricultural sectors as generators of waste products.

- The requirements for control of waste disposal in tidal and estuarine areas.

- There is more heterogeneity in the types of wastes to be controlled and fewer interrelationships and communalities among the various pollutants to be controlled.

This means that the variety of possible control strategies is much greater. For example, it would be possible to have one implementation schedule for control of BOD in streams, a different schedule for control of phosphates, and yet a third schedule for control of oil.

Past work on economic modelling in pollution control related to water and solid wastes has been heavily oriented toward direct cost optimization models, in which the model's function is to evaluate the economic efficiency alternative control methods. There has been almost no work in attempting to identify the total economic effects of alternative implementation plans on either a regional or national basis.

There is no detailed complete compilation of the costs and benefits of water and solid waste pollution control. This lack can be attributed to at least two distinct causes -- (1) the lack of commonly accepted standards as the level of control required and (2) the extensive system interdependencies extant in water-solid waste pollution controls, which makes the determination of control costs a more complex problem than in air. However, costs have been estimated for a number of regions, watersheds and industries, for specific standards.* Data are also avail-

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* See positions 41, 42, 43, 44, 47, 51, 53, 55, 56, 58, 61, and 73 in Appendix A.

able on waste generation for various industrial processes.* The task of developing a set of complete costs estimating relationships for regions as a function of industrial structure, standards, population, and other important factors, while a sizeable task, is by no means impossible. It appears that sufficient data exists to utilize a statistical estimating approach. The collection and standardization of the extensive existing data would involve a considerable effort.

## B. Required Model Extensions

### 1. Public Sector

These differences mean that the potential range of strategies must include possibilities for public funding and operation of waste treatment and disposal facilities, with alternative fee arrangements. It must also include options for more variety in time phasing of differing standards.

In terms of the model specifics, the control costs as applied to specific industrial sectors will operate satisfactorily. However, the share of control costs funded by the government must be associated with the appropriate government unit -- local, state, or national --

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* (1971) U. S. Environmental Protection Agency, pos. 37, Appendix A.

since the effects will differ in each instance. If the government funding is in the form of Federal subsidies, the current model will be appropriate. If the funding is at the state level, the result will be a reduction in disposable income for the state. If funding comes at the local level, disposable income in the region will be reduced. The model must be able to represent each of these possibilities or any combination of them, since strategies involving construction of municipal treatment facilities serving a number of plants and built with both state and Federal assistance are very probable. This will require modification of the regional income segment to allow for changes in disposable income corresponding to the selected strategies.

This same part of the model will also incorporate the effects of expenditure on municipal waste treatment facilities. The major economic effects will be to reduce disposable income for the governmental unit.

Another element which must be evaluated is the effect of water quality on industrial production costs. In contrast to air, water is an essential input into many industrial processes and control of water pollution could result in a cost reduction for some industries, due to a reduction in the need for extensive pre-treatment. The evidence available indicates that the cost reduction obtainable as a result of higher quality input water is small, but the evidence is inconclusive, and such direct benefits of pollution control could have major economic effects.

2. Food Processing

Food processing and agriculture have a particularly large input to water pollution. Unlike air pollution, where the contribution of food processing and agriculture frequently does not add significantly to pollutant concentrations in urban areas, watershed characteristics sometimes concentrate pollutants, such as chlorinated hydrocarbons and nitrogen and bring them to urban areas. It will be necessary to consider the control costs of agricultural pollution and to determine whether it is necessary to explicitly consider agriculture as a sector and to what extent the costs will be passed on to the food processing sector.

3. Final Consumption

It will be necessary to determine the control costs associated with solid waste disposal and to determine the portion of these that will be borne directly by consumers and the portion that will result in increased production costs.

The final consumption sector is a major producer of solid wastes, the majority of which are the result of industrial packaging operations. Possible strategies for control of these involve requiring industries to modify packaging methods, e.g., requiring returnable bottles or biodegradable packages. Some estimates must be developed relative to what portion of the costs related to such strategies will be passed on directly as price increases and what portion will be borne by the respective industries. The model will also have to incorporate the extent to which such strategies force structural changes in the industries producing packaging material.

4. Tidal Areas

If the model is to include the costs of control in tidal and estuarine areas, estimates of the economic effects of the required control will have to be developed. Control in these instances may involve restrictions on shipping and docking and the required restrictions would have to be translated into economic effects on shipping, fishing and other affected coastal activities.

5. Flexibility

The model must incorporate options to permit differing enforcement strategies for different pollutants. For example, it may be desirable to evaluate strategies which will involve control of heavy metals within one year, industrial organic discharges within two years, and sewage within three years. The model presently allows variations in the timing of control costs, but the timing must be the same for all sectors in a given region. For water pollution and solid wastes, a control strategy which varies the timing for specific pollutants implies that the time pattern of control expenditures must vary by industrial sector.

## C. Extant Models and Available Data

A rather extensive survey of recent studies of the economies of water pollution control and solid waste management was carried out and is summarized in the appendix. The results of the survey can be highlighted as follows:

- Sophisticated analyses of water quality management tend to limit their scope to a given geographic unit such as a water basin.
- In general, the optimization approach has been more popular than macro simulation models.
- Cost-benefit or cost-effective analyses help in providing evaluation of the direct costs of alternative planning strategies rather than of the economy-wide impacts on key economic variables.

However, there are instances of general equilibrium approaches. For instance, Ayres and Kneese apply a Walras-Cassel general equilibrium model with a conceptual integration of material flow from extraction and agriculture production to material processing to final consumption, and refuses from production and consumption will follow the flow of material for recycling.*

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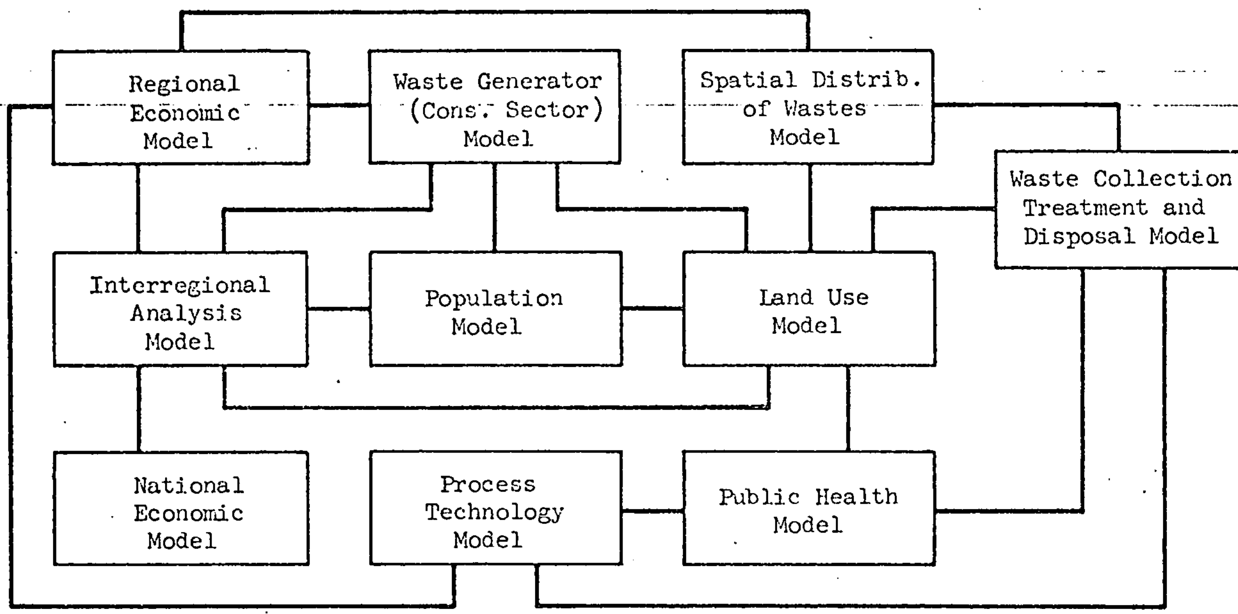
*Ayres, R. U., and Kneese, A. V., "Production, Consumption, and Externalities," American Economic Review, Vol. 59, No. 3, June, 1969, pp. 282-297.

FIGURE 5.1
REGIONAL WASTE GENERATION AND EVALUATION MODEL



Another outstanding model system on the solid waste management by Golueke and McGauhey* is quite similar to the current OAP Regional Economic Model. The major block flow diagram of Golueke and McGauhey is shown in Figure 5.1. Other interesting model systems are briefly discussed in the appendix.

The key to operationalize conceptual frameworks such as Ayers and Kneese or Golueke and McGauhey into computer models for strategy simulation is the availability of relevant economic and control data. Since the solid waste management is a major function of local government, considerable data are available on the volume of solid waste per capita. However, refuse data by industrial categories needs further investigation. **

For water, data of the total water intake and discharge by each manufacturing industry were published in the Census of Manufacturers (see Table 5.1). The annual report of Cost of Clean Water also provides data on estimated BODs by major industry (see Table 5.2), and various cost estimates are also available as shown in Table 5.3. A large amount of data is available in a variety of forms. The bibliography in Appendix A includes a number of sources of cost data for waste treatment, in the form of engineering data, industry data, and regional data. This wide variety of data must be synthesized in the forms required for

* Position 58, Appendix A.
** See Appendix A, Section E.

TABLE 5.

WATER INTAKE BY PURPOSE, GROSS WATER USED, AND WATER DISCHARGED: 1968

(All water data in billions of gallons)

| SIC Code | Industry Group | Total | Water Intake by Purpose of Intake: Process | Steam electric power Generation | Gross water used, including recirculation or reverse | Total Water Discharged |
|---|---|---|---|---|---|---|
| | All Industries, Total | 15466.5 | 4295.1 | 3008.7 | 35700.6 | 14275.9 |
| 20 | Food & Kindred Prod. | 810.9 | 290.6 | 74.7 | 1346.0 | 752.8 |
| 21 | Tobacco Mfr. | 5.8 | 1.7 | .2 | 77.0 | 4.8 |
| 22 | Textile Mill Products | 154.2 | 109.0 | 5.7 | 327.5 | 136.0 |
| 24 | Lumber & Wood Prod. | 117.9 | 36.5 | 44.7 | 204.9 | 92.7 |
| 25 | Furniture & Fixtures | 4.3 | 1.8 | (Z)* | 6.3 | 3.8 |
| 26 | Paper & Allied Prod. | 2252.0 | 1477.9 | 407.2 | 6521.5 | 2077.6 |
| 28 | Chemical & Allied Prod. | 4476.2 | 733.4 | 693.8 | 9415.8 | 4175.6 |
| 29 | Petroleum and Coal Prod. | 1435.1 | 94.6 | 169.2 | 7290.1 | 1217.0 |
| 30 | Rubber & Plastic Prod NEC | 134.9 | 23.8 | 16.1 | 268.5 | 128.4 |
| 31 | Leather & Leather Prod. | 15.8 | 13.9 | .2 | 19.5 | 14.9 |
| 32 | Stone, clay & Glass Prod. | 251.1 | 89.1 | 83.1 | 412.8 | 218.4 |
| 33 | Primary Metal Indus. | 5004.7 | 1207.2 | 1414.8 | 7779.8 | 4695.5 |
| 34 | Fabricated Metal Prod. | 67.7 | 37.1 | 1.9 | 168.9 | 65.0 |
| 35 | Machinery, except elec. | 189.0 | 28.9 | 70.5 | 338.4 | 180.8 |
| 36 | Electrical Equip. & Supplies | 126.6 | 46.6 | 9.6 | 369.7 | 118.4 |
| 37 | Trans. Equipment | 312.8 | 63.3 | 5.3 | 910.6 | 293.1 |
| 38 | Instruments & Related Prod. | 37.6 | 16.6 | 8.1 | 117.9 | 36.0 |
| 39 | Misc. Mfg. Industries | 14.4 | 4.6 | 3.3 | 23.8 | 13.0 |

* (Z) Less than 50 million gallons

TABLE 5.2
INDUSTRIAL WASTE WATER
DISCHARGE AND ESTIMATED
BODs in 1968

| SIC Code | Waste Source | Total Water* Discharged in billions of gallons | Estimated BODs** in millions of pounds | BODs per unit of waste water*** per pound 1000 gallons |
|---|---|---|---|---|
| 20 | Food Processing | 752.8 | 4,600 | 6.11 |
| 22 | Textile Mill Products | 136.0 | 1,100 | 8.09 |
| 26 | Paper & Allied Prod. | 2077.6 | 7,800 | 3.75 |
| 28 | Chemical & Allied Prod. | 4175.6 | 14,200 | 3.4 |
| 29 | Petroleum & Coal | 1217.0 | 550 | .43 |
| 30 | Rubber & Plastics | 128.4 | 60 | .47 |
| 33 | Primary Metals | 4695.5 | 550 | .12 |
| 35 | Machinery | 180.8 | 180 | 1.00 |
| 37 | Transportation Equip. | 293.1 | 160 | .54 |
| | All Other | 567.0 | 470 | .83 |
| | Manufacturing Total | 14275.9 | 29,670 | 2.08 |

* Census of Manufactures, 1967
** Cost of Clean Water, March 1971, Vol. II Cost Effectiveness and Clean Water
*** This column is obtained by column 4 divided by column 3

TABLE 5.3
COST ESTIMATES OF CLEAN WATER BY
MAJOR MANUFACTURING INDUSTRY

(millions of 1968 dollars)

| SIC | INDUSTRY | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|---|
| 20 | Food and Kindred Products | 129.3 | 159.1 | 172.4 | 188.6 | 200.4 | 212.0 |
| 201 | Meat Products | 22.3 | 26,5 | 28.9 | 30.2 | 32.0 | 33.2 |
| 202 | Dairy Products | 20.7 | 22.2 | 24.0 | 24.9 | 26.0 | 27.1 |
| 203 | Canned and Frozen Foods | 24.6 | 31.3 | 34.4 | 36.8 | 39.4 | 41.7 |
| 206 | Sugar Refining | 32.6 | 41.8 | 44.2 | 52.4 | 54.9 | 58.8 |
| 204, 5, 7, 8, 9 | All Other | 29.1 | 37.3 | 40.9 | 44.3 | 48.1 | 51.2 |
| 22 | Textile Mill Products | 44.3 | 51.5 | 55.7 | 59.0 | 62.0 | 65.9 |
| 26 | Paper and Allied Products | 48.4 | 55.0 | 64.8 | 68.8 | 72.8 | 77.0 |
| 28 | Chemicals and Allied Prod. | 77.1 | 112.9 | 130.4 | 147.7 | 166.2 | 181.2 |
| 29 | Petroleum and Coal | 75.9 | 79.0 | 85.3 | 103.8 | 111.3 | 118.2 |
| 30 | Rubber and Plastics, ne.c. | 8.0 | 10.0 | 12.3 | 12.8 | 14.2 | 15.3 |
| 33 | Primary Metals | 167.7 | 230.2 | 247.2 | 259.0 | 271.9 | 283.7 |
| 3312 | Blast Furnaces and Steel Mills | 109.7 | 147.9 | 160.7 | 168.0 | 177.4 | 184.0 |
| 33ex. 3312 | All Other | 58.0 | 82.2 | 86.5 | 91.0 | 95.5 | 99.7 |
| 35 | Machinery | 7.5 | 10.6 | 11.8 | 13.3 | 14.6 | 16.0 |
| 36 | Electrical Machinery | 6.5 | 9.1 | 9.8 | 10.6 | 11.5 | 12.3 |
| 37 | Transportation Equipment | 37.7 | 43.1 | 45.3 | 47.7 | 49.6 | 51.9 |
| 21, 23, 24, 25 27, 31, 32, 34, 38, 39 | All Other Manufacturing | 38.8 | 53.3 | 59.4 | 65.6 | 72.0 | 78.3 |
| | All Manufactures | | | | | | |
| | By Wastewater Profiles and Estimates | 641.2 | 813.7 | 894.5 | 976.9 | 1046.5 | 1111.8 |
| | By Census-Municipal Projections | 877.2 | 1130.5 | 1271.4 | 1411.4 | 1542.3 | 1665.0 |

Source: The Cost of Clean Water, Vol. II, Federal Water Pollution Control Administration, U.S. Department of the Interior, January 10, 1968.

economic modeling. These data would have to be compiled and catelogued to determine whether additional data are required. A preliminary overview indicates that problem is one of "too much" data--i.e., the major work effort will lie in reconciliation of alternative lost estimates rather than in collection of new cost data. One element of such reconciliation worthy of mention is the need for consistency in the composition of costs as stated in air and water control. The latter costs (as outlined in Cost of Clean Water) do not currently include depreciation in annual operating costs as done in estimating costs of clean air

D. Proposed Application of the OAP Economic Model System

With a brief survey of the existing data sources and modeling approach in water and solid waste pollution, it indicates:

- The macro model simulation approach of the current OAP Regional Economic Model for the air pollution study can be extended to other media.
- Such an extension would require some sectoral reformulation, in particular, the government sector and water use oriented industries.
- From the existing data sources, it is feasible to use the refined model to provide the overall economic impact of water and solid waste pollution at a macro level. More detailed comments are possible only after further identification of data sources of such requirements than has been possible here.

As shown in Figure 5.2, the extension of the model to other media would imply additions to the existing components of the OAP Economic Model System. Four new components are suggested, namely, national economic model; water demand and discharge model; solid waste generator model and an extended government sector.

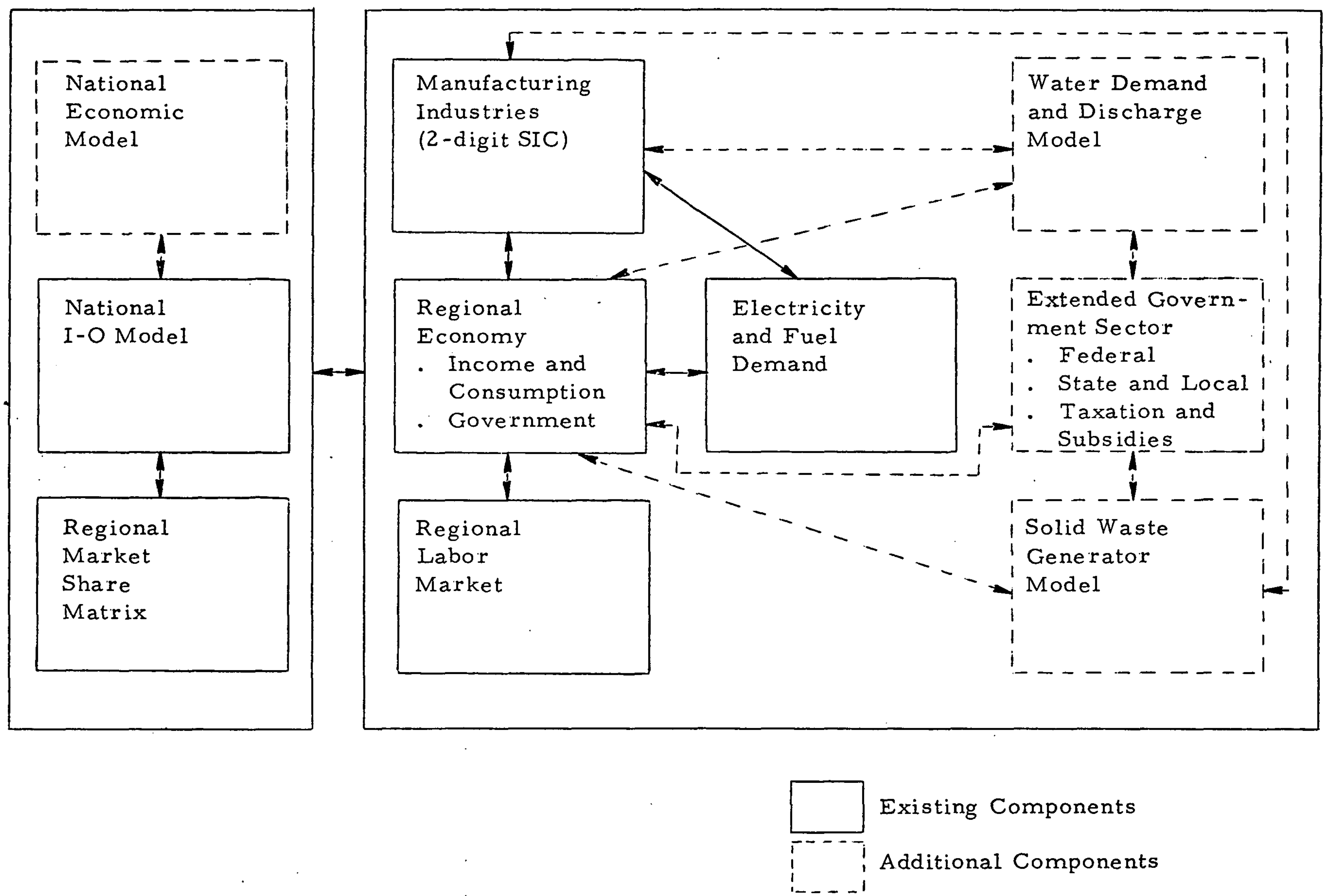
A national economic model is included, in addition to the current I-O model and regional market share matrix, to provide a dynamic external market scheme to the current cross-sectional regional model.

The water demand and discharge model can be linked to the existing manufacturing sector so that total water intake and discharge can be related to the production levels of each industry. In the case of water, primary and secondary treatment of waste water are, in general, a public sector effort. Therefore a tax or charge must be determined for each industrial userpossibly based on the amount of discharges and BOD content. Such charges or taxes would become additional costs to the industries which can be then treated in a manner similar to the operating costs of air pollution control in the OAP Economic Model.

The solid waste generator model is similar to the water model in that physical relations can be determined between economic

Figure 5.2

PROPOSED MODIFICATION OF THE OAP ECONOMIC MODEL SYSTEM FOR WATER AND SOLID WASTE POLLUTION CONTROL SIMULATION



activities (both production and consumption) and solid waste generation. Again, taxes and public expenditures for the treatment of solid wastes can be included in the model as in the case of water. As new water and solid waste components are added to the model, the need for an extended government sector as detailed in the next chapter is obvious.

A more detailed look at the additional components of the model is provided in Figure 5.3*. What is outlined is only a scheme and detailed specifications of the model can be undertaken. The water demand and discharge model, essentially, established the relations between manufacturing productions and waste water discharged. Detail data available for each industry includes:

- Total water intake.
- Water treated prior to use.
- Water for process.
- Water for air conditioning.
- Water for steam electric power generation.
- Water for other cooling and condensing.

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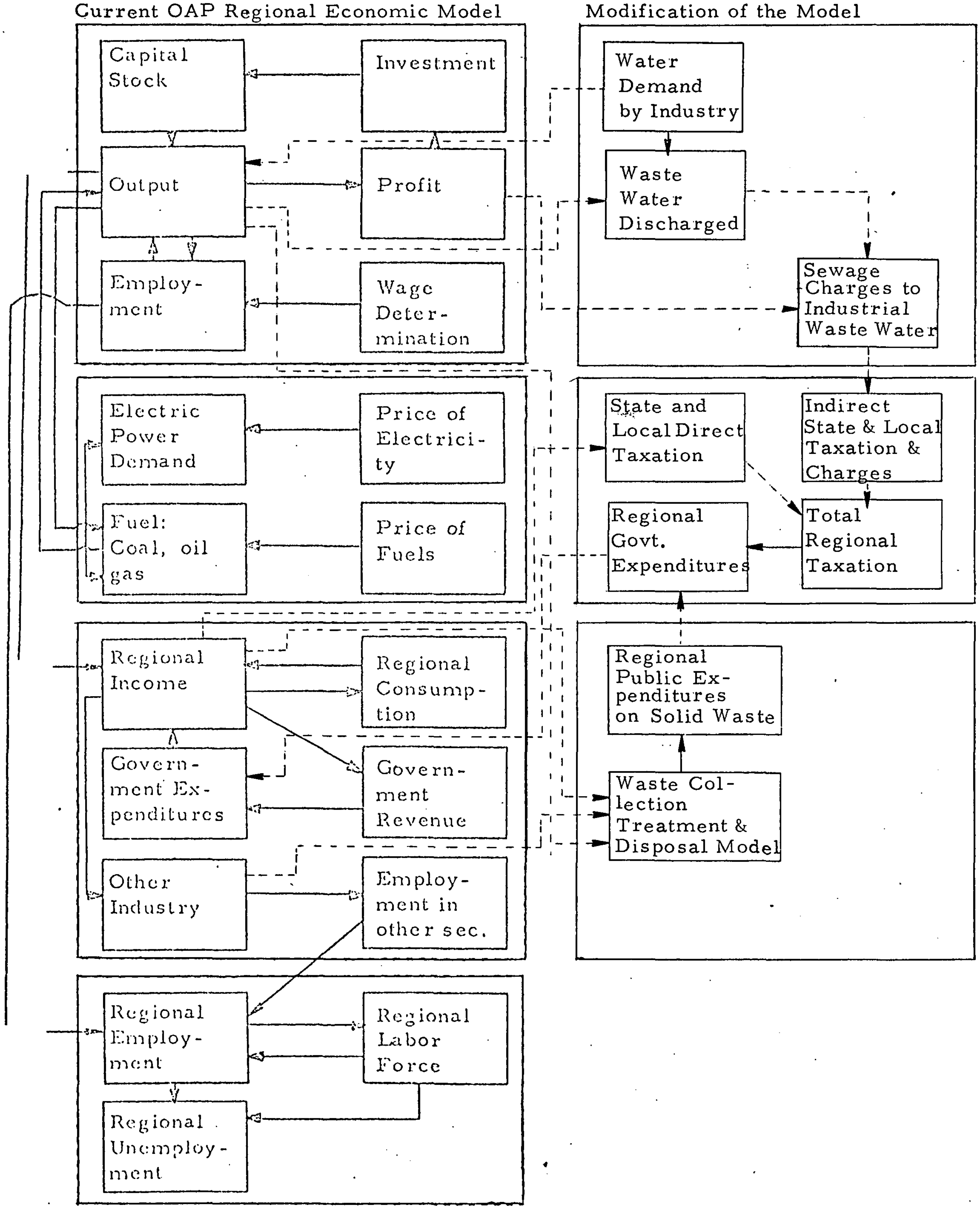
* See CONSAD Research Corporation - op. cit. p. 37

Figure 5.3
PROPOSED MODIFICATION FOR THE REGIONAL MODEL
- A MORE DETAILED LOOK:



- Water for boiler feed, sanitary services and other uses.
- Total water discharged.
- Water discharged into public utility sewer.
- Water discharged into tidal water body.
- Water discharged into the ground.
- Waste water transferred to other users.
- Waste water treated before discharged, etc.

Data on BODs and control cost estimates by industry are also available (Tables 5.2 and 5.3).

Once the relations between industrial productions and water demand and discharge relations are estimated, control cost - both investment and operating costs - can be introduced in a manner similar to air pollution control costs. In addition, water discharged into public sewers may lead to sewer charges to industry according to amounts of BODs to be treated in public facilities. This position again becomes an additional cost to the industries. At the same time, an increased demand for sewage capacity and primary and secondary treatment facilities would lead to increased public investments and in turn to higher taxation at the Federal, State and local levels. Therefore, a detailed sectioning of government sector in the OAP model becomes important as the role of government increases. A possible formulation is given in Chapter 6.

Solid waste control costs are partially in the air pollution control costs and partially borne by the public sector which costs could enter the model as additional taxes.

# CHAPTER 6: REMARKS AND RECOMMENDATIONS

Phase I of the effort to utilize the OAP Economic Model was guided by three objectives. The first objective was to exercise the model through the simulation and indepth interpretation of the economic effects of a wide range of implementation strategies. The second was to incorporate economic and control cost data more recent than 1967. The third objective was to utilize the model system to identify potential areas for model refinement and extension prior to further applications. It is to the assessment of the third objective that this chapter is addressed.

Suggestions for refinement of the model structure naturally begins from an assessment of the performance of the model in the simulation of strategies. Consequently, this chapter opens with a brief discussion of the nature of simulation and its accuracy through a convergency test. This discussion suggests that the results of convergency tests, while encouraging, ought to be reinforced by a validation of the Regional Model. While the full range of model refinements must await the validation test, the experience gained in the strategy simulation described in this report does suggest a number of refinements which are described in the rest of the chapter.

A. Simulation and Accuracy

The OAP model was estimated with cross-sectional data for 1967. The OBE projections by AQCR were used to describe the regional economies of these AQCRs from 1973 through 1977. Some assumptions underlying these projections and their use in the simulation warrant comment.

First, the OBE projections must be regarded as a "trend" projection by each AQCRs. Consequently, they tend to ignore cyclical fluctuations of the real economy. In particular, OBE assumes a four percent regional unemployment rate for the years 1973-1977.

How accurate are the estimates of endogenous variables in the simulation? Generally, simulation results are subject to three types of errors:

- error in specification,
- error in measurement, and
- error in simulation.

Errors of specification arise from a misunderstanding or purposeful simplification in the phenomena being represented in the model; non-inclusion of relevant variables or improper formulation of functional relationship (e.g., linear instead of a non-linear relationship). Errors in measurement arise from inaccuracy in assessing a magnitude such as an economic forecast, and control cost data. Finally, an error of simulation may result from the process of simulation, e.g., the Newton Method to solve a non-linear system by an iteration procedure.* Again, while a set of equations are solved in a recursive manner, errors from previous stages of simulation will be cumulatively propogated to later stages.

With all types of errors combined in the estimated results obtained from the model, there is no unique method to distinguish the sources of error as described above. This is to say, it is not easy to break down a given measurement of the error, say $Y - \hat{y}$, into the three categories described above.

Second, the simulation of the OAP regional model is structured to measure changes due to the control strategy in each year. These "changes with control" of each endogenous variable were measured under the following assumptions.

Suppose

$$y = a + bx + u$$

where

y is endogenous variable

x is exogenous variable

a, b are "true" coefficients

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* Evans, M. K. and L. R. Klein, The Wharton Econometric Forecasting Model, Wharton School of Finance and Commerce, University of Pennsylvania, 1967, Chapter IV, pp. 39-43.

u is error term

then the estimated relation will be:

$$\hat{y} = \hat{a} + \hat{b}x \tag{1}$$

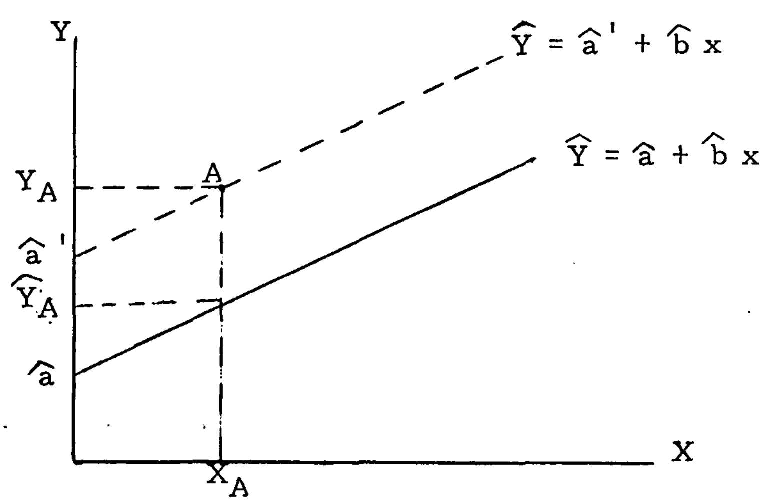
If the value of x with "control strategy" becomes $x^*$, then the y becomes $y^*$.

$$y^* = \hat{a} + \hat{b}x^* \tag{2}$$

And, if we take the difference between (1) and (2) which is, by definition, the "change with control", we get:

$$\begin{array}{rl} & \hat{y} = \hat{a} + \hat{b}x \\ -) & \underline{y^* = \hat{a} + \hat{b}x^*} \\ & \Delta\hat{y} = \hat{b}\,\Delta x \end{array} \qquad \text{where } \begin{array}{l} \Delta x = x - x^* \\ \Delta y = \hat{y} - y^* \end{array}$$

This demonstration shows that the measurements of "changes with control" are affected only by the accuracy of b coefficients and not by the accuracy of a coefficients.



As shown in the preceeding figure, for a given region A, given XA, the estimated value will be $\hat{Y}_A$ rather than $Y_A$ (which is the true value). If the slope of equations is a "true" estimate ($\hat{b} = b$) then the difference between $Y_A$ and $\hat{Y}_A$ will be $\hat{a}' - a$. In some econometric models, that are estimated combining cross-sectional and time-series data, it is customary to introduce a set of "dummy variables" which are no more than $(\hat{a}' - \hat{a})$ for each geographic unit in the model. *

Third, the regional model simulation provides not only changes due to control for each year but also the cumulative values for the endogenous variables over the implementation period. The only exception is unemployment rate, for which annual changes from the OBE four percent rate are provided. For all other endogenous variables, the cumulative effects of control strategies over the implementation period are produced as illustrated in the cost of regional personal income in Pittsburgh from 1973 to 1975. (Figure 6.1)

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* A model of this kind is Crow, Robert T., <u>An Econometric Model of the Northeast Corridor of the United States</u>, prepared for the U. S. Department of Transportation, March, 1969. In this model the entire region has been divided into three subregions, for the estimation of the model, a set of subregional dummy variables have been used which can be viewed as the equivalent of $(\hat{a}' - \hat{a})$.

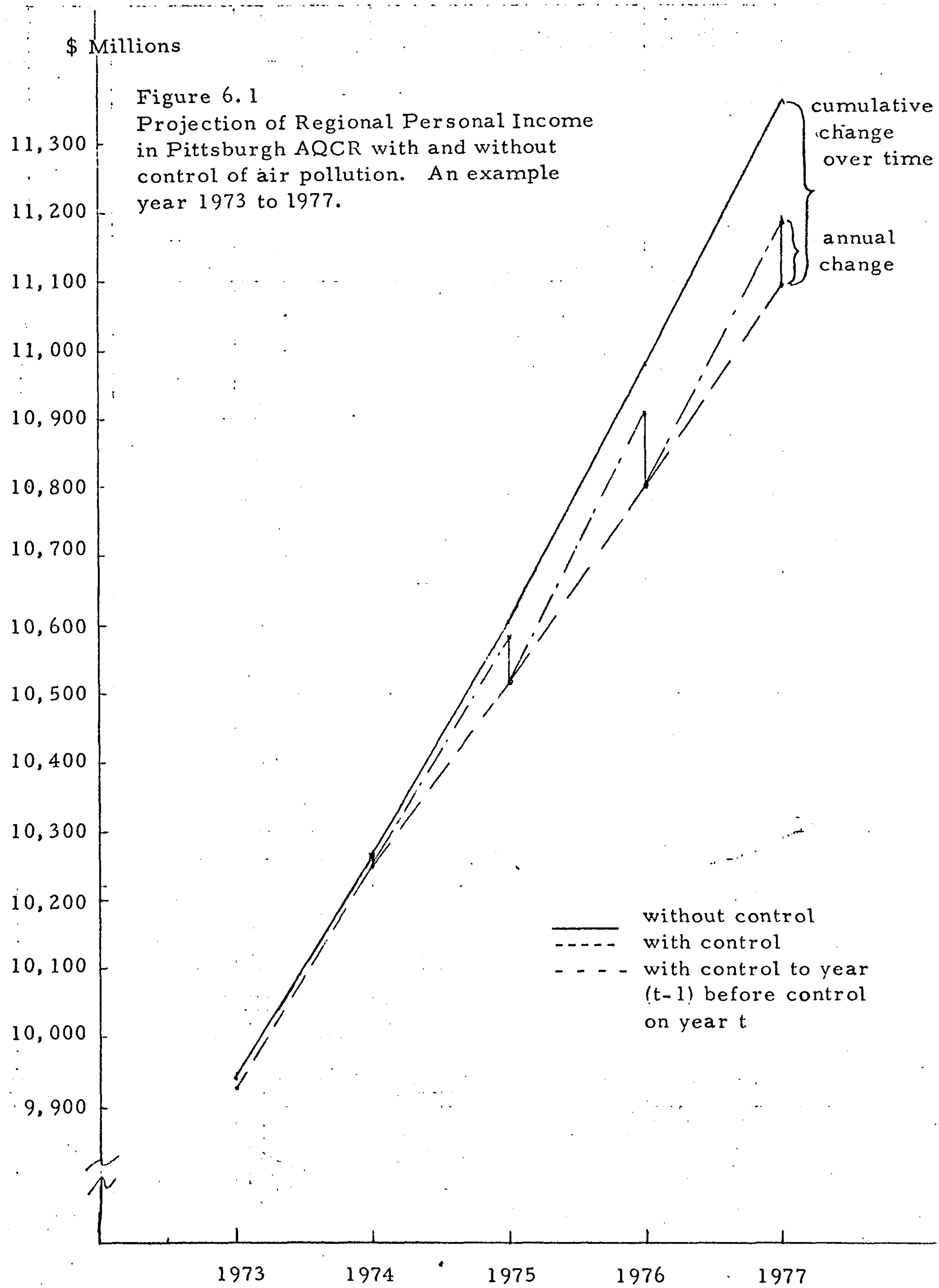


Figure 6.1
Projection of Regional Personal Income in Pittsburgh AQCR with and without control of air pollution. An example year 1973 to 1977.

| | Personal income without control ($ million in 1967 dollars) | Personal income with control ($ million in 1967 dollars) | Annual change with control ($ million) | Cumulative change with control ($ million) |
|---|---|---|---|---|
| 1973 | 9942.7 | 9937.9 | - 4.8 | - 4.8 |
| 1974 | 10273.8 | 10252.0 | - 17.0 | - 21.8 |
| 1975 | 10604.9 | 10516.7 | - 66.4 | - 88.2 |
| 1976 | 10996.8 | 10802.9 | -105.7 | -193.9 |
| 1977 | 11388.7 | 11096.1 | - 98.7 | -292.6 |

However, preliminary comments about the simulation results are possible from a convergency test of the simulation program. The income determination and labor market blocks of the regional model were included in this convergency test. The criterion of the iteration method used in this test was the following:

$$\left[\frac{Y_i^{(v)} - Y_i^{(v-1)}}{Y_i^{(v-1)}}\right] \leq 0.001$$

The results for 16 AQCRs are shown in Appendix D.* When the estimated values for the endogenous variables in the labor market block -- non-manufacturing employment, labor force, unemployment rate and total manufacturing employment -- are compared with the actual values, the differences are encouragingly under 2% for the AQCRs.

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* Results are also shown in Table 6. 1.

Table 6.1
Comparison of Estimated and Actual Values of Personal Income, 1967

| AQCR | Degree of Under-production by Model (%) | Degree of Over-production by Model (%) |
|---|---|---|
| New York | | 3.3 |
| Chicago | 11.1 | |
| Los Angeles | | 3.2 |
| Philadelphia | 7.9 | |
| Detroit | | 0.9 |
| San Francisco | 10.7 | |
| Boston | 17.9 | |
| Pittsburgh | 4.6 | |
| St. Louis | 4.5 | |
| Washington | 34.2 | |
| Cleveland | | 2.0 |
| Baltimore | | |
| Minneapolis | 1.4 | |
| Houston | | 10.4 |
| Buffalo | | 33.5 |

For the endogenous variables -- personal income, consumption and government expenditures -- in the income block, the fit is less adequate; however, the differences between actual and estimated values display on interesting pattern.

The model estimates in the first iteration within five percent of actual value for nine of the 15 AQCRs -- in Appendix D. For five AQCRs -- Chicago, Philadelphia, San Francisco, Boston and Washington, D. C. -- the model underestimates the regional personal income far in excess of five percent of actual value. It must be noted that regional personal income data used here pertains to the income of the residents. These AQCRs, except for Washington, D. C., are dominant regional metropolitan centers, with large numbers of headquarter offices and whose residents receive income from other regions. Washington, D. C., is, of course, the seat of the federal government.

On the other hand, for two AQCRs -- Buffalo and Houston -- are in the nature of "colonial" centers whose incomes are "diverted" partly to residents in other regions. Other examples of this type of AQCR are Allentown, Youngstown, and Johnstown, which house plants that are headquartered elsewhere.

Convergency tests provide only a partial assessment of the model. As VanHorn suggests, the "learning" from a simulation comprises two stages.* The first stage helps understand the behavior of the simulation itself in terms of the relations between inputs and outputs. The second and, often, the more difficult stage, is to translate the "learning" from the simulation to "learning" about the actual process -- functioning of the economy. A validation test is an example of the second type of learning and is appropriate as the springboard for future refinement of the OAP regional economic model.

The experience gained in the simulation of strategies in Phase I, however, suggests a number of refinements in the model to be more responsive to the emerging needs of EPA. These are presented in order next.

## B. Policy Simulation and Government Sector

One of the most important dimensions of an implementation strategy specification is the cost sharing scheme between the government and industries. The simulations in Phase I used 59 percent of government assistance under the assumption that this kind of assistance is the result of a combination of cost sharing provisions such as accelerated

* Richard L. VanHorn, "Validation of Simulation Results", Management Science, Vol. 17, No. 5, January , 1971, page 247.

depreciation, investment tax credits, tax exemptions, government loans and loan guarantees and direct aid in the form of grants and technical assistance. It would be definitely desirable to introduce each of these cost sharing provisions separately in the model instead of inputing this overall level of assistance.

Such a capability can be built into the model if the federal, state and local government sectors are recognized in the model. Currently, only the local government sector has been included in the model. Given the result that the regional economy is quite sensitive to the cost sharing scheme in any given strategy, further refinement of the public sector of the current model is warranted.

Klein has suggested that in an "ideal" regional model, the following government sector equations should be included.*

| | | |
|---|---|---|
| (1) | $T^{SL}_{Pi} = f_1(W_i L_i \pi_i)$ | direct regional taxation (state and local) |
| (2) | $T^{SL}_{Xi} = f_2(P_i X_i)$ | indirect regional taxation |
| (3) | $T^{F}_{i} = f_3(W_i L_i \pi_i)$ | Federal taxation |
| (4) | $T^{R}_{i} = f_4(U_i N_i)$ | regional transfer payment |
| (5) | $G^{SL}_{i} = f_5(T^{SL}_{i}, N_i, r)$ | Regional government expenditure |
| (6) | $T^{SL}_{i} = T^{SL}_{Pi} + T^{SL}_{Xi}$ | total regional taxation |

*Klein, Lawrence R., "The Specification of Regional Econometric Models", Papers, the Regional Science Association, Vol. 23, 1969, pp. 105-115.

where:

$T_i^{SL}$ = state and local direct taxes

$W_i$ = wage rate

$L_i$ = employment

$\pi_i$ = non-wage factor income

$T_{Xi}^{SL}$ = state and local indirect taxes

$T_{Pi}^{SL}$ = state and local direct taxes

$P_i$ = GRP (gross regional product) deflater

$X_i$ = gross regional product

$T_i^F$ = taxes paid to federal government

$T_i^R$ = transfer payment

$U_i$ = regional unemployment

$N_i$ = population

$G_i^{SL}$ = state and local expenditures

$T_i^{SL}$ = state and local receipts

$r$ = interest rate

This specification of the public sector needs to be augmented by additional equations appropriate for air pollution control strategies. For example, property taxes can be separated from equation (1) so that when the regional estimate of property values are available before and after control, the reliability of estimates of benefits in the regional model can be improved.

Second, indirect taxes in equation (2) can be used to alter different cost sharing schemes and economic incentive schemes in air pollution control in conjunction with profit and investment equations of the manufacturing sector.

C. Investment Function

Besides the government sector, another sensitive variable in the model is the investment behavior of the high emission industries. In Chapter 4, investments for manufacturing production appeared to be the most sensitive variable under the alternative implementation strategies. As more detail is provided to introduce cost sharing and economic incentive schemes during model refinement, improvement of the profit and investment equations will be necessary. In the current model, the investment equations were estimated with cross-sectional data for 1967. Any improvement of the investment equations must include some analysis of overtime investment behavior, often described as "lag distribution" of the investment behavior. An example of such an analysis is provided by Shirley Almon.* Almon's empirical study shows different patterns of investment among different manufacturing industries. It may be, therefore, desirable to estimate investment functions by industry based on time series data in order to account for the time lags of the business investment phenomena.

D. Treatment of Benefits

The level of benefits of air pollution control is current assumed at $10 billion or $15 billion over the implementation period. This is no more than a rough estimate of net benefits based on a list of independent studies on health, expenditure, damage to buildings, property values, agriculture, etc. Further, the induction of this benefit into the model leaves something to be desired. It has been argued that the regions with a higher level of emissions before control will experience a considerably greater benefit after control. Thus, the increases of property values in Pittsburgh, for example, would be higher under a given control strategy than in San Francisco. The way benefits are fed into the model currently, such variations are not likely to be reflected.

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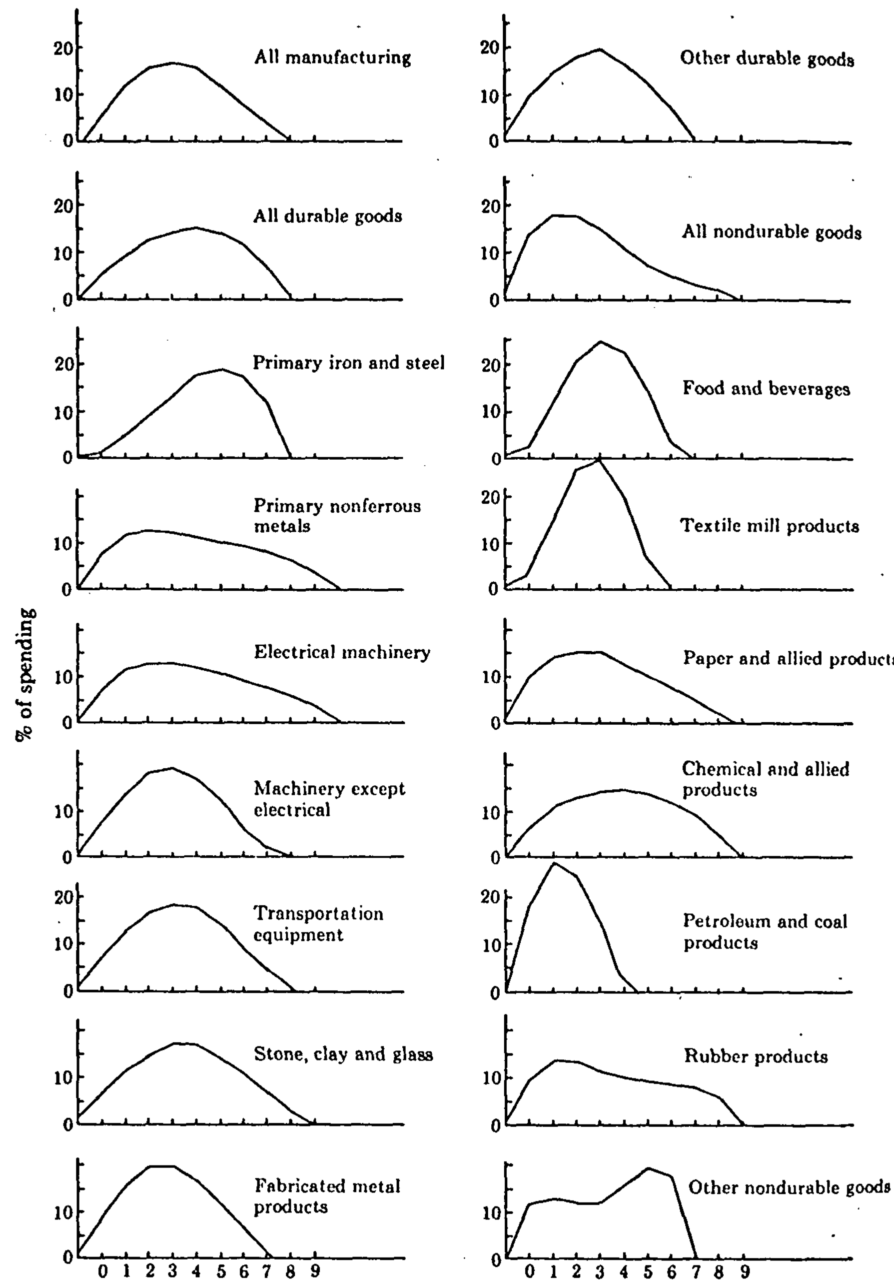
* Almon, Shirley, "The Distributed Lag Between Capital Appropriations and Expenditures," Econometrica, January, 1965, pp. 178-186.




Best Distributed Lags for Manufacturing Industries

Source: Reprinted from Shirley Almon's "The Distributed Lag Between Capital Appropriates and Expenditures", Econometrica, January 1965.

Third, instead of using total estimate of benefits, it may be more desirable to treat more specifically itemized benefit categories. Examples of such categories are regional property values, increase in labor productivity in terms of reduction of number of sick days due to the air pollution, increased demands for control devices and man-power requirement, etc. With more reliable data on each specific benefit category, the reliability of simulation output will be improved. Alternatively, specific parameters of the model may be judgmentally modified to reflect these changes.

# APPENDIX A

## A SELECTIVE SURVEY OF RECENT STUDIES OF THE ECONOMICS OF WATER QUALITY AND SOLID WASTE MANAGEMENT

# TABLE OF CONTENTS

## I. INTRODUCTION

A state-of-the-art survey of the literature relevant to the economics of water pollution and solid waste management was initiated as a first step in the assessment of feasibility of applying the current economic model system to water pollution control and solid waste management. This annotated bibliography was restricted to the most recent literature, apart from the classical references on environmental management.

Key words to characterize the selective literature survey provided in this working paper are:

- Economics of waste management,
- Costs of control,
- Key pollutant types by industrial classification, and
- Legislation and administration.

This bibliography was prepared by Teresa Romanowska-Lakshmanan, Library Consultant.

# II. BIBLIOGRAPHY

## A. STANDARDS AND CRITERIA FOR WATER POLLUTION CONTROL

1. National Association of Manufacturers. Water in Industry: A Survey of Water Use in Industry. New York, 1965.

Survey by type of industry, tables and data on industry water requirements.

2. Santaniello, R. M. "Water Quality Criteria and Standards for Industrial Pollution Control Effluents." Industrial Pollution Control Handbook. Edited by H. F. Lund. New York: McGraw-Hill, 1971, Chp. 4, pt. 2, pp. 4-23 -- 4-40.

The water physical and chemical pollutants are listed with the concise definition of each, the source and polluting effects, and required standards (or maximum permissible quantity present) of pollution control are given. Standards are designed to meet pollution control requirements of 1971.

3. U. S. Federal Water Pollution Control Administration. Water Quality Criteria. Report of the National Technical Advisory Committee to the Secretary of the Interior. Washington, D. C.: U. S. Government Printing Office, 1968, x, 234 p. ("literature cited" after each chapter).

Water pollution control standards for recreation and aesthetics, public water supplies, fish, other aquatic life and wildlife, agricultural uses, and industry (seven most polluting industries represented: (1) steam generation and cooling, (2) textile, lumber, paper, (3) chemical and allied products, (4) petroleum and coal, (5) primary metal industry, (6) food and kindred products, and (7) cement industry).

## B. SOURCES AND TYPES OF POLLUTANTS AND METHODS OF TREATMENT


4. Besselieve, E. B. The Treatment of Industrial Wastes. New York: McGraw-Hill, 1969.

This is one of the first comprehensive textbooks on the subject, with emphasis on cost analysis and modern management. A comprehensive coverage of the methods of waste water treatment given in chapter eight. The author has been a consultant on water pollution problems for many years. The textbook written for engineers but may be used by a non-technical reader.

5. Clark, J. W.; Viessman, Jr., W.; and Hammer, M. J. Water Supply and Pollution Control. 2nd ed. Scranton, Pennsylvania: International Textbook Company, 1971, 661 p. (bibliography included after each chapter).

Comprehensive coverage of problems of water supplies, requirements, and waste quantities. The systems for treating water and wastes and treatment processes are discussed in detail. Numerous mathematical formulae, tables, diagrams, and flow charts are given. Although meant for engineering students, may be used as a reference by a layman.

6. Culp, R. L.; and Culp, G. L. Advanced Waste Water Treatment. Cincinnati, Ohio: Van Nostrand Reinhold Company, 1971, 317 p.

This book describes the work on pollution abatement in Lake Tahoe, California. A concise description of characteristics of secondary effluents: organic, inorganic, particulates, viruses, is given. Several modern methods of secondary waste water treatments used at the Lake Tahoe Project are discussed. Emphasis is put on costs and efficiency of the methods. A long list of references, many tables, diagrams and statistics make this book an excellent reference tool, even for a layman.

7. Eckenfelder, W. W. Industrial Water Pollution Control. New York: McGraw-Hill, 1966, 275 p. (includes bibliographies).

A textbook on waste water treatment. Description of methods, many mathematical formulae and diagrams are given. A typical textbook for engineers. A summary of "Source and Characteristics of Industrial Wastes" is given in the first chapter.

8. Grava, S. Urban Planning Aspects of Water Pollution Control. New York: Columbia University Press, 1969, 223 p. (annotated bibliography, pp. 188-209).

A comprehensive coverage of the planning aspects of water pollution in the cities (a watershed management model, technological aspects of sewage, administrative and regulatory aspects, financial situation and local planning agencies) is given. Chapter three contains a description of "Source and Types of Pollutants," with some statistical data. This textbook constitutes one of the first efforts to present the pollution problem from the urban planning point of view. Reading may be useful to an interested layman.

9. Gurnham, C. F., ed. Industrial Waste Water Control: A Textbook and Reference Work. New York: Academic Press, 1965, 476 p.

A basic textbook on methods of waste water and solid wastes treatment in various industries (organic and inorganic). No mathematical formulae.

10. "Industrial Wastes Profile, No. 1-10." Vol. 3, pt. 1-10 of U. S. Federal Water Pollution Control Administration. The Cost of Clean Water. Washington, D.C.: U. S. Government Printing Office, January 10, 1968, 4 v.

This volume constitutes a detailed survey of the ten most polluting industries. The costs of the processes of waste reduction or removal from the polluted water are given. The summary tables, flow charts and diagrams are included.

11. "Inorganic Chemical Industry Product Profiles." Vol. 3, pt. 1-10, of U. S. Federal Water Pollution Control Administration. The Economics of Clean Water. Washington, D.C.: U. S. Government Printing Office, 1970, 4 v.

The appendix contains the survey of individual product profiles of inorganic chemical industry with data on 1969 and 1974 production tons/year, uses, process, and waste problem. Compiled from various available published sources. Process flow charts and summary cost pollution control tables are included.

12. "Inorganic Chemicals Industry Profile." Vol. 3, xvii, 467 p. of U. S. Federal Water Pollution Control Administration. The Economics of Clean Water. Washington, D. C.: U. S. Government Printing Office, 1970, 4 v.

The description of the inorganic chemical industries (product, technology, process, waster water treatment) and the costs that the industry would incur in attaining various levels of pollution abatement over the five-year period through 1974 are given. A description of manpower requirements for the operation and maintenance of foregoing waste treatment facilities is provided. The corresponding cost estimates are based on published data from Manufacturing Chemists Association. The summary tables and process flow charts are included. The detailed survey of the various industries is included in the Appendix C, pp. 178-244.

13. Klein, L. River Pollution. III: Control. London: Butterworths, 1966, 484 p. (list of references included).

A comprehensive coverage of pollution problems in the rivers: detection, measurement and abatement. Methods of sewage disposal and purification, and disposal and treatment of industrial waste water are discussed in detail. Many tables, diagrams, statistics and bibliographical references are given. This is a textbook for students in Great Britain. The water quality standards for rivers, sewage effluents and industrial waste water in the British content are given. Very useful for comparison of the situations in Great Britain and the United States.

14. Lund, H. F., ed. Industrial Pollution Control Handbook. New York: McGraw-Hill, 1971, lv. various paging.

Very comprehensive coverage of all aspects of the industrial pollution control. Designed to provide guidance in what should be done and how it can be done to eliminate pollution and prevent further pollution. History of Federal and state pollution control, pollution control by industry (every major industry where pollution is a major problem) have been described. Operating costs and procedures of industry pollution control engineering and pollution control equipment are discussed in detail. All throughout the book the emphasis is given to cost, efficiency of performance to attain new standard requirements, and up-to-date technology is given. May be used by interested layman.

15. "Pollution Control by Industry Problem." Industrial Pollution Control Handbook. Edited by H. F. Lund. New York: McGraw-Hill, 1971, Sections 2 and 3 (Chapters 10-26).

Air and water pollution control methods and equipment in ten major pollution industries are described. Emphasis on cost and efficiency of system operation. Up-to-date processes and equipment. The pollution control systems in European industries are included.

16. Ross, R. D. "Pollution Waste Control." Industrial Pollution Control Handbook. Edited by H. F. Lund. New York: McGraw-Hill, 1971, Chapter 7.

Description of sources, methods (engineering), and equipment of waste control. Up-to-date processes and equipment applied in disposal of gaseous wastes, liquid wastes and solid wastes are described in detail. The emphasis is on the efficiency of the treatment processes and cost estimates.

17. Sitting, M. Water Pollution Control and Solid Waste Disposal. (Chemical Process Review, No. 32). Park Ridge, New Jersey: Noyes Development Corporation, 1969, 244 p.

A short discussion of the problem of population growth and increase of solid waste and water pollution. The types of water pollutants from major polluting sources (watercraft, oil industry, chemical industry, etc.) and the processes of their removal are discussed in detail. Description of the processes are concise and based on up-to-date patented materials and methods. Numerous diagrams, photographs of the equipment and process flow charts are included. Good background reading on pollution sources and processes for a technician and a layman alike.

18. Tebbutt, T. H. Y. Principles of Water Quality Control. Oxford: Paragon Press, 1971, 179 p.

Concise textbook on characteristics of waters and waste waters, and treatments of waste water. Numerous tables and diagrams. Intended as an introductory textbook.

## C. ECONOMICS OF WATER RESOURCE DEVELOPMENT AND MANAGEMENT

19. Bramhall, D. F.; and Mills, E. S. "Alternative Methods of Improving Stream Quality: An Economic and Policy Analysis." Water Resources Research, Vol. 2 (3rd Quarter), 1966. pp. 355-363.

There are no market or other institutional mechanisms to register the benefits-and-costs of stream qualities. It is necessary to study economics of the design, as well as public policies, in treatment of stream qualities. There are two methods analyzed: (1) waste treatment, and (2) augmentation of low flow. Estimates of both methods are given for a stream in Maryland State, applicable to all humid eastern United States.

Conclusions are: (1) low flow augmentation is a less economical method than 90% waste removal by secondary treatment at the point of waste generation, and (2) a combination of effluent fees and enforcement is judged desirable.

The mathematical formula for determination of optimum process (model) is given, and public policies for improving water quality are evaluated. Includes mathematical formulae, diagrams and tables.

20. Cleary, E. J. The ORSANCO Story: Water Quality Management in the Ohio Valley Under an Interstate Compact. Baltimore: The Johns Hopkins Press, 1967, 335 p.

In this book, the experience of the Ohio River Valley Water Sanitary Commission is recorded and appraised by its executive director and chief engineer since its establishment in 1948. ORSANCO is a unique institution for water quality management with a remarkable record of accomplishment in combating water pollution through a large river valley and over the state's boundaries. Its story shows day-to-day problems in planning and enforcing the water pollution control. The political aspects, as well as technical aspects, are discussed.

21. Davis, R. K. The Range of Choice in Water Management: A Study of Dissolved Oxygen in the Potomac Estuary. With the contributions by R. M. Steinberg, L. J. Hetling, and N. C. Matalas. Baltimore: published for Resources for the Future by the Johns Hopkins Press, 1968, 196 p. (bibliographical footnotes).

The study is an application of economic analysis to the water resources planning process. Benefit-cost analysis is used in defining water quality level, developing system components and choice of alternatives in water quality management. Mathematical models are presented in detail. The political process in water management is discussed.

22. Goodman, A. S.; and Dobbins, W. E. "Mathematical Model for Water Pollution Control Studies." American Society of Civil Engineers, Journal of the Sanitary Engineering Division, Vol. 92, No. SA6, 1966, pp. 1-19.

The article discusses a methodology (model) for analysis of the physical, economic and administrative relationships in water pollution control. The model is devised for a river and tributaries. The water from the river is used as municipal water supply, disposal of treated sewage, and recreation by the population and industries along the river. The equations and procedures of pollution control are discussed in detail. The model may be applied in engineering and planning studies of pollution control. Numerous tables and diagrams are given. Very clear presentation may be useful to a layman interested in the problem.

23. Hammond, R. J. Benefit-Cost Analysis and Water-Pollution Control. Stanford: Stanford Food Research Institute, Stanford University, 1960, 95 p. (bibliography, pp. 81-88).

The book consists of a descriptive cost-benefit analysis of water pollution. It is the first summary of application of this method to water pollution control problem. No mathematical model given. Historical background of cost-benefit method application by Corps of Engineers to water reclamation projects, etc.; critic of late 1950's approach to cost-benefit is given. Very good analysis of water pollution problem, the pollution abatement and application of cost-benefit. Understandable to an educated layman.

24. Harvard Water Program, Harvard University. The Economics of Water Supply and Quality. For the Water Quality Office, Environmental Protection Agency. (Water Pollution Research Series 116 110 DTF 02/71). Washington, D.C.: February, 1971, 71 p.

The introduction is given in Section I.

Section II of the report discusses: the economics of clean water supply, drought and water supply shortage in municipal system planning, and includes a mathematical model for clean water system planning. Economics of water quality management for a river basin and a mathematical model are also discussed. The pollution problem is analyzed in municipal waste management problem with a discussion of cost-sharing schemes, and a model of municipal decision process. An estuary water quality management is given as a sample application of the model.

Section III consists of a monograph on water quality management. Reading requires some background in economics.

25. Hufschmidt, M.; and Fiering, M. B. Simulation Techniques for Design of Water Resource Systems. Cambridge: Harvard University Press, 1966.

Presentation of the simulation of a water resource system: (1) system definition, (2) data analysis, (3) system variables, (4) operating procedure, (5) cost and benefit functions, and (6) summary of economic analysis. This is a highly technical work, most of the book consists of the detailed analysis of the simulation program and its subroutines, with a chapter on lessons and future prospects of applications. Requires background in economics.

26. Karrer, D. A Systems Approach to the Establishment of a Basin Organization for Water Quality Management. Unpublished thesis, University of Pittsburgh, 1969.

Detailed analysis of the hypothetical, most efficient organization of a River Basin Commission, its authority and methods applied in pollution control. Hypothetical model for BOD content for effluent standards to estimate cost of waste treatment is included (pp. 79-83).

27. Kneese, A. V. The Economics of Regional Water Quality Management. Baltimore: The Johns Hopkins Press for Resources for the Future, 1964, 214 p. (bibliographical footnotes).

28. Kneese, A. V.; and Bower, B. T. Managing Water Quality: Economics, Technology, Institutions. Baltimore: The Johns Hopkins Press for Resources for the Future, 1968, 328 p. (bibliographical footnotes).

This book is a substantial revision and extension of the 1964 edition. It presents the water management problem and the pollution control problem in an exhaustive, but clear fashion.

The nature of the water quality problem is derived from three issues: What levels of quality?, How can a given level be achieved at least cost?, and What institutional and organizational arrangements are needed?

Water pollution is examined from the standpoint of type of pollutants, uses of water, managing of wastes. The economic concepts and policies for controlling pollution are analyzed for individual and regional systems.

The book is written very clearly and may be understood by a non-economist.

29. Maas, A., et al. Design of Water-Resource Systems: New Techniques for Relating Economic Objectives, Engineering Analysis, and Governmental Planning. By A. Mass, M. M. Hufschmidt, R. Dorfman, H. A. Thomas, Jr., S. A. Marglin, and G. M. Fair. Cambridge: Harvard University Press, 1962, 620 p. (bibliographical footnotes).

The book reports the results of a large-scale program devoted to the methodology of planning or designing complex, multiunit, multipurpose water resource systems. It is a detailed presentation of basic economic concepts of a system design (production function, net benefit function and optimality conditions), and the economic factors affecting the system (budgetary constraints, dynamics of water resource development). The model is presented in graphic and mathematical form. Conventional and new economic methods and techniques (simulation, mathematical model) are described. Also the governmental factors, i.e., influence of political process on system design is analyzed. Rather technical.

30. McJunkin, F. E. "Economics of Water Quality Management." Proceedings of the Fifteenth Southern Water Resources and Pollution Control Conference Sponsored by Duke University, North Carolina State University, and University of North Carolina. Held at North Carolina University, Raleigh, North Carolina, April 6-8, 1966, pp. 34-43 (list of references included).

This article presents a review of current (1960's) situation of public water policy, "the water resources of the State shall be prudently utilized in the best interest of the public." In the free market economy, such a policy allowed pollution to grow. Thus, the system approach to economic efficiency of pollution control or water quality management is discussed as one of the methods. The effluent charges, low flow augmentation are discussed as techniques that can be applied within the system.

Review of the trends in Federal policy for the future is also given.

31. Pillsbury, A. F., ed. *Proceedings of the Water Pricing Policy Conference, University of California, Los Angeles, 1968*. (University of California Water Resources Center, Report No. 13). Los Angeles: Water Resources Center, University of California, 1968, 109 p.

Discussion of several aspects of price of clean water use: role of planning in pricing water, economist role, and "production" of water, social constraints on water policy, and consumer's viewpoint and policy decisions.

32. Timmons, J. F. "Economics of Water Quality." *Water Pollution, Control and Abatement*. Edited by T. L. Willrich and N. W. Hines. Ames: Iowa State University Press, 1967, 194 p. (bibliographical references, pp. 33-50).

This article presents a general discussion on economics of water quality: (1) identifying levels of water quality, (2) the technological means for achieving particular water quality, i.e., cleaning of polluted waters, (3) criteria, (4) cost and benefits, and (5) structure of law and administrative procedures.

33. U. S. Federal Water Pollution Control Administration. *The Cost of Clean Water: Economic Impact on Affected Units of Government*. Washington, D.C.: U. S. Government Printing Office, 1968, 227 p.

This study presents and evaluates all available data on water-borne waste sources, treatment technology, control deficiency, and the requirements of state and local governments to achieve the desired water quality standards for beneficial uses. The study relates the requirements for sewage treatment plant construction in perspective to other competing proj-

ects confronting the affected units of government, and it appraises the major financial and legal problems which will be encountered in implementing the Water Quality Standards (Preface).

The requirements, capital outlays, financial ability of states, legal constraints on states and local governments in financing the require capital outlays are discussed. (Detailed tables included in Appendix IV, pp. 202-226.)

34. (1968) U. S. Federal Water Pollution Control Administration. The Cost of Clean Water. Washington, D. C.: U. S. Government Printing Office, January 10, 1968, 4 v.

Vol. 1: Summary Report, 39 p. ("references cited," p. 39).

This report presents summary and conclusions on initial estimates of the National requirements for and the costs of treating municipal, industrial and other effluents during the FY 1969-1973 to meet water quality standards established under the Water Pollution Act (1965, 1966).

Some of the findings are: (1) the cost of constructing waste treatment plants and interceptor sewers is estimated at $8 billion, (2) by 1973, the urban population required the sewer facilities will comprise circa 75% of the population of the country, (3) the significant cost reduction may be achieved through establishment of the intermunicipal sewage treatment and disposal system and districts, (4) better in-plant controls and process changes, and joint municipal and industrial treatment will improve efficiency of waste abatement, (5) operating costs will increase and continue to rise, and (6) constructing costs will require new capital outlays (charges, bonds, etc.).

Vol. 2: Detailed Analyses, in three parts, varioug paging.

Vol. 2, part I: Municipal Requirements and Cost Estimates, xv, 47 p. (bibliography, pp. 44-47).

The requirement for, and the costs of, treating municipal waste effluents to attain water quality standards during the FY 1969-1973 by state and water region are discussed.

The cost estimates include the requirements and costs of controlling water pollution from unsewered urban population and from combined sewer overflows since these, too, are related to the total problem. The costs are considerable. Summary tables included.

Vol. 2, part II: Industrial Requirements and Cost Estimates, pp. 51-163 (bibliography, pp. 153-163).

The volume of industrial wastes and then costs of methods of industrial waste control, unit costs, and cost of regional facilities are analyzed. Summary tables included.

Vol. 2, part III: Other Effluent Requirements and Cost Estimates, pp. 167-244 (bibliography, pp. 242-244).

Costs of control of wastes from watercraft, radioactive industrial wastes, erosion and sedimentation, acid mine drainage, feedlot pollution, pesticides, lake salinity, oil pollution are analyzed and estimates given. Summary tables included.

Vol. 3: Industrial Waste Profiles, No. 1-10, in ten parts, various paging.

The wastes produced by ten most polluting industries are discussed along the following lines: projected waste loads (in tons and dollars), the replacement values for the existing treatment facilities, as well as anticipated costs for future treatment practices in terms of capital and operating costs. Each industry has been surveyed in detail; the waste water sources are discussed, as well as treatment methods, and processes of production. Flow charts, diagrams and numerous tables are included.

Vol. 4: State Major River Basin Municipal Tables, v, 44 p.

Costs of standards attainment by 1973, adequate waste treatment, urban population used as measure of industrial maintenance and sanitary costs are discussed. Summary tables given (in 1968 dollars).

35. (1969) U. S. Federal Water Pollution Control Administration. The Cost of Clean Water and Its Economic Impact. Washington, D. C.: U. S. Government Printing Office, 1969, 4 v.

Vol. 1: The Report, xiv, 220 p.

This report updates the 1968 analysis of costs. The progress and needs of waste treatment facilities investment are analyzed. The conclusion being that current and expected rate on municipal investment are inadequate to meet the water quality requirements by 1973. The industry's corresponding rate has been more adequate. Summary tables, diagrams, maps included.

Vol. 2: Appendix, v, 541 p.
This appendix provides the statistical data from 1962 and 1968 Federal Water Pollution Control Administration Municipal Waste Treatment Inventories, and State water quality standards implementation plans.

Vol. 3: Sewage Charges, viii, 103 p. ("references cited," pp. 98-103).
This is a review of methods of financing waste water collection and treatment systems with discussion of the user charge program by local government units as a means of raising needed revenues. The analysis of various user charge systems is provided on the basis of results of a model system analysis.
The data on sewerage charges by state are presented in summary tables (Appendix).

Vol. 4: Projected Water Treatment Costs in the Organic Chemicals Industries.
(1) five-year projected range of cost estimates for attaining various levels of water pollution controls, and (2) improved methodology for projecting treatment cost estimates for other industries (models) are discussed.

36. (1970) U. S. Federal Water Pollution Control Administration. The Economics of Clean Water. Washington, D. C.: U. S. Government Printing Office, 1970, 4 v. (bibliography in vol. 3, pp. 460-467, Appendix F).

Vol. 1: Detailed Analysis, xi, 168 p., tables and charts.
Contains analysis of the investment trends and needs in pollution facilities treatment, Federal cost sharing, priority systems, public treatment of industrial wastes, regional-waste-handling systems, and the facilities evaluation model. Summary statistical tables are included.

Vol. 2: Animal Wastes Profile, xv, 85 p., tables, diagrams, maps.
Overview of animal wastes production, and of cost estimation, common characteristics of animal wastes discharged to water (by type of animal) and control methods are described.

Vol. 3: Inorganic Chemicals Industry Profile, xvii, 467 p. (bibliography, Appendix F, pp. 460-467).

Projected industry growth, waste water characteristics, treatment methods and industrial waste treatment practices, plant survey data, costs of unit waste water treatment methods, costs versus effluent quality relationships, projected industry costs and manpower requirements are discussed and statistical data included.

Vol. 4: Summary Report, ix, 41 p.

This report combines the concept of investment processes developed in the 1969 report with the generally held concept of an investment gap that was evaluated in the 1968 report.

Its product is the definition of rate of investment that will close the gap for municipal and industrial waste treatment facilities in the five year period (Introduction).

Sixteen summary tables on pollution control investments to substantiate the analysis are included.

37. (1971) U. S. Environmental Protection Agency, Water Quality Office. Cost of Clean Water. Washington, D. C.: U. S. Government Printing Office, March, 1971. 2 v.

Vol. 1: Municipal Investment Needs, xi, 21 p.

The 1970 studies on assessment of needs are described. Five summary cost tables are given in attachments.

The result of the 1970 studies led to a request for $6 billion Federal program, $2 billion in each of the FY 1972-1974 to meet the total investment goals of $12 billion.

Vol. 2: Cost Effectiveness and Clean Water, xiv, 128 p.

The emphasis is put on the discussion of inefficiencies of planning, design and operating of waste water treatments. The conclusion is drawn that while construction sector inflation and changing requirements will operate with increased cost, the convincing evidence is that substantial savings in investment requirements can result from cost-effective planning of municipal waste systems.

The result of the user charge study and cost analysis show that improvement of high order of municipal utility management and an adequate user charge system may lead to self-sufficient municipal systems freeing them from the dependency on Federal funds.

The investment needs of waste treatment facilities, trend of waste discharges, diseconomics in public waste management facilities, operation and maintenance costs are discussed in detail. Over 30 summary tables on costs are included, as well as maps and diagrams.

38. U. S. Federal Water Pollution Control Administration. Water Pollution Control, The Federal Costs, 1970/74. Washington, D. C., 1969, 36 p.

It is a financial report for 1970-1974 submitted to the Congress by the Federal Water Pollution Control Administration on the costs of carrying out provisions of the Federal Water Pollution Act of 1966.

Report includes cost estimates on: comprehensive programs for water pollution control, grants to non-Federal water pollution planning organization funds to uniform state laws and interstate cooperation, Resource Development and Demonstration Program (municipal pollution control, other sources of pollution control, water quality control, waste technology, and disposal, water quality requirements), costs of manpower and training, etc.

39. University of California, Graduate School of Business Administration. Mathematical Programming for Regional Water Quality Management (with references). Prepared for the U. S. Water Quality Administration, August, 1970. (Water Pollution Control Research Series, 16110FPX08/70). Washington, D. C.: U. S. Government Printing Office, 1970.

Non-linear programming has been applied to the problem of optimal water quality control in Delaware River Estuary. The mathematical model developed gives solutions to the general mixed case of a source treatment, regional treatment plans and bypass piping.

The results indicate that a regional treatment system for the Delaware Estuary is superior in terms of total cost to other proposed schemes. Model formula and variables are discussed. Statistical tables and diagrams are included.

40. Watson, K. S. "The Coordinated Industrial-Municipal-Regional Approach to Air and Water Pollution Control." Industrial Pollution Control Handbook. Edited by H. F. Lund. New York: McGraw-Hill, 1971, Chapter 8, 28 p.

Specific case of industrial, municipal and regional cooperation in water pollution control are described. The preparation, coordination and financing of a joint approach for industries are discussed. Regional air pollution control programs are also included.

For an extensive survey of cost-benefit studies on water pollution published in 1958-1967, see: Hinote, H. cf. 92.

D. ECONOMICS OF INDUSTRIAL WATER MANAGEMENT AND POLLUTION CONTROL

41. Berger, H. F. "Evaluating Water Reclamation Against Rising Costs of Water and Effluent Treatment." TAPPI, The Journal of the Technical Association of the Pulp and Paper Industry, Vol. 49, No. 8, 1966, pp. 79A-82A (diagrams and tables).

This is a description of a pilot plant for complete renovation of total effluent from an unbleached kraft effluent. The "cleaned up" water may be reused to avoid paying for new water and the reclaimed raw materials may be used again. Costs and methods of reclaiming water are given. A theoretical flow scheme for nearly closed kraft mill system is presented. Very clear presentation even to a non-technical reader.

42. Bubbis, N. S. "Industrial Waste Control in Metropolitan Winnepeg." Journal of Water Pollution Control Federation, Vol. 35, No. 11, 1963, pp. 1403-1409, Appendix.

Formula for surcharge of sewage payment is given (in the Appendix). Payment depends on effluent characteristics, BOD, chlorine demand, substances requiring additional treatment, including benefits on installation of the pre-treatment facilities, etc.

43. Davis, R. K. "Some Economic Aspects of Advanced Waste Treatments." Journal of the Water Pollution Control Federation, Vol. 37, No. 12 (December, 1965), pp. 1617-1628.

Originally prepared for presentation to the Senate Select Committee on Water Resources by Resources for the Future, Inc., the paper presents detailed discussion of the economics of optimization (or economic efficiency) of the waste water treatment in the Potomac Estuary. The derivation of waste treatment, requirements, costs, and the model are discussed. General conclusion: higher costs of waste water treatment are associated with low-flow of water because of high BOD. Several tables and diagrams are given.

44. First National Symposium on Food Processing Wastes Proceedings, April 6-8, 1970. Held in Portland, Oregon. Sponsored by Federal Water Quality Administration, Northwest Water Laboratory, U.S.D.A., Western Regional Research Laboratory,

National Canners Association, and Northwest Food Processors Association. Washington, D. C. : Federal Water Quality Administration, 1971, 405 p.

An in-depth review of current research and demonstration projects funded by the Federal Water Quality Administration on water pollution control research is presented, including research on improved in-plant and in-field processing intended to reduce the quantities of waste needing treatment in food industries.

45. Giglio, R. J., et al. "Regional Waste Water Management Systems." Developments in Water Quality Research. Proceedings of the Jerusalem International Conference on Water Quality and Pollution Research, June, 1969. Hillel I. Shuval, general editor. Ann Arbor, Michigan: Humphrey-Science Publisher, 1970, pp. 229-239.

General description of regional waste water management system. Discussion of a mathematical model as a tool for decision-making in planning. The subsystems of the model to be quantified for various alternatives are: collection system, trunk sewer, interceptor, treatment plant, and outfall sewer. A diagram of the system is given. The model may be applied to determine cost and feasibility of different alternatives to help decision-making. A regional model is discussed. Useful reading to an interested layman.

46. Kerri, K. D. "An Economic Approach to Water Quality Control." Journal of the Water Pollution Control Federation, Vol. 35, No. 12 (December, 1966), pp. 1883-1897.

A discussion of the methods of regulating pollution discharge: (1) effluent standards, and (2) stream standards. The model developed determines the degrees of treatment required of each waste discharger in order to achieve a desired quality of water at the minimum cost to all dischargers in the infested region. The model favors industries by reducing degree of treatment required because its marginal cost tends to be greater than that of the municipalities. The purpose of the model is to assist the regulatory agencies to examine discharge requirements savings to the industries, by requiring effluent standards instead of stream quality standards. The benefits from the model may exceed high data collection expenses. Many tables and diagrams are presented, but rather technical reading, requires economic background.

47. Olliffe, J. J. "Sewer Service Charges and Surcharges." Journal of the Water Pollution Control Federation, Vol. 35, No. 5 (1963), pp. 607-613.

The article deals with sewer and water charges developed in Pittsburgh, Pennsylvania. The Sanitary Authority of Allegheny County where Pittsburgh is located is the sole disposal agency, but the municipalities are responsible for delivery of sewage and industrial wastes to predetermined points in the Authority's sewer system. Tables on the detail of rates, analysis of rates, unit cost for quantity of sewage, etc., are given. Also formulas used for surcharges depending on BOD, SS, and chlorine demand are given. Very clearly presented analysis.

48. Paulson, E. G. "Water Pollution Control Programs and Systems." Industrial Pollution Control Handbook. Edited by H. F. Lund. New York: McGraw-Hill, 1971, Chapter 6.

Very clear description of how to construct a water pollution control system for discharged waste water. The phases of a full pollution control program are as follows: (1) definition of the problem and development of the action plan, (2) detailed engineering, (3) construction and start-up, and (4) implementation. Each of the phases is described in detail.

49. Rocheleau, R. F.; and Taylor, E. F. "An Industry Approach to Pollution Abatement." Journal of the Water Pollution Control Federation, Vol. 36, No. 10 (1964), pp. 1185-1194.

The article presents some control methods applied to waste water treatment. Emphasis is placed on in-plant waste water treatment. The industrial approach does not have to rely on conventional waste water treatment processes. Often the satisfactory water pollution control can be achieved by production process controls and improvements. General approach should be: Do not waste "Wastes." The difficulty lies in getting personnel to appreciate significance of the losses. One of the methods may be an application of in-plant charges for waste water discharge depending on quantity of waste. Production people are keenly aware of their production costs and may strive for its decrease by voluntary in-plant water quality control.

50. Russell, C. "Effluent Charges." Economics of Air and Water Pollution. Edited by W. R. Walker. (Virginia Polytechnic Institute, Blackburg, Water Resource Center, Bulletin 26). Blackburg, Virginia: Water Resources Research Center, Virginia Polytechnic Institute, 1969, pp. 37-55 (bibliographic references included.

An analysis of economics of effluent charges. Many tables.

51. Thomas, R. V.; and Marks, D. H. "Result from a System Analysis Approach to the Optimum Control of Estuarine Water Quality." Vol. 3 of Advances in Water Research Proceedings of the Third International Conference. Held in Munich, Germany, September, 1966. Washington, D.C.: Water Pollution Control Federation, 1967, pp. 29-48.

This paper presents some results from a system analysis approach to a given level of water quality for decision-making to arrive at a desired (specified) water quality level. The analysis is applied to the Delaware Estuary which is bordered by a large metropolitan and industrial area (oil and chemical). The basic mathematical model of physical environment and results of number of alternatives of water quality control model are discussed. Least-cost solutions are given.

52. Weddle, C. L.; Mukherjee, S. K.; Porter, J. W.; and Skarheim, H. P. "Mathematical Model for Water-Waste Systems." Journal of American Water Works Association, Vol. 62, No. 12 (December, 1970), pp. 769-775.

Determining most economical uses of all water sources, including conventional. Network analysis based model for selecting least-cost water supply and waste water disposal system for a municipal area.

53. Weston, R. F. "Environmental Quality Control by Industry: Problems and Solutions." Water and Sewage Works (Chicago), 1970 Reference Number (November 28, 1970), pp. R223-R227.

General views on pollution control, role of law enforcement, financial and technical problems to industry are given. The alternative methods as: (1) preventive measures, (2) on-site treatment, and (3) off-site treatment and/or disposal are mentioned. Definition of a role of a consultant, a designer and constructor is given. Some statistics and curves on BOD in petrochemical plant, monthly flow and biological treatment are presented.

E. ECONOMICS AND MANAGEMENT OF SOLID WASTE

54. Clark, R. M. "Economics of Solid Waste Investment Decisions." American Society of Civil Engineers, Journal of the Urban and Development Division, Proceedings, Vol. 96, No. UP1, Proc. Paper 7151 (March, 1970), pp. 65-79 (references, pp. 78-79).

The mathematical model of interdependence of engineering design, timing and money supply in solid waste investments is discussed. The mathematical formulae and variables are analyzed.

55. Combustion Engineering, Inc. Technical-Economic Study of Solid Waste Disposal Needs and Practices (Public Health Service Publication, 1886). Washington, D. C.: U. S. Government Printing Office, 1969, 4 v.

The report presents an analysis of the statistical data collected from 600 cities in 1966-1967 on the amount of refuse generated from residential and commercial sources, and on the number of installed incinerators and composting plants in the United States.

Analysis includes presentation of mathematical models to predict capacity of installed incinerators and composting plants in 1975 in the United States.

In addition, a mathematical model for the State of Connecticut to predict the quantities of commercial, residential and industrial waste production and the requirements for waste reduction facilities in 1975 is presented.

This comprehensive study is divided into four volumes: the "Municipal Inventory" is given in Volume I, the "Industrial Inventory" in Volume II, the "Information System" in Volume III, and "Technical Overview" in Volume IV.

Extensive statistical tables and lists of references are included.

56. Engdahl, R. B. Solid Waste Processing: A State-of-the-Art Report on Unit Operations and Processes. (U. S. Public Health Service Publication, 1856) Washington, D.C.: U.S. Government Printing Office, 1970, 77 p. (bibliography included).

Report is divided into two parts: (1) unit operations and processes, and (2) major waste categories. Part one includes concise description of the size reduction, separation, sanitary landfill and open dumping, incineration, chemical processing and recovery and utilization.

In part two, under the major waste categories, a short description of methods of disposal of major pollutants (over 110) is given in alphabetical order from Acetylen wastes through Zirconium.

The bibliography of over 500 entries is included. Many tables and diagrams are included.

The book, although meant for a technician, may be easily used by an interested layman.

57. Gluckman, L. A., ed. "Planning for Solid Waste Management." Symposium of State and Interstate Solid Waste Planning Agencies. September 9-11, 1969, St. Louis, Missouri. Washington, D.C.: U.S. Environmental Protection Agency, 1971, 91 p.

Reports on planning and data for solid waste disposal, intergovernmental cooperation, solid waste legislation, etc.

58. Golueke, C. G., and McGauhey, P. H. Comprehensive Studies of Solid Waste Management, First and Second Annual Reports. (Public Health Service Publication, 2039). Washington, D.C. Bureau of Solid Waste, HEW, 1970, 2 v. in one.

The First Annual Report discusses among the others, the following aspects of solid waste management: the waste generation and evaluation model and waste collection treatment-disposal model; planning and economics: the Santa Clara County study; public health and waste management; technology of solid waste management and technological processes of solid waste disposal (anaerobic digestion with sewage sludge, wet oxidation of organic wastes, biological fractiontation of organic wastes). Includes tables, diagrams and photos.

The Second Annual Report is structured along the same lines, reporting on continuation of the studies. The operation research part of the study concentrates on optimal location and flow pattern and optimalization of treatment operation. The mathematical formulae are analyzed.

Economics concentrates on analysis of costs data of the various treatment methods: hauling, landfill, composting, biofraction, wet oxidation, etc. In the public health section, very interesting summary tables are given on "Public Health Evaluation of Demestic Wastes," "Industrial Wastes," "Commercial Wastes," and "Special Wastes," i.e., junk automobiles. The tables take up over 20 pages. Bibliographies are included after each subject throughout the reports.

59. ______________. Comprehensive Studies of Solid Waste Management. Third Annual Report. Washington, D.C.: U. S. Environmental Protection Agency, 1971, 201 p.

This is a continuation of the First and Second Annual Reports. It concentrates on Planning and Economics; Review of Work to date is given. Structural models for various types of solid wastes are discussed in detail. The discussion of costs studies of different methods of solid waste disposal is continued. Model for ten-year forecasting of wastes loads for nine-county San Francisco Bay Region is given. In continuation of the processes of solid waste disposal (anerobic digestion, incineration, wet oxidation, etc.), the experimental unit construction is discussed.

60. Haskell, E. H. Managing the Environment: Nine States Look for New Answers. Washington, D.C.: Smithsonian Institution, April, 1971, 445 p.

This report describes recent changes initiated by nine state governments to improve their management of the environment. The focus is on governmental structures designed to give fresh impetus to existing environmental programs and on organizations which states have created to carry out a new state responsibility, such as land-use control and waste treatment and disposal. The analysis combines the institutional design with legal and environmental aspects. (Introduction)

61. Jones and Henry Engineers, Ltd. Proposal for a Refuse Disposal System in Oakland County, Michigan, Final Report on Solid Waste Demonstration Grant Project. (Public Health Service Publication, 1960). Washington, D.C.: Bureau of Solid Waste Management, HEW, 1970, 146 p.

Study presents proposed solutions of facility for solid waste disposals in a county. The design criteria, disposal methods, and proposed solutions and costs of reuse are discussed. Tables include population projections, solid waste in tons and costs.

Written clearly and not very technical, may be good reference for a layman.

62. Marks, D. H.; and Liebman, J. C. Mathematical Analysis of Solid Waste Collection, Final Report. (Public Health Service Publication, 2104). Washington, D.C.: Bureau of Solid Waste

Management, HEW, 1970, 196 p. (bibliography, pp. 191-196).

This report represents an application of operations research to the analysis of solid waste collection system in a large metropolitan area of Baltimore, Maryland.

A model for location of transfer facilities and large-scale truck operation for waste disposal is developed. The model may be applied to a smaller area with a smaller truck fleet. The formulae and statistical data are included. This is a final report on research work under Grant No. EC-00309 performed at Johns Hopkins University, Department of Geography and Environmental Engineering.

63. Morse, N.; and Roth, E. W. System Analysis of Regional Solid Waste Handling. (Public Health Service Pulbication, 2065). Washington, D. C.: Bureau of Solid Waste Management, HEW, 1970, 125 p., Appendices. (References, pp. 121-123).

This report presents a systems analysis of regional solid waste management -- the theoretical analysis, mathematical model and analysis of Buffalo (SMSA) as a sample area. Statistical tables and mathematical equations are given. Report was prepared at Cornell Aeronautical Laboratory, Inc., under Contract No. PH 86-67-254.

64. Muhlich, A. J.; Klee, A. J.; and Britton, P. W. Preliminary Data Analysis: 1968 National Survey of Community Solid Wastes Practices. (Public Health Service Publication, 1867). Washington, D. C.: U.S. Government Printing Office, 1968, 483 p.

The survey covers the SMSA's and communities of 5,000 population and smaller in 1967. The United States and territories are divided into nine regions, and survey includes all land disposal sites and public collectors, with exception of on-site disposal or reduction facilities such as apartment house incinerators and household garbage grinders or self-contained small business facilities.

Statistical analysis includes: national analysis, urban analysis, land disposal reports, and report on incinerators. Statistical data covers more than 50 headings such as ownership, size, actual amount of disposed matter, etc.

65. Muhlich, A. J.; Klee, A. J.; and Hampel, C. R. 1968 National Survey of Community Solid Waste Practices. (Public Health

Service Publication, 1866). Washington, D. C.: U.S. Government Printing Office, 1968, 9 v.

The 1968 National Survey of Community Solid Waste Practices is a statistical data compilation in nine volumes (one for each region).

The data are tabulated under such headings as community description, storage of refuse, disposal of refuse, budget and fiscal, collection of refuse, and many others.

66. (1966) National Academy of Sciences-National Research Council, Committee on Pollution. Waste Management and Control: A Report to the Federal Council for Science and Technology. (NAS-NRC Pulbication, 1400). Washington, D.C.: NAS-NRC, 1966, 257 p.

First comprehensive descriptive, qualitative and quantitative assessment of pollution problems; identifies the scientific and technological areas which could assist in controlling pollution. This analysis influenced the Federal policies in pollution control, and was instrumental in the creation of the Bureau of Solid Waste Management as a Federal institution responsible for solid waste pollution control. Sometimes called the Spilhaus Report from the name of the Committee Chairman, Athelstan Spilhaus.

67. (1970) National Academy of Sciences-National Academy of Engineering, Ad Hoc Committee on Solid Waste Management of the Division of Engineering, Committee on Pollution Abatement and NAS. Policies for Solid Waste Management. (Public Health Service Publication, 2018). Washington, D.C.: Bureau of Solid Waste Management, HEW, 1970, 64 p. (Selected Bibliography, pp. 58-64).

This report is an evaluation of the 1966 NAS-NRC report. The study analyses: institutional activities in present and future, NAS-NRC waste management recommendations, and functions of the Bureau of Solid Waste Management. The general view of solid waste technologies is included, as well as estimates of the costs of implementation of recommended action for the future objectives in solid waste management on the Federal level.

68. Ross, R. D., ed. Industrial Waste Disposal. (Van Nostrand-Reinhold Environmental Engineering Series). New York: Van Nostrand-Reinhold Company, 1971.

A textbook on the waste gas and waste liquid treatment, incineration, and radioactive waste management. The most recent engineering methods are presented with emphasis on environmental protection. Textbook for engineers.

69. Solid Waste Management Plan, Statute Report, 1970. Rockville, Maryland: U. S. Environmental Protection Agency, 1971-date, several volumes.

Reports submitted by 14 states (D. C., California, Kentucky, Oregon, etc.) to encourage systematic planning for better management of the nation's solid waste. Each report includes survey of laws and legislation, method of collection, disposal, environmental effects of solid waste (many documentary photographs of unsightly waste dumps), solid waste planning, etc. Includes statistics, maps, and diagrams.

70. Tofner, R. O. Developing a State Solid Waste Management Plan. (Public Health Service Publication, 2031). Washington, D. C.: U. S. Government Printing Office, 1970, 50 p.

Description of the basic features of the planning process and their utilization in the development of a state plan for its solid waste management. Purpose of this publication is to aid states in preparing comprehensive solid waste management plans. Flow chart of basic planning model is included.

71. Tofner, R. O.; and Clark, R. M. Intergovernmental Approaches to Solid Waste Management. Rockville, Maryland: Solid Waste Management Office, Environmental Protection Agency, 1971, 17 p.

Paper contains discussion of the form for intergovernmental coordination of solid waste management: SMSA? COG? Counties? Development of any intergovernmental system involves creation of a region-wide intergovernmental jurisdiction and an actual organization. The organization should have authority to manage and control solid wastes, therefore, must be given financial base, manpower and power of control and evaluation of the systems operation and performance.

72. Truitt, M. M.; Lieberman, J. C.; and Krause, C. W. Mathematical Modeling of Solid Waste Collection Policies. (Public Health Service Publication, 2030). Washington, D. C.: U. S. Government Printing Office, 2 v.

The report is a result of refuse collection survey in urban residential area of Baltimore and its environs. Three models were prepared (with different population densities, haul distances, size of trucks, etc.) for refuse collection system. The models may be applied to any city or urban area.

Discussion of the mathematical model is contained as an aid to decision-making for solid waste management is diccussed in volume two: "User's Guide to the Johns Hopkins Solid Waste Collection Simulation Model."

This is a final report on research work performed under Grant No. VI-00539 at Johns Hopkins University, Department of Geography and Environmental Engineering.

73. University of Louisville, Institute of Industrial Research. Louisville, Ky.-Ind. Metropolitan Region Solid Waste Disposal Study, Interim Report on Solid Waste Demonstration Project, Vol. 1: Jefferson County, Kentucky. Washington, D.C.: Bureau of Solid Waste Management, HEW, 1970, 205 p.

Study of current conditions of the area (SMSA) refuse quantities and composition, alternative disposal methods (transfer stations, sanitary landfill, incineration, etc.), transporation system analysis (model), and land requirements. An example of the interstate management organization.

74. U.S. Congress, House, 91st Congress, 2nd Session, Committee on Science and Astronautics, Subcommittee on Science Research and Development. Technology and Solid Waste Management. By A. S. Darney, Hearings, Technology Assessment, 1970. Washington, D.C.: U.S. Government Printing Office, 1970. pp. 901-913.

Discussion of the following current problems in solid waste management: (1) the increasing per capita generation of waste (table) (2) technical problems in waste processing, and (3) absence of markets for recoverable waste commodities due to uncontrolled production of new materials, which cause difficulities in equipment designed for traditional waste disposal and cannot be recovered.

New directons: (1) the waste management should anitcipate and prevent problems by monitoring the industries to prevent production of products which cannot be recycled, (2) there is a need for research in new methods and equipment of waste collection, and (3) necessity for reorganization on local levels for efficiency and more economic operations.

75. U. S. Department of Health, Education and Welfare. Solid Waste Program. Solid Waste Handling in Metropolitan Areas. prepared for the Surgion General's Advisory Committee on Urban Health Afiars. (Public Health Service Publication, 1554). Cincinnati, Ohio: Solid Waste Program, HEW, 1968, 41 p.

The economic impact and policy questions of solid waste handling are discussed among the other aspects. Concise summary of the waste problems in metropolitan areas. Bibliography and listing of the research projects between 1960-1964 are included.

76. Vaugham, R. D. Solid Waste Management: The Federal Role. Cincinnati, Ohio: U. S. Department of Health, Education and Welfare, 1969, 22 p.

Presented at the Environmental Equilibrium: Criteria, Cost, Cooperation, National Pollution Control Conference and Exposition, Houston, April 22-24, 1969.

77. Weaver, L., ed. Proceedings: The Surgeon General's Conference on Solid Waste Management for Metropolitan Washington, July 19-20, 1967. (Public Health Service Publication, 1729). Washington, D. C.: U. S. Government Printing Office, 1967, 194 p.

The proceedings of a two-day conference on various aspects of the solid waste disposal in metropolitan Washington, D. C. The subjects discussed are grouped under three large headings: Present practices and needs in the metropolitan area, Technology today, and Development of a regional solid waste disposal plan. The experience of Washington, D. C. may be applied to any metropolitan area.

## F. LEGISLATION AND ADMINISTRATION

78. Baldwin, F. B., ed. Legal Control of Water Pollution. (University of California Law Review, Vol. 1). Davis, California: School of Law, University of California, 1969, x, 273 p. (Bibliographical footnotes).

79. Blatnik, J. A. "History of Federal Pollution Control Legislation." Industrial Pollution Control Handbook. Edited by H. F. Lund. New York: McGraw-Hill, 1971, Chapter 2.

    Concise history of Federal acts pertaining to water pollution control since nineteenth century to present is given.

    Water Quality Act of 1965 and Clean Water Restoration Act of 1969 are analyzed in detail. In contrast to previous acts, the 1965-1966 Acts provided for a comprehensive water pollution control action. The Federal Water Pollution Control Administration has been established to carry out comprehensive studies of needs and costs of waste water treatment installations, to establish water quality standards, and to implement them in the next five years (1969-1975).

    Summary tables of sewage treatment needs in the largest 100 cities, and summary costs to meet the provisions of the Federal Pollution Act of 1966, and the Water Pollution Control Funding Gap are given.

80. Degler, S. E.; and Bloom, S. C. Federal Pollution Control Programs: Water, Air and Solid Wastes. Washington, D. C.: Bureau of National Affairs Books, 1969.

    Includes texts of legislations, Federal water pollution quality standards and enforcement programs.

81. Environmental Reporter: Federal Laws. Washington, D. C.: Bureau of National Affairs, 1970-date (loose leaf).

    Includes Federal laws on air and water pollution control, solid waste disposal, water supply, noise, pesticides and radiation.

82. Environmental Reporter: State Water Laws. Washington, D. C.: Bureau of National Affairs, 1970-date (loose leaf).

    Contains the water pollution control statutes of the 50 states, the District of Columbia and Puerto Rico, in full text.

83. League of Women Voters of the United States. Current Review of Water Resources, No. 3 (August, 1966).

Includes 24 bills for water pollution presented to the Congress in 1966.

84. Murphy, E. F. Water Purity: A Study in Legal Control of Natural Resources. Madison: University of Wisconsin Press, 1961, 212 p. (Bibliography, pp. 162-164).

The book presents a discussion of basis for water resource regulations, history of their changes, transition to central administration water pollution control, historical development and operation of the State central administrative agency. More than 80 legal cases against the water pollutants in Wisconsin and other states are discussed.

85. Solid Waste Disposal Act Amendment of 1968. Report of the Committee on Public Works, U. S. Senate, to accompany S. 3201, 90th Congress, 2nd Session, Report No. 1447. Washington, D. C.: U. S. Government Printing Office, 1968, 33 p.

86. The Solid Waste Disposal Act. Title II of Public Law 89-272, 89th Congress, S. 306, October 20, 1965, Public Law 91-512, 91st Congress, House 11833, October 26, 1970 as amended. Washington, D. C.: U. S. Environmental Protection Agency, Solid Waste Management Office, 1971, 17 p.

87. U. S. Congress, House, 91st Congress, 2nd Session, Committee on Public Works. Laws of the United States Relating to Water Pollution Control and Environmental Quality. (Committee Print, 91-33, July, 1970). Washington, D. C.: U. S. Government Printing Office, 1970, III, 265 p.

88. Wilkenfeld, J. "History of State and Local Pollution Laws." Industrial Pollution Control Handbook. Edited by H. F. Lund. New York: McGraw-Hill, 1971, Chapter 3.

Concise historical analysis of pollution control methods and trends through ancient times, middle ages, the Victorian age, and the modern age.

Detailed interpretation of Federal Water Quality Act implications to local governments. Short descriptions of several existing local legislations in New Jersey, New York, San Francisco Bay and others.

## G. BIBLIOGRAPHIES AND REFERENCE TOOLS

89. "Glossary: Industrial Air Pollution Control Terms, Industrial Water Pollution Control Terms." Industrial Pollution Control Handbook. Edited by H. F. Lund. New York: McGraw-Hill, 1971, pp. 1-39.

90. Golueke, C. G.; and Staff of the College of Engineering, University of California. Solid Waste Management: Abstracts and Excerpts from the Literature. (Public Health Service Publication, 2038). Washington, D.C.: Bureau of Solid Waste Management, HEW, 1968-1970, 3 v. (Vol. 1 (1968); Vol. 2 (July, 1969); Vol. 3 (August, 1970)).

This is an extensive bibliography with abstracts covering professional journal literature from 1958 through 1970. Some foreign literature is included. Extent of the coverage can be shown by listing just a few of the classifications covered: Management, Collection and Transport, Economics, Disposal, Salvage, Agricultural and Food Processing Waste, Environmental and Public Health, etc.

91. Great Britain. Ministry of Technology. Water Pollution Abstracts. London: Her Majesty's Stationary Office. (Vol. 42, 1969; Vol. 44, 1971).

Abstracts of literature in all aspects of water pollution are included.

92. Hinote, H. Benefit-Cost Analysis for Water Resource Projects: A Selected Annotated Bibliography. Rev. ed. Knoxville, Tennessee: Center for Business and Economic Research, University of Tennessee, June, 1969.

Extensive coverage of the cost-benefit studies done between 1958-1967. Detailed annotations included.

93. Lefke, L. W.; Keene, A. G.; and Chapman, R. A. Summaries of Solid Waste Research and Training Grants: 1970. Washington, D.C.: U. S. Environmental Protection Agency, Solid Waste Management Office, 1971, 134 p.

Listing of the research in progress on solid waste and its disposal in 1965-1975, supported by Federal grants. Each description includes the list of publications already issued in connection with the research. Subjects presented: Compost and

Composting, Farm Fields Wastes, Hospitals, Planning and Management, Reclamation and Reuse, etc.

94. Levine, B. S. U.S.S.R. Literature on Water Supply and Pollution Control, A Survey. Washington, D.C.: U. S. Department of Commerce, Clearinghouse for Federal and Scientific Information, 1962. (Vol. 1, 1961; Vol. 2, 1962; Vol. 3, 1962; Vol. 4, 1962; Vol. 5, no date; Vol. 6, "Condition for the Sanitary Discharge of Sewage and Waste Water into Natural Water Basins," By S.N. Cherkinskij, 1962 (translated from Russian by B.S. Levine).

These six volumes contain translations of articles from Russian technical journals in sanitary engineering, chemistry, biology and others dealing with water pollution. Emphasis is put on technical processes. Numerous diagrams, tables and bibliographies (in Russian) are included.

95. Pollution Abstracts. Published six times yearly (May, June, August, September, October, December. La Jolla, California: 6811 La Jolla Boulevard. (Vol. 1, 1970; Vol. 2, 1971).

96. Research in Selected Problems in Sewage Treatment Project, Bibliography on Coagulation and Sedimentation in Water and Sewage Treatment. Prepared with the assistance of official project No. 45-97-3-35, "Research in Selected Problems in Sewage Treatment." Directed by L. V. Carpenter. U. S. Work Projects Administration for the City of New York, 2nd ed., 1939.

Very thorough bibliography of technical processes in waste water treatment. Arranged in chronological sequence. May be useful from historical point of view.

97. Tofner, R. O., et al. State, Solid Waste Planning Grants Agencies and Progress, 1970. Report of activities through June 30, 1970. Washington, D.C.: U. S. Environmental Protection Agency, Solid Waste Management Office, 1971.

Listing of projects in progress in solid waste disposal research, by state.

98. U. S. Bureau of Solid Waste Management. Solid Waste Management: A List of Available Literature. Cincinnati: June, 1970.
__________, January, 1971.
__________, April, 1971.
__________, July, 1971.

Includes the list of publications available on request from the Bureau in Cincinnati. In subsequent lists, the out-of-print publications have been deleted.

99. U. S. Federal Water Pollution Control Administration. Water Pollution Control: Waste Treatment and Water Treatment, Selected Biological References on Fresh and Marine Waters. By. R. K. Stewart, W. M. Ingram, and K. M. MacKenthun. Washington, D.C.: 1966, 126 p. illus.

Selected references dealing with water quality and use have been prepared for persons interested in and responsible for biological aspects of water pollution control, waste treatment and water treatment.

Supercedes four previous publications: (1) Public Health Service Publication 214, 1953, (2) Public Health Service Publication 214, revised 1957, (3) Estuarine and Marine Pollution (Public Health Service Technical Report W-61-4, 1961), and (4) Public Health Service Publication 1053, 1963.

Most references of previous publications have been retained and selected references subsequent to 1962-1965 added.

100. U. S. Government Printing Office. Monthly Catalog of United States Government Publications. Washington, D.C.: 1969 to date.

List of the publications of all the branches of Federal government. The publications on water pollution, waste and economics are included.

101. U. S. Public Health Service. Handbook of Selected Biological References on Water Pollution Control, Sewage Treatment, Water Treatment, by W. M. Ingram. (Public Health Service Publication 214, Revised 1957). Washington, D.C.: U. S. Public Health Service, Water Supply and Water Pollution Control Program, 1957, 95 p. illus.

Selected biological references on water pollution control (including bottom organisms, fish, bioassays and methods, etc.), sewage treatment (including organisms of overall sewage treatment, organisms of oxidation ponds, etc.), water treatment (including taste and odor control, algae, insects, etc.), and on organism identification.

102. U. S. Public Health Service. Refuse Collection and Disposal: A Bibliography. (Public Health Service Bibliography Series, No. 4).

Complete listing of this series includes:

Refuse Collection and Disposal: A Bibliography, 1941-1950 (PHS Publication No. 91, 1951), out of print.

Refuse Collection and Disposal: A Bibliography, 1951-1953 (PHS Publication No. 91, Supplement A), 1954.

Refuse Collection and Disposal: An Annotated Bibliography, 1954-1955 (PHS Publication No. 91, Supplement B), 1956.

Refuse Collection and Disposal: An Annotated Bibliography, 1956-1957 (PHS Publication No. 91, Supplement C), 1958.

Refuse Collection and Disposal: An Annotated Bibliography, 1958-1959 (PHS Publication No. 91, Supplement D), 1961.

Refuse Collection and Disposal: An Annotated Bibliography, 1960-1961 (PHS Publication No. 91, Supplement E), 1963.

Refuse Collection and Disposal: An Annotated Bibliography, 1960-1961. By R. J. Black and P. L. Davis. Revised 1966. (PHS Publication No. 91, Supplement E, revised 1966).

Refuse Collection and Disposal: An Annotated Bibliography, 1962-1963. By R. J. Black, J. B. Wheeler and W. G. Henderson. (PHS Publication No. 91, Supplement F, 1966).

The main subjects covered are: regulations (including the legislations), finances, storage and various methods of collection and disposal.

H. Tables On Major Water Polluting Industries and Major Waste Categories

Table 1 -- Major Polluting Industries

| Code | |
|---|---|
| | Food and Kindred Products |
| 201 | Meat products |
| 2011 | Meat slaughtering plants |
| 2013 | Meat processing plants |
| 2015 | Poultry dressing plants |
| 202 | Dairies |
| 2021 | Creamery butter |
| 2022 | Natural and process cheese |
| 2023 | Condensed and evaporated milk |
| 2026 | Fluid milk |
| 203 | Canned and frozen foods |
| 2033 | Canned fruits and vegetables |
| 2034 | Dehydrated foods products |
| 2035 | Pickles, sauces, salad dressings |
| 2037 | Frozen fruits and vegetables |
| 204 | Grain mills |
| 2041 | Flour mills |
| 2043 | Cereal preparations |
| 2046 | Wet corn milling |
| 205 | Bakery products |
| 206 | Sugar |
| 207 | Candy and related products |
| 208 | Beverages |
| 2082 | Malt liquors |
| 2084 | Wines and brandy |
| 2085 | Distilled liquor |
| 2086 | Soft drinks |

Source: Lacy, W. J., and H. G. Keeler, "Federal Water Quality Administration Research, Development and Demonstration Program", the First National Symposium on Food Processing Wastes Proceedings, pp. 5-16. Washington, D.C.: Federal Water Control Administration, 1970.

Table 1 (continued)

| Code | |
|---|---|
| 209 | Miscellaneous foods and kindred products |
| 2091 | Cottonseed oil mills |
| 2092 | Soybean oil mills |
| 2094 | Animal and marine fats and oils |
| 2096 | Shortening and cooking oils |
| | Textile Mill Products |
| 2211 | Weaving mills, cotton |
| 2221 | Weaving mills, synthetic |
| 2231 | Weaving, finishing mills, wool |
| 225 | Knitting mills |
| 226 | Textile finishing, except wool |
| 228 | Yarn and thread mills |
| 229 | Miscellaneous textile goods |
| 24 | Lumber and Wood products |
| 242 | Sawmills and planing mills |
| 2421 | Sawmills and planing mills |
| 26 | Paper and Allied Products |
| 2611 | Pulp mills |
| 2621 | Paper mills, except building |
| 2631 | Paperboard mills |
| 264 | Paper and paperboard products |
| 265 | Paperboard containers and boxes |
| 2661 | Building paper and board mills |
| 28 | Chemicals and Allied Products |
| 281 | Basic chemicals |
| 2812 | Alkalies and chlorine |
| 2818 | Organic chemicals, n.e.c. |
| 2819 | Inorganic chemicals, n.e.c. |
| 282 | Fibers, plastics, rubbers |
| 2821 | Plastics materials and resins |
| 2823 | Cellulosic man-made fibers |
| 2824 | Organic fibers, noncellulosic |
| 283 | Drugs |

Table 1 (continued)

| Code | |
|---|---|
| 284 | Cleaning and toilet goods |
| 2851 | Paints and allied products |
| 2861 | Gum and wood chemicals |
| 287 | Agricultural chemicals |
| 289 | Miscellaneous chemical products |
| 29 | Petroleum and Coal Products |
| 2911 | Petroleum refining |
| 295 | Paving and roofing materials |
| 30 | Rubber and Plastics Products, n. e. c. |
| 3069 | Rubber products, n. e. c. |
| 3079 | Plastics products, n. e. c. |
| 31 | Leather and Leather Products |
| 3111 | Leather tanning and finishing |
| 32 | Stone, Clay, and Glass Products |
| 3211 | Flat glass |
| 3341 | Cement, hydraulic |
| 325 | Structural clay products |
| 326 | Pottery and related products |
| 327 | Concrete and plaster products |
| 3281 | Cut stone and stone products |
| 329 | Nonmetallic mineral products |
| 33 | Primary Metal Products |
| 331 | Steel rolling and finishing |
| 332 | Iron and steel foundries |
| 333 | Primary nonferrous metal |
| 3341 | Secondary nonferrous metals |

Table 2
Industrial Source vs. Significant Constituent Pollution

| Sector | Constituent | | | | | | |
|---|---|---|---|---|---|---|---|
| | BOD | SS | TDS | Acid | Heavy Metals | Oil | B[illegible] |
| Metal and metal products | | X | X | X | X | X | |
| Chemicals and allied products | X | X | | | | | |
| Power production | | | | | | | |
| Paper and allied products | X | X | | | | | |
| Petroleum and coal products | X | | X | | | X | |
| Food and kindred products | X | X | X | | | | |
| Machinery and transportation equipment | X | X | X | | X | | |
| Stone, clay and glass products | | X | X | | | | |
| Textile mill products | X | X | | | | | |
| Lumber and wood products | X | X | X | | | | |
| Rubber and plastic | X | X | | | | | |

Source: Lacy, W. J. and H. G. Keeler, "Federal Water Quality Administration, Research, Development and Demonstration Program," First National Symposium on Food Processing Wastes Proceedings, Washington, D.C., Federal Water Quality Administration, 1970.

Table 3
Waste Generation Coefficients, after Bower, RFF

| | Standard Industrial Classification Sector | Pounds BOD/Employee |
|---|---|---|
| 2011 | Meat packing | 4596 |
| 2026 | Fluid milk | 1770 |
| 2033 | Canned fruits and vegetables | 16200 |
| 2037 | Frozen fruits and vegetables | 24450 |
| 2061 | Raw cane sugar | 3336 |
| 2062 | Cane sugar refining | 3420 |
| 2085 | Distilled liquor | 3000 |
| 2261 | Finishing plants, cotton | 33200 |
| 2262 | Finishing plants, synthetic | 11580 |
| 2621 | Paper mills | 28960 |
| 2631 | Paperboard mills | 45200 |
| 2641 | Paper coating and glazing | 4260 |
| 2654 | Sanitary food containers | 4500 |
| 2911 | Petroleum refining | 8400 |
| 3111 | Leather tanning | 14700 |

Source: Lacy, W. J. and H. G. Keeler, "Federal Water Quality Administration, Research, Development and Demonstration Program," First National Symposium on Food Processing Wastes Proceedings, Washington, D. C., Federal Water Quality Administration, 1970.

Table 4

Major Waste Categories

Acetylene Wastes
Agricultural Wastes
Aluminum
Animal-Product Residues
Antimony
Asbestos
Ash, Cinders, Flue Dust, Fly Ash
Asphalt
Bagasse
Bauxite Residue
Beryllium
Bismuth
Brass
Brewing, Distilling, Fermenting Wastes
Brick Plant Waste
Bronze
Cadmium
Calcium
Carbides
Carbonaceous Shales
Chemical Wastes
Chromium
Cinders
Coal
Cobalt
Coffee
Coke-Oven Gas
Copper
Cotton
Dairy Wastes
Diamond Grinding Wheel Dust
Distilling Wastes
Electroplating Residues
Fermenting Wastes
Fish
Flue Dust
Fluorine
Fly Ash
Food-Processing Wastes
Foundry Wastes
Fruit Wastes
Furniture
Germanium
Glass
Glass Wool
Gypsum
Hemp
Hydrogen Fluoride
Inorganic Residues
Iron
Lead
Leather Fabricating and Tannery Wastes
Leaves
Lime
Magnesium
Manganese
Mica
Mineral Wool
Molasses
Molybdenum
Municipal Wastes
Nonferrous Scrap
Nuts
Nylon
Organic Wastes
Paint
Paper
Petroleum Residues
Photographic Paper
Pickle Liquor
Plastic
Poppy
Pottery Wastes
Precious Metals
Pulp and Paper
Pyrite Cinders and Tailings
Refractory
Refrigerators
Rice
Rubber
Sal Skimmings
Sand
Seafood
Shingles
Sisal
Slag
Sodium
Starch
Stone Spalls
Sugar Beets
Sugar Cane
Sulfur
Tantalum
Tetraethyllead
Textiles
Tin
Titanium
Tobacco
Tungsten
Uranium
Vanadium
Vegetable Wastes
Wastepaper
Wood Wastes
Wool
Yttrium
Zinc
Zircaloy
Zirconium

Source: Engdahl, R. B., Solid Waste Processing, A State-of-the-Art Report on Recent Operation Processes, 1969, U. S. Public Health Service Publication No. 1856.

# APPENDIX B

## FIVE KEY ECONOMIC INDICATORS OF 91 AQCRs UNDER ALTERNATIVE STRATEGIES FOR 1975 OR 1976

Strategy 1
Three Year Implementation 1973-1975 Without Government Financial Assistance For 1975
Benefit = $10.0 Billion

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 1 | New York, New York | - .11 | - 9.06 | - .04 | .096 | - .04 |
| 2 | Chicago, Illinois | - .84 | -14.08 | - .44 | .467 | - .70 |
| 3 | Los Angeles, Calif. | - .10 | - 5.18 | - .03 | .019 | - .03 |
| 4 | Philadelphia, Pa. | - .42 | - 7.04 | - .20 | .195 | - .29 |
| 5 | Detroit, Michigan | - .84 | - 9.09 | - .49 | .529 | - .64 |
| 6 | San Francisco, Calif. | - .72 | -23.88 | - .13 | .081 | - .13 |
| 7 | Boston, Mass. | - .20 | - 6.35 | - .08 | .105 | - .11 |
| 8 | Pittsburgh, Pa. | -3.26 | -28.11 | -1.56 | 1.089 | -2.28 |
| 9 | St. Louis, Missouri | -1.19 | -19.34 | - .61 | .614 | - .94 |
| 10 | Washington, D. C. | -1.58 | -24.42 | - .14 | .266 | - .16 |
| 11 | Cleveland, Ohio | -1.17 | -13.13 | - .52 | .399 | - .75 |
| 12 | Baltimore, Maryland | -1.32 | -15.84 | - .57 | .455 | - .65 |
| 14 | Minneapolis-St. Paul, Minnesota | - .25 | - 7.86 | - .15 | .211 | - .19 |
| 15 | Houston, Texas | - .57 | - 6.05 | - .30 | .161 | - .41 |
| 16 | Buffalo, New York | -1.61 | -16.42 | -1.01 | .751 | - .96 |
| 17 | Milwaukee, Wisconsin | -1.08 | -18.85 | - .83 | .906 | - .83 |
| 18 | Cincinnati, Ohio | - .58 | -12.02 | - .39 | .485 | - .51 |
| 19 | Louisville, Kentucky | - .44 | - 7.70 | - .47 | .584 | - .67 |
| 20 | Dallas, Texas | - .12 | - 2.38 | - .06 | .071 | - .11 |
| 21 | Seattle-Everett, Wash. | - .67 | -10.55 | - .24 | .176 | - .34 |
| 22 | Kansas City, Missouri | - .35 | -10.39 | - .20 | .159 | - .30 |
| 23 | San Diego, Calif. | .07 | - 1.24 | .01 | -.007 | .01 |
| 24 | Atlanta, Georgia | - .11 | - 4.97 | .07 | -.048 | .10 |
| 25 | Indianapolis, Indiana | - 1.06 | -22.19 | - .55 | .444 | - .80 |
| 26 | Miami, Florida | - .12 | - 2.38 | - .02 | .019 | - .03 |
| 27 | Denver, Colorado | - .37 | - 6.87 | - .15 | .190 | - .19 |
| 28 | New Orleans, Louisiana | - .32 | - 4.96 | - .08 | .038 | - .12 |
| 29 | Portland, Oregon | - .87 | -18.90 | - .32 | .277 | - .41 |
| 30 | Providence-Pawtuckett, Rhode Island | - .36 | - 6.34 | - .16 | .134 | - .26 |
| 31 | Phoenix, Arizona | - .26 | - 1.38 | - .14 | .225 | - .15 |
| 32 | Tampa, Florida | - .63 | - 8.94 | - .11 | .115 | - .13 |
| 33 | Columbus, Ohio | - .50 | - 7.65 | - .18 | .159 | - .27 |
| 34 | San Antonio, Texas | - .63 | - 6.56 | - .10 | .112 | - .16 |
| 35 | Dayton, Ohio | - .25 | - 4.76 | - .22 | .269 | - .33 |
| 36 | Birmingham, Alabama | -4.84 | -58.81 | -2.09 | 1.296 | -3.10 |
| 37 | Toledo, Ohio | -1.26 | -16.08 | - .76 | .616 | -1.07 |
| 38 | Steubenville-Weirton, Ohio/ Wheeling, West Virginia | -8.76 | -28.50 | -6.42 | 1.730 | -5.74 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. In-vest-ment | Reg. Per-sonal Inc. | Reg. Unem-mnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 39 | Chattanooga, Tenn. | - .99 | -11.62 | - .71 | .410 | - .86 |
| 40 | Memphis, Tennessee | - .31 | - 8.81 | - .12 | .071 | - .15 |
| 41 | Salt Lake City, Utah | - .32 | - 3.16 | - .12 | .194 | - .14 |
| 42 | Oklahoma City, Oklahoma | - .66 | - 7.20 | - .19 | .263 | - .27 |
| 43 | Omaha, Nebraska | - .41 | - 8.00 | - .30 | .547 | - .40 |
| 44 | Honolulu, Hawaii | - .30 | - 6.96 | - .04 | .040 | - .09 |
| 45 | Beaumont-Port Arthur-Orange, Texas | -3.50 | -18.61 | -4.53 | .899 | -4.60 |
| 46 | Charlotte, N. C. | - .28 | - 1.63 | - .22 | .378 | - .33 |
| 47 | Portland, Maine | - .43 | - 3.95 | - .26 | .427 | - .46 |
| 48 | Albuquerque, N. M. | - .10 | - 4.72 | - .00 | -.007 | - .01 |
| 50 | El Paso, Texas | .03 | - 1.81 | - .02 | .016 | - .03 |
| 51 | Las Vegas, Nevada | - .17 | - 1.80 | - .02 | .015 | - .02 |
| 52 | Fargo-Moorhead, N.D., Minnesota | -2.17 | -14.35 | - .42 | .742 | - .40 |
| 53 | Boise, Idaho | - .48 | - 8.83 | - .11 | .226 | - .15 |
| 54 | Billings, Montana | -5.00 | -39.58 | - .98 | 1.310 | -1.12 |
| 55 | Sioux City, Iowa | -2.02 | -133.60 | - .36 | .340 | - .49 |
| 61 | Allentown-Bethlehem-Easton, Pa. | -1.83 | -10.25 | - .98 | .840 | -1.56 |
| 63 | Bakersfield, Calif. | -8.89 | -75.14 | - .82 | 1.500 | - .57 |
| 64 | Davenport-Rock Island-Moline, Iowa, Illinois | -1.04 | - 4.98 | - .69 | .552 | - .90 |
| 66 | Grand Rapids/Muskegon-Muskegon Heights, Migh. | -1.15 | -10.72 | - .59 | .397 | - .60 |
| 67 | Greensboro, N. C. | - .32 | - 6.86 | - .20 | .121 | - .27 |
| 68 | Harrisburg, Pa. | -1.52 | -21.71 | - .60 | .644 | - .85 |
| 69 | Jacksonville, Florida | -1.69 | -15.53 | - .31 | .345 | - .50 |
| 70 | Knoxville, Tenn. | - .95 | -11.71 | - .51 | .553 | - .69 |
| 71 | Nashville, Tenn. | - .36 | - 4.85 | - .12 | .112 | - .16 |
| 72 | Peoria, Illinois | -1.17 | - 8.30 | - .70 | .572 | -1.07 |
| 73 | Richmond, Virginia | - .70 | - 7.16 | - .25 | .240 | - .43 |
| 74 | Rochester, New York | - .07 | - 2.71 | - .08 | .081 | - .08 |
| 75 | Saginaw/Bay City, Mich. | -1.29 | - 2.94 | - .77 | .842 | - .97 |
| 76 | Scranton/Wilkes Barre-Hazelton, Pa. | -2.21 | -35.07 | -1.23 | 1.780 | -2.20 |
| 77 | Syracuse, New York | -1.20 | -12.87 | - .65 | .754 | - .57 |
| 78 | Tulsa, Oklahoma | - .96 | -18.40 | - .29 | .209 | - .47 |
| 80 | Youngstown-Warren, Ohio | -2.95 | -33.29 | -1.90 | 1.226 | -2.94 |
| 81 | Albany-Schenectady-Troy, New York | -1.08 | -11.48 | - .39 | .372 | - .42 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 82 | Binghamton, New York | -.60 | -9.97 | -.44 | .600 | -.36 |
| 83 | Charleston, S.C. | -1.65 | -8.47 | -.31 | .384 | -.49 |
| 84 | Charleston, W. Va. | -1.11 | -8.31 | -.90 | .559 | -1.38 |
| 85 | Des Moines, Iowa | -1.80 | -23.05 | -.78 | .738 | -1.00 |
| 86 | Fresno, Calif. | -1.54 | -12.08 | -.35 | .574 | -.18 |
| 87 | Fort Wayne, Indiana | -.72 | -13.18 | -.32 | -.211 | -.55 |
| 88 | Jackson, Mississippi | -1.47 | -18.74 | -.37 | .384 | -.43 |
| 89 | Johnstown, Pa. | -1.05 | -5.52 | -.61 | .902 | -.80 |
| 90 | Lancaster, Pa. | -.93 | -15.55 | -.69 | .598 | -1.16 |
| 91 | Mobile, Alabama | -1.19 | -15.10 | -.37 | .375 | -.49 |
| 92 | Norfolk-Portsmouth/Newport News-Hampton, Va. | -1.32 | -16.86 | -.22 | .283 | -.28 |
| 93 | Raleigh/Durham, N.C. | -1.07 | -7.67 | -.35 | .758 | -.46 |
| 94 | Reading, Pa. | -2.23 | -35.21 | -1.14 | .864 | -1.86 |
| 95 | Rockford, Illinois | -.66 | -8.32 | -.47 | .288 | -.75 |
| 96 | Sacramento, Calif | -.72 | -9.91 | -.16 | .161 | -.12 |
| 97 | South Bend, Indiana | -.65 | -5.24 | -.50 | .696 | -.64 |
| 98 | Utica-Rome, New York | -1.42 | -24.22 | -.90 | .966 | -.85 |
| 99 | Wichita, Kansas | -.17 | -14.98 | -.14 | .172 | -.16 |
| 100 | York, Pa. | -.45 | -6.66 | -.31 | .339 | -.31 |

Strategy 2
Five Year Extended Implementation Without Government Financial Assistance for 1976
Benefit = $10.0 Billion

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 1 | New York, New York | -.16 | -6.79 | -.05 | .074 | -.04 |
| 2 | Chicago, Illinois | -.60 | -9.57 | -.34 | .393 | -.53 |
| 3 | Los Angeles, Calif. | -.12 | -3.94 | -.04 | .019 | -.04 |
| 4 | Philadelphia, Pa. | -.32 | -5.24 | -.16 | .155 | -.23 |
| 5 | Detroit, Michigan | -.56 | -6.43 | -.37 | .468 | -.48 |
| 6 | San Francisco, Calif. | -.58 | -18.23 | -.10 | .042 | -.10 |
| 7 | Boston, Mass. | -.25 | -5.30 | -.09 | .089 | -.12 |
| 8 | Pittsburgh, Pa. | -1.94 | -20.46 | -.97 | .739 | -1.41 |
| 9 | St. Louis, Missouri | -.85 | -13.26 | -.43 | .476 | -.65 |
| 10 | Washington, D. C. | -1.39 | -20.84 | -.16 | .251 | -.18 |
| 11 | Cleveland, Ohio | -.75 | -9.58 | -.29 | .213 | -.42 |
| 12 | Baltimore, Maryland | -.83 | -11.75 | -.37 | .297 | -.43 |
| 14 | Minneapolis-St. Paul, Minnesota | -.26 | -6.23 | -.15 | .176 | -.18 |
| 15 | Houston, Texas | -.50 | -4.79 | -.21 | .079 | -.28 |
| 16 | Buffalo, New York | -1.11 | -1.11 | -.67 | .44 | -.64 |
| 17 | Milwaukee, Wisconsin | -.84 | -14.90 | -.66 | .112 | -.66 |
| 18 | Cincinnati, Ohio | -.49 | -8.11 | -.34 | .433 | -.44 |
| 19 | Louisville, Kentucky | -.32 | -4.52 | -.38 | .512 | -.53 |
| 20 | Dallas, Texas | -.11 | -2.01 | .04 | -.062 | .07 |
| 21 | Seattle-Everett, Wash. | -.62 | -8.37 | -.22 | .155 | -.31 |
| 22 | Kansas City, Missouri | -.29 | -7.57 | -.13 | .113 | -.20 |
| 23 | San Diego, Calif. | -.01 | -1.01 | -.001 | -.00 | -.00 |
| 24 | Atlanta, Georgia | -.14 | -3.33 | -.07 | .080 | -.10 |
| 25 | Indianapolis, Indiana | -.93 | -17.42 | -.49 | .43 | -.71 |
| 26 | Miami, Florida | -.14 | -1.88 | -.02 | .026 | -.03 |
| 27 | Denver, Colorado | -.30 | -3.74 | -.14 | .218 | -.18 |
| 28 | New Orleans, Louisiana | -.28 | -3.82 | -.07 | .029 | -.10 |
| 29 | Portland, Oregon | -.65 | -14.60 | -.21 | .120 | -.27 |
| 30 | Providence-Pawtuckett, Rhode Island | -.24 | -4.50 | -.11 | .098 | -.17 |
| 31 | Phoenix, Arizona | -.37 | -2.50 | -.14 | .155 | -.16 |
| 32 | Tampa, Florida | -.41 | -5.01 | -.08 | .117 | -.10 |
| 33 | Columbus, Ohio | -.44 | -6.24 | -.13 | .081 | -.20 |
| 34 | San Antonio, Texas | -.55 | -5.93 | -.08 | .089 | -.13 |
| 35 | Dayton, Ohio | -.22 | -3.55 | -.20 | .230 | -.29 |
| 36 | Birmingham, Alabama | -2.21 | -38.75 | -1.21 | .826 | -1.80 |
| 37 | Toledo, Ohio | -.94 | -11.77 | -.60 | .539 | -.83 |
| 38 | Steubenville-Weirton, Ohio/ Wheeling, West Virginia | -6.41 | -19.39 | -5.29 | 1.568 | -4.74 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 39 | Chattanooga, Tenn. | -.83 | -9.10 | -.60 | .331 | -.72 |
| 40 | Memphis, Tennessee | -.35 | -6.96 | -.13 | .071 | -.16 |
| 41 | Salt Lake City, Utah | -.40 | -3.98 | -.11 | .131 | -.13 |
| 42 | Oklahoma City, Oklahoma | -.73 | -10.18 | -.17 | .180 | -.24 |
| 43 | Omaha, Nebraska | -.51 | -8.35 | -.28 | .398 | -.38 |
| 44 | Honolulu, Hawaii | -.27 | -4.73 | -.03 | .009 | -.06 |
| 45 | Beaumont-Port Arthur-Orange, Texas | -2.69 | -14.24 | -3.52 | .672 | -3.56 |
| 46 | Charlotte, N. C. | -.38 | -2.20 | -.18 | .25 | -.27 |
| 47 | Portland, Maine | -.41 | -4.43 | -.20 | .285 | -.38 |
| 48 | Albuquerque, N. M. | -.15 | -3.87 | -.01 | -.008 | -.01 |
| 50 | El Paso, Texas | -.06 | -1.88 | -.01 | .006 | -.01 |
| 51 | Las Vegas, Nevada | -.20 | -1.50 | -.02 | .013 | -.02 |
| 52 | Fargo-Moorhead, N.D., Minnesota | -1.93 | -19.21 | -.27 | .428 | -.25 |
| 53 | Boise, Idaho | -.71 | -16.75 | .05 | -.007 | .07 |
| 54 | Billings, Montana | -4.74 | -36.80 | -1.43 | 1.441 | -1.63 |
| 55 | Sioux City, Iowa | -1.91 | -118.36 | -.33 | .260 | -.45 |
| 61 | Allentown-Bethlehem-Easton, Pa. | -1.33 | -8.97 | -.67 | .541 | -1.08 |
| 63 | Bakersfield, Calif. | -7.45 | -66.42 | -.66 | 1.159 | -.45 |
| 64 | Davenport-Rock Island-Moline, Iowa, Illinois | -.75 | -4.94 | -.46 | .322 | -.61 |
| 66 | Grand Rapids/Muskegon-Muskegon Heights, Migh. | -.94 | -8.83 | -.48 | .310 | -.48 |
| 67 | Greensboro, N. C. | -.30 | -5.33 | -.21 | .144 | -.28 |
| 68 | Harrisburg, Pa. | -1.44 | -24.03 | -.49 | .430 | -.70 |
| 69 | Jacksonville, Florida | -1.49 | -14.66 | -.25 | .25 | -.40 |
| 70. | Knoxville, Tenn. | -.94 | -13.34 | -.41 | .371 | -.56 |
| 71 | Nashville, Tenn. | -.42 | -4.55 | -.13 | .095 | -.18 |
| 72 | Peoria, Illinois | -.99 | -7.40 | -.55 | .397 | -.85 |
| 73 | Richmond, Virginia | -.68 | -6.76 | -.22 | .179 | -.38 |
| 74 | Rochester, New York | -.19 | -2.50 | -.18 | .152 | -.19 |
| 75 | Saginaw/Bay City, Mich. | -1.10 | -2.53 | -.62 | .644 | -.74 |
| 76 | Scranton/Wilkes Barre-Hazelton, Pa. | -2.29 | -49.01 | -1.08 | 1.248 | -1.93 |
| 77 | Syracuse, New York - | -1.09 | -12.74 | -.52 | .506 | -.46 |
| 78 | Tulsa, Oklahoma | -.96 | -20.29 | -.24 | .21 | -.40 |
| 80 | Youngstown-Warren, Ohio | -1.86 | -28.13 | -1.19 | .754 | -1.84 |
| 81 | Albany-Schenectady-Troy, New York | -.95 | -9.56 | -.34 | .326 | -.37 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 82 | Binghamton, New York | -.63 | -10.28 | -.39 | .427 | -.31 |
| 83 | Charleston, S. C. | -1.66 | -9.84 | -.25 | .256 | -.40 |
| 84 | Charleston, W. Va. | -.92 | -7.00 | -1.03 | .649 | -1.58 |
| 85 | Des Moines, Iowa | -1.51 | -19.77 | -.63 | .564 | -.80 |
| 86 | Fresno, Calif. | -1.32 | -12.04 | -.26 | .379 | -.14 |
| 87 | Fort Wayne, Indiana | -.61 | -11.08 | -.26 | -.158 | -.44 |
| 88 | Jackson, Mississippi | -1.28 | -17.68 | -.29 | .265 | -.34 |
| 89 | Johnstown, Pa. | -1.12 | -7.95 | -.52 | .569 | -.68 |
| 90 | Lancaster, Pa. | -.90 | -15.32 | -.60 | .406 | -1.00 |
| 91 | Mobile, Alabama | -1.32 | -14.87 | -.39 | .327 | -.50 |
| 92 | Norfolk-Portsmouth/Newport News-Hampton, Va. | -1.21 | -17.25 | -.19 | .203 | -.24 |
| 93 | Raleigh/Durham, N. C. | -1.04 | -8.86 | -.29 | .512 | -.39 |
| 94 | Reading, Pa. | -1.74 | -29.80 | -.85 | .589 | -.39 |
| 95 | Rockford, Illinois | -.63 | -7.92 | -.41 | .202 | -.66 |
| 96 | Sacramento, Calif | -.61 | -8.79 | -.12 | .102 | -.09 |
| 97 | South Bend, Indiana | -.60 | -6.66 | -.40 | .469 | -.52 |
| 98 | Utica-Rome, New York | -1.10 | -21.05 | -.67 | .654 | -.62 |
| 99 | Wichita, Kansas | -.29 | -13.07 | -.16 | .130 | -.19 |
| 100 | York, Pa. | -.46 | -5.94 | -.27 | .243 | -.28 |

Strategy 3
Three Year Implementation 1973-1975 With Government Financial Assistance
Benefits = $10.0 Billion

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 1 | New York, New York | - .06 | - 3.56 | - .04 | .086 | - .03 |
| 2 | Chicago, Illinois | - .34 | - 5.37 | - .18 | .193 | - .29 |
| 3 | Los Angeles, Calif. | - .03 | - 2.06 | - .01 | .005 | - .01 |
| 4 | Philadelphia, Pa. | - .17 | - 2.79 | - .08 | .080 | - .12 |
| 5 | Detroit, Michigan | - .36 | - 3.60 | - .22 | .239 | - .29 |
| 6 | San Francisco, Calif. | - .30 | - 8.59 | - .06 | .051 | = .06 |
| 7 | Boston, Mass. | - .06 | - 2.50 | - .04 | .047 | - .04 |
| 8 | Pittsburgh, Pa. | -1.45 | -10.24 | - .68 | .450 | - .99 |
| 9 | St. Louis, Missouri | - .49 | - 7.17 | - .24 | .243 | - .37 |
| 10 | Washington, D. C. | - .55 | - 8.67 | - .06 | .098 | - .08 |
| 11 | Cleveland, Ohio | - .50 | - 5.08 | - .19 | .126 | - .27 |
| 12 | Baltimore, Maryland | - .58 | - 6.08 | - .24 | .189 | - .28 |
| 14 | Minneapolis-St. Paul, | - .06 | - 3.03 | - .03 | .014 | - .03 |
| | Minnesota | - .06 | - 3.03 | - .03 | ,014 | - .03 |
| 15 | Houston, Texas | - .22 | - 2.39 | - .13 | .076 | - .18 |
| 16 | Buffalo, New York | - .70 | - 6.26 | - .44 | .321 | - .42 |
| 17 | Milwaukee, Wisconsin | - .44 | - 7.02 | - .34 | .371 | - .34 |
| 18 | Cincinnati, Ohio | - .22 | - 4.60 | - .16 | .212 | - .21 |
| 19 | Louisville, Kentucky | - .17 | - 3.01 | - .18 | .235 | - .25 |
| 20 | Dallas, Texas | - .04 | - .97 | - .03 | .031 | - .05 |
| 21 | Seattle-Everett, Wash. | - .26 | - 4.07 | - .09. | .072 | - .13 |
| 22 | Kansas City, Missouri | - .13 | - 4.02 | - .04 | .028 | - .06 |
| 23 | San Diego, Calif. | + .04 | - .50 | + .03 | -.033 | + .03 |
| 24 | Atlanta, Georgia | - .04 | - 1.99 | - .14 | .146 | - .20 |
| 25 | Indianapolis, Indiana | - .44 | - 8.07 | - .24 | .227 | - .34 |
| 26 | Miami, Florida | - .02 | - .95 | + .00 | -.016 | + .00 |
| 27 | Denver, Colorado | - .14 | - 2.70 | - .06 | .088 | - .08 |
| 28 | New Orleans, Louisiana | - .12 | - 1.98 | - .03 | .015 | = .05 |
| 29 | Portland, Oregon | - .26 | - 6.91 | - .04 | -.079 | - .05 |
| 30 | Providence-Pawtuckett, Rhode Island | - .16 | - 2.56 | - .07 | .623 | - .11 |
| 31 | Phoenix, Arizona | - .11 | - .57 | - .06 | .092 | - .06 |
| 32 | Tampa, Florida | - .25 | - 3.47 | - .04 | .038 | - .05 |
| 33 | Columbus, Ohio | - .18 | - 2.99 | - .06 | .047 | - .09 |
| 34 | San Antonio, Texas | - .26 | - 2.59 | - .04 | .047 | - .07 |
| 35 | Dayton, Ohio | - .10 | - 1.90 | - .09 | .106 | - .13 |
| 36 | Birmingham, Alabama | -2.14 | -18.66 | - .93 | .570 | -1.38 |
| 37 | Toledo, Ohio | - .51 | - 6.03 | - .31 | .253 | - .43 |
| 38 | Steubenville-Weirton, Ohio/ Wheeling, West Virginia | - .32 | -10.13 | -2.60 | .699 | -2.33 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 39 | Chattanooga, Tenn. | - .39 | - 4.46 | - .27 | .152 | - .32 |
| 40 | Memphis, Tennessee | - .10 | - 3.41 | - .04 | .028 | - .05 |
| 41 | Salt Lake City, Utah | - .12 | - 1.27 | - .06 | .085 | - .07 |
| 42 | Oklahoma City, Oklahoma | - .27 | - 2.84 | - .08 | .106 | - .11 |
| 43 | Omaha, Nebraska | - .13 | - 3.10 | - .10 | .198 | - .14 |
| 44 | Honolulu, Hawaii | - .10 | - 2.72 | - .01 | .014 | - .03 |
| 45 | Beaumont-Port Arthur-Orange, Texas | -1.41 | - 6.85 | -1.81 | .367 | -1.83 |
| 46 | Charlotte, N. C. | - .10 | - .66 | - .04 | .113 | - .06 |
| 47 | Portland, Maine | - .19 | - 1.60 | +1.80 | -1.567 | +3.31 |
| 48 | Albuquerque, N. M. | - .07 | - 1.92 | - .01 | .061 | - .01 |
| 50 | El Paso, Texas | + .03 | - .72 | - .02 | .018 | - .03 |
| 51 | Las Vegas, Nevada | - .10 | - .74 | - .02 | .038 | - .02 |
| 52 | Fargo-Moorhead, N.D., Minnesota | - .88 | - 5.47 | - .18 | .308 | - .17 |
| 53 | Boise, Idaho | - .18 | - 3.44 | - .07 | .120 | - .10 |
| 54 | Billings, Montana | -1.94 | -13.40 | - .62 | .746 | - .71 |
| 55 | Sioux City, Iowa | - .76 | -30.39 | - .15 | .145 | - .20 |
| 61 | Allentown-Bethlehem-Easton, Pa. | - .79 | - 4.07 | - .42 | .350 | - .67 |
| 63 | Bakersfield, Calif. | -3.52 | -22.82 | - .34 | .614 | - .23 |
| 64 | Davenport-Rock Island-Moline, Iowa, Illinois | - .46 | - 2.05 | - .29 | .288 | - .38 |
| 66 | Grand Rapids/Muskegon-Muskegon Heights, Migh. | - .46 | - 4.16 | - .24 | .157 | - .24 |
| 67 | Greensboro, N. C. | - .12 | - 2.71 | - .68 | .043 | - .10 |
| 68 | Harrisburg, Pa. | - .63 | - 8.02 | - .26 | .284 | - .38 |
| 69 | Jacksonville, Florida | - .69 | - 5.91 | - .13 | .146 | - .21 |
| 70 | Knoxville, Tenn. | - .39 | - 4.55 | - .20 | .224 | - .27 |
| 71 | Nashville, Tenn. | - .13 | - 1.93 | - .04 | .046 | - .06 |
| 72 | Peoria, Illinois | - .48 | - 3.28 | - .29 | .236 | - .44 |
| 73 | Richmond, Virginia | - .28 | - 2.84 | - .10 | .098 | - .17 |
| 74 | Rochester, New York | - .01 | - 1.09 | - .02 | .028 | - .02 |
| 75 | Saginaw/Bay City, Mich. | - .53 | - 1.19 | - .32 | .347 | - .40 |
| 76 | Scranton/Wilkes Barre-Hazelton, Pa. | - .90 | -12.38 | - .49 | .179 | - .88 |
| 77 | Syracuse, New York | - .49 | - 4.98 | - .26 | .298 | - .23 |
| 78 | Tulsa, Oklahoma | - .38 | - 6.88 | - .11 | .121 | - .19 |
| 80 | Youngstown-Warren, Ohio | -1.33 | -12.11 | - .86 | .549 | - 1.33 |
| 81 | Albany-Schenectady-Troy, New York | - .44 | - 4.47 | - .16 | .156 | - .17 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 82 | Binghamton, New York | - .22 | - 3.88 | - .16 | .214 | - .13 |
| 83 | Charleston, S. C. | - .67 | - 3.34 | - .12 | .155 | - .20 |
| 84 | Charleston, W. Va. | - .46 | - 3.27 | - .04 | -.002 | - .06 |
| 85 | Des Moines, Iowa | - .73 | - 8.50 | - .30 | .282 | - .38 |
| 86 | Fresno, Calif. | - .63 | - 4.66 | - .13 | .225 | - .07 |
| 87 | Fort Wayne, Indiana | - .29 | - 5.03 | - .13 | .087 | - .22 |
| 88 | Jackson, Mississippi | - .59 | - 7.02 | - .14 | .146 | - .17 |
| 89 | Johnstown, Pa. | - .42 | - 2.20 | - .24 | .348 | - .32 |
| 90 | Lancaster, Pa. | - .37 | - 5.91 | - .28 | .245 | - .47 |
| 91 | Mobile, Alabama | - .45 | - 5.72 | - .19 | .187 | - .25 |
| 92 | Norfolk-Portsmouth/Newport News-Hampton, Va. | - .56 | - 6.41 | - .10 | .136 | - .13 |
| 93 | Raleigh/Durham, N. C. | - .44 | - 3.04 | - .14 | .312 | - .19 |
| 94 | Reading, Pa. | - .93 | -12.16 | - .48 | .360 | - .78 |
| 95 | Rockford, Illinois | - .27 | - 3.27 | - .19 | .118 | - .31 |
| 96 | Sacramento, Calif | - .29 | - 3.85 | - .06 | .063 | - .05 |
| 97 | South Bend, Indiana | - .26 | - 2.48 | - .19 | .264 | - .25 |
| 98 | Utica-Rome, New York | - .60 | - 8.91 | - .38 | .398 | - .35 |
| 99 | Wichita, Kansas | - .05 | - 5.59 | - .04 | .066 | - .05 |
| 100 | York, Pa. | - .18 | - 2.64 | - .12 | .138 | - .12 |

Strategy 4
Five Year Extended Implementation 1973-77
With Government Assistance
Benefit = $10.0 Billion

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 1 | New York, New York | -.09 | -2.74 | -.04 | .081 | -.03 |
| 2 | Chicago, Illinois | -.24 | -3.69 | -.14 | .158 | -.21 |
| 3 | Los Angeles, Calif. | -.04 | -1.57 | -.02 | .010 | -.02 |
| 4 | Philadelphia, Pa. | -.13 | -2.08 | -.06 | .060 | -.09 |
| 5 | Detroit, Michigan | -.24 | -2.56 | -.16 | .192 | -.20 |
| 6 | San Francisco, Calif. | -.24 | -6.59 | -.05 | .027 | -.05 |
| 7 | Boston, Mass. | -.09 | -2.09 | -.03 | .037 | -.05 |
| 8 | Pittsburgh, Pa. | -.87 | -7.49 | -.41 | .305 | -.60 |
| 9 | St. Louis, Missouri | -.35 | -4.98 | -.20 | .222 | -.31 |
| 10 | Washington, D. C. | -.56 | -7.41 | -.07 | .107 | -.08 |
| 11 | Cleveland, Ohio | -.34 | -3.74 | -.11 | .093 | -.15 |
| 12 | Baltimore, Maryland | -.36 | -4.51 | -.15 | .118 | -.17 |
| 14 | Minneapolis-St. Paul, Minnesota | -.10 | -2.42 | -.06 | .075 | -.08 |
| 15 | Houston, Texas | -.20 | -1.89 | -.08 | .032 | -.11 |
| 16 | Buffalo, New York | -.45 | -4.95 | -.25 | .116 | -.24 |
| 17 | Milwaukee, Wisconsin | -.35 | -5.55 | -.27 | .290 | -.27 |
| 18 | Cincinnati, Ohio | -.19 | -3.14 | -.13 | .171 | -.17 |
| 19 | Louisville, Kentucky | -.12 | -1.79 | -.14 | .194 | -.19 |
| 20 | Dallas, Texas | -.07 | - .83 | +.03 | -.001 | +.06 |
| 21 | Seattle-Everett, Wash. | -.24 | -3.23 | -.09 | .065 | -.12 |
| 22 | Kansas City, Missouri | -.11 | -2.94 | -.14 | .129 | -.21 |
| 23 | San Diego, Calif. | +.01 | - .40 | +.00 | -.001 | +.00 |
| 24 | Atlanta, Georgia | -.05 | -1.33 | -.02 | .032 | -.04 |
| 25 | Indianapolis, Indiana | -.37 | -6.34 | -.20 | .171 | -.28 |
| 26 | Miami, Florida | +.03 | -.70 | +.03 | -.099 | +.05 |
| 27 | Denver, Colorado | -.15 | -1.53 | -.09 | .159 | -.11 |
| 28 | New Orleans, Louisiana | -.11 | -1.53 | -.03 | .012 | -.04 |
| 29 | Portland, Oregon | -.27 | -5.42 | -.09 | .058 | -.12 |
| 30 | Providence-Pawtuckett, Rhode Island | -.10 | -1.82 | -.05 | .045 | -.08 |
| 31 | Phoenix, Arizona | -.15 | -1.01 | -.06 | .062 | -.07 |
| 32 | Tampa, Florida | -.08 | -1.89 | +.00 | -.033 | +.00 |
| 33 | Columbus, Ohio | -.18 | -2.45 | -.05 | .036 | -.08 |
| 34 | San Antonio, Texas | -.22 | -2.32 | -.03 | .030 | -.05 |
| 35 | Dayton, Ohio | -.09 | -1.43 | -.09 | .111 | -.13 |
| 36 | Birmingham, Alabama | -1.21 | -12.78 | -.54 | .364 | -.80 |
| 37 | Toledo, Ohio | -.38 | -4.45 | -.24 | .212 | -.33 |
| 38 | Steubenville-Weirton, Ohio/ Wheeling, West Virginia | -2.57 | -7.06 | -2.13 | .632 | -1.91 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 39 | Chattanooga, Tenn. | -.33 | -3.50 | -.24 | .131 | -.20 |
| 40 | Memphis, Tennessee | -.13 | -2.70 | -.05 | .028 | -.06 |
| 41 | Salt Lake City, Utah | -.16 | -1.59 | -.05 | .059 | -.06 |
| 42 | Oklahoma City, Oklahoma | -.30 | -3.87 | -.07 | .077 | -.10 |
| 43 | Omaha, Nebraska | -.19 | -3.20 | -.10 | .148 | -.14 |
| 44 | Honolulu, Hawaii | -.13 | -1.89 | -.02 | .037 | -.05 |
| 45 | Beaumont-Port Arthur-Orange, Texas | -1.08 | -5.26 | +.43 | -.439 | +.43 |
| 46 | Charlotte, N. C. | -.15 | - .89 | -.09 | .111 | -.13 |
| 47 | Portland, Maine | -.17 | -1.76 | -.13 | .163 | -.25 |
| 48 | Albuquerque, N. M. | -.07 | -1.55 | -.06 | .003 | -.01 |
| 50 | El Paso, Texas | -.01 | - ..76 | -.02 | .013 | -.02 |
| 51 | Las Vegas, Nevada | -.08 | -.61 | -.02 | .016 | -.01 |
| 52 | Fargo-Moorhead, N.D., Minnesota | -.78 | -6.88 | -.11 | .172 | -.10 |
| 53 | Boise, Idaho | -.28 | -6.07 | -.10 | .107 | -.13 |
| 54 | Billings, Montana | -1.85 | -12.13 | -.45 | .465 | -.51 |
| 55 | Sioux City, Iowa | -.73 | -25.66 | -.10 | .063 | -.13 |
| 61 | Allentown-Bethlehem-Easton, Pa. | -.57 | -3.51 | -.29 | .228 | -.46 |
| 63 | Bakersfield, Calif. | -2.95 | -19.51 | -.26 | .462 | -.18 |
| 64 | Davenport-Rock Island-Moline, Iowa, Illinois | -.33 | -1.99 | -.20 | .137 | -.26 |
| 66 | Grand Rapids/Muskegon-Muskegon Heights, Migh. | -.38 | -3.42 | -.21 | .135 | -.21 |
| 67 | Greensboro, N. C. | -.14 | -2.14 | -.11 | .096 | -.15 |
| 68 | Harrisburg, Pa. | -.59 | -8.44 | -.20 | .178 | -.29 |
| 69 | Jacksonville, Florida | -.61 | -5.49 | -.10 | .103 | -.17 |
| 70 | Knoxville, Tenn. | -.38 | -5.02 | -.16 | .144 | -.21 |
| 71 | Nashville, Tenn. | -.16 | -1.80 | -.05 | .034 | -.06 |
| 72 | Peoria, Illinois | -.41 | -2.90 | -.23 | .162 | -.35 |
| 73 | Richmond, Virginia | -.27 | -2.66 | -.09 | .073 | -.15 |
| 74 | Rochester, New York | -.05 | - .99 | -.04 | .020 | -.04 |
| 75 | Saginaw/Bay City, Mich. | -.44 | -1.02 | -.24 | .245 | -.31 |
| 76 | Scranton/Wilkes Barre-Hazelton, Pa. | -.93 | -1.15 | -.44 | .509 | -.78 |
| 77 | Syracuse, New York | -.44 | -4.83 | -.21 | .207 | -.19 |
| 78 | Tulsa, Oklahoma | -.39 | -7.29 | -.10 | .086 | -.16 |
| 80 | Youngstown-Warren, Ohio | -.83 | -9.96 | -.53 | .327 | -.81 |
| 81 | Albany-Schenectady-Troy, New York | -.33 | -3.67 | -.10 | .051 | -.10 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 82 | Binghamton, New York | -.25 | -3.96 | -.15 | .170 | -.12 |
| 83 | Charleston, S.C. | -.67 | -3.79 | -.06 | .076 | -.10 |
| 84 | Charleston, W. Va. | -.38 | -2.75 | -.37 | .233 | -.57 |
| 85 | Des Moines, Iowa | -.61 | -7.25 | -.26 | .235 | -.33 |
| 86 | Fresno, Calif. | -.53 | -4.55 | -.12 | .157 | -.06 |
| 87 | Fort Wayne, Indiana | -.25 | 14.21 | -.10 | .062 | -.18 |
| 88 | Jackson, Mississippi | -.51 | -6.50 | -.12 | .103 | -.14 |
| 89 | Johnstown, Pa. | -.46 | -3.09 | -.19 | .214 | -.25 |
| 90 | Lancaster, Pa. | -.37 | -5.69 | -.22 | .161 | -.37 |
| 91 | Mobile, Alabama | -.52 | -5.53 | -.15 | .125 | -.19 |
| 92 | Norfolk-Portsmouth/Newport News-Hampton, Va. | -.49 | -6.35 | -.07 | .075 | -.09 |
| 93 | Raleigh/Durham, N.C. | -.41 | -3.42 | -.11 | .178 | -.14 |
| 94 | Reading, Pa. | -.72 | -10.14 | -.36 | .244 | -.58 |
| 95 | Rockford, Illinois | -.26 | -3.08 | -.16 | .082 | -.27 |
| 96 | Sacramento, Calif | -.25 | -3.40 | -.05 | .046 | -.04 |
| 97 | South Bend, Indiana | -.24 | -2.62 | -.16 | .191 | -.21 |
| 98 | Utica-Rome, New York | -.46 | -7.62 | -.28 | .275 | -.26 |
| 99 | Wichita, Kansas | -.10 | -4.86 | -.08 | .070 | -.09 |
| 100 | York, Pa. | -.18 | -2.34 | -.11 | .104 | -.11 |

Strategy 5
Three Year Straight Implementation 1973-1975
Without Government Financial Assistance
Benefit = %15.0 Billion

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 1 | New York, New York | + .19 | - 8.59 | + .01 | .067 | + .01 |
| 2 | Chicago, Illinois | - .56 | -13.75 | - .33 | .409 | - .51 |
| 3 | Los Angeles, Calif. | + .12 | - 4.90 | + .04 | -.017 | + .04 |
| 4 | Philadelphia, Pa. | - .11 | - 6.70 | - .08 | .138 | - .12 |
| 5 | Detroit, Michigan | - .60 | - 8.89 | - .39 | .479 | - .50 |
| 6 | San Francisco, Calif. | - .34 | -23.15 | - .06 | .048 | - .06 |
| 7 | Boston, Mass. | + .05 | - 6.08 | - .02 | .067 | - .02 |
| 8 | Pittsburgh, Pa. | -3.01 | -27.79 | -1.47 | 1.052 | -2.15 |
| 9 | St. Louis, Missouri | - .83 | -18.85 | - .49 | .570 | - .76 |
| 10 | Washington, D. C. | -1.27 | -24.04 | - .11 | .216 | - .13 |
| 11 | Cleveland, Ohio | - .92 | -12.85 | - .37 | .302 | - .54 |
| 12 | Baltimore, Maryland | -1.02 | -15.49 | - .44 | .366 | - .51 |
| 14 | Minneapolis-St. Paul, Minnesota | - .02 | - 7.52 | - .08 | .190 | - .10 |
| 15 | Houston, Texas | - .23 | - 5.82 | - .12 | .062 | - .16 |
| 16 | Buffalo, New York | -1.32 | -16.11 | - .84 | .670 | - .81 |
| 17 | Milwaukee, Wisconsin | - .89 | -18.63 | - .72 | .850 | - .72 |
| 18 | Cincinnati, Ohio | - .25 | -11.64 | - .23 | .410 | - .30 |
| 19 | Louisville, Kentucky | - .22 | - 7.45 | - .46 | .661 | - .66 |
| 20 | Dallas, Texas | + .02 | - 2.28 | - .01 | .033 | - .01 |
| 21 | Seattle-Everett, Wash. | - .42 | -10.42 | - .15 | .116 | - .21 |
| 22 | Kansas City, Missouri | - .08 | - 9.90 | - .08 | .098 | - .11 |
| 23 | San Diego, Calif. | + .23 | - 1.10 | + .03 | -.019 | + .03 |
| 24 | Atlanta, Georgia | + .14 | - 4.74 | - .01 | .069 | - .01 |
| 25 | Indianapolis, Indiana | - .84 | -21.96 | - .49 | .528 | - .71 |
| 26 | Miami, Florida | + .02 | - 2.29 | - .00 | .015 | - .00 |
| 27 | Denver, Colorado | - .11 | - 6.61 | - .08 | .178 | - .10 |
| 28 | New Orleans, Louisiana | + .00 | - 4.70 | + .00 | .001 | + .00 |
| 29 | Portland, Oregon | - .52 | -18.49 | - .17 | .105 | - .22 |
| 30 | Providence-Pawtuckett, Rhode Island | - .13 | - 6.10 | - .06 | .062 | - .10 |
| 31 | Phoenix, Arizona | - .10 | - 1.30 | - .09 | .200 | - .10 |
| 32 | Tampa, Florida | - .63 | - 8.94 | - .11 | .115 | - .13 |
| 33 | Columbus, Ohio | - .20 | - 7.46 | - .07 | .071 | - .11 |
| 34 | San Antonio, Texas | - .63 | - 6.56 | - .10 | .112 | - .16 |
| 35 | Dayton, Ohio | - .08 | - 4.57 | - .11 | .207 | - .16 |
| 36 | Birmingham, Alabama | -4.52 | -58.20 | -1.96 | 1.222 | -2.91 |
| 37 | Toledo, Ohio | - .99 | -15.79 | - .61 | .542 | - .86 |
| 38 | Steubenville-Weirton, Ohio/ Wheeling, West Virginia | -8.63 | -28.43 | -6.38 | 1.729 | -5.71 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 39 | Chattanooga, Tenn. | - .72 | -11.46 | - .52 | .329 | - .63 |
| 40 | Memphis, Tennessee | + .02 | - 8.44 | + .00 | .012 | + .00 |
| 41 | Salt Lake City, Utah | = .17 | - 3.06 | - .07 | .160 | - .09 |
| 42 | Oklahoma City, Oklahoma | - .66 | - 7.20 | - .19 | .263 | - .27 |
| 43 | Omaha, Nebraska | - .13 | - 7.69 | - .20 | .501 | - .27 |
| 44 | Honolulu, Hawaii | + .00 | - 6.72 | - .01 | .022 | - .01 |
| 45 | Beaumont-Port Arthur-Orange, Texas | -3.50 | -18.61 | -4.53 | .899 | -4.60 |
| 46 | Charlotte, N. C. | - .03 | - 1.52 | - .11 | .304 | - .16 |
| 47 | Portland, Maine | - .43 | - 3.95 | - .26 | .427 | - .46 |
| 48 | Albuquerque, N. M. | + .07 | - 4.55 | + .01 | .000 | + .01 |
| 50 | El Paso, Texas | + .20 | - 1.70 | + .04 | -.034 | + .06 |
| 51 | Las Vegas, Nevada | + .07 | - 1.69 | + .06 | -.067 | + .06 |
| 52 | Fargo-Moorhead, N.D., Minnesota | -2.17 | -14.35 | - .42 | .742 | - .40 |
| 53 | Boise, Idaho | - .31 | - 8.60 | - .09 | .211 | - .11 |
| 54 | Billings, Montana | -4.39 | -38.70 | -1.22 | 1.220 | -1.39 |
| 55 | Sioux City, Iowa | -1.37 | -130.30 | - .37 | .409 | - .51 |
| 61 | Allentown-Bethlehem-Easton, Pa. | -1.55 | -10.08 | - .84 | .753 | -1.35 |
| 63 | Bakersfield, Calif. | -8.89 | -76.14 | - .82 | 1.500 | - .57 |
| 64 | Davenport-Rock Island-Moline, Iowa, Illinois | - .88 | -4.86 | - .61 | .552 | - .80 |
| 66 | Grand Rapids/Muskegon-Muskegon Heights, Migh. | -1.15 | -10.72 | - .59 | .397 | - .60 |
| 67 | Greensboro, N. C. | - .23 | - 6.76 | - .15 | .100 | - .20 |
| 68 | Harrisburg, Pa. | -1.52 | -21.71 | - .60 | .644 | - .85 |
| 69 | Jacksonville, Florida | -1.69 | -15.53 | - .31 | .345 | - .50 |
| 70 | Knoxville, Tenn. | - .95 | -11.71 | - .51 | .553 | - .69 |
| 71 | Nashville, Tenn. | - .12 | - 4.68 | - .06 | .090 | - .08 |
| 72 | Peoria, Illinois | - .92 | - 8.16 | - .57 | .524 | - .88 |
| 73 | Richmond, Virginia | - .48 | - 6.99 | - .18 | .210 | - .31 |
| 74 | Rochester, New York | + .14 | - 2.56 | + .05 | .041 | + .05 |
| 75 | Saginaw/Bay City, Mich. | -1.29 | - 2.94 | - .77 | .842 | - .97 |
| 76 | Scranton/Wilkes Barre-Hazelton, Pa. | -2.21 | -35.07 | -1.23 | 1.780 | -2.20 |
| 77 | Syracuse, New York | - .91 | -12.60 | - .55 | .718 | - .49 |
| 78 | Tulsa, Oklahoma | - .96 | -18.40 | - .28 | .309 | - .47 |
| 80 | Youngstown-Warren, Ohio | -2.75 | -32.88 | -1.79 | 1.178 | -2.76 |
| 81 | Albany-Schenectady-Troy, New York | - .80 | -11.25 | - .31 | .342 | - .34 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 82 | Binghamton, New York | - .39 | - 9.75 | - .35 | .550 | - .28 |
| 83 | Charleston, S. C. | -1.65 | - 8.47 | - .31 | .384 | - .49 |
| 84 | Charleston, W. Va. | -1.11 | - 8.31 | - .90 | .559 | -1.38 |
| 85 | Des Moines, Iowa | -1.80 | -23.05 | - .78 | .738 | -1.00 |
| 86 | Fresno, Calif. | -1.54 | -12.08 | - .35 | .574 | - .18 |
| 87 | Fort Wayne, Indiana | - .72 | -13.18 | - .32 | .211 | - .55 |
| 88 | Jackson, Mississippi | -1.47 | -18.74 | - .37 | .384 | - .43 |
| 89 | Johnstown, Pa. | -1.05 | - 5.52 | - .61 | .902 | - .80 |
| 90 | Lancaster, Pa. | - .72 | .15.36 | - .58 | .556 | - .96 |
| 91 | Mobile, Alabama | - .78 | -14.74 | - .27 | .332 | - .36 |
| 92 | Norfolk-Portsmouth/Newport News-Hampton, Va. | -1.32 | -16.86 | - .22 | .283 | - .28 |
| 93 | Raleigh/Durham, N. C. | -1.07 | -7.67 | - .35 | .758 | - .46 |
| 94 | Reading, Pa. | -1.96 | -34.92 | -1.01 | .795 | -1.66 |
| 95 | Rockford, Illinois | - .50 | -8.20 | - .39 | .272 | - .62 |
| 96 | Sacramento, Calif | - .72 | - 9.91 | - .16 | .161 | - .12 |
| 97 | South Bend, Indiana | - .55 | - 6.15 | - .44 | .638 | - .56 |
| 98 | Utica-Rome, New York | -1.22 | -23.92 | - .80 | .911 | - .75 |
| 99 | Wichita, Kansas | + .13 | -14.26 | + .00 | .115 | + .00 |
| 100 | York, Pa. | - .21 | - 6.48 | - .20 | .299 | - .20 |

Strategy 6
Five Year Extended Implementation 1973-1975 With
Government Financial Assistance
Benefit = $15.0 Billion

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. In-vest-ment | Reg. Per-sonal Inc. | Reg. Unem-mnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 1 | New York, New York | + .01 | - 2.58 | - .01 | .041 | - .01 |
| 2 | Chicago, Illinois | - .18 | - 3.63 | - .11 | .148 | - .17 |
| 3 | Los Angeles, Calif. | + .01 | - 1.50 | + .01 | -.007 | + .01 |
| 4 | Philadelphia, Pa. | - .05 | - 2.00 | - .02 | .024 | - .03 |
| 5 | Detroit, Michigan | - .19 | - 2.52 | - .15 | .204 | - .20 |
| 6 | San Francisco, Calif. | - .15 | - 6.45 | - .03 | .015 | - .03 |
| 7 | Boston, Mass. | - .02 | - 2.01 | - .00 | .033 | - .00 |
| 8 | Pittsburgh, Pa. | - .84 | - 7.48 | - .40 | .301 | - .58 |
| 9 | St. Louis, Missouri | - .27 | - 4.89 | - .17 | .209 | - .26 |
| 10 | Washington, D. C. | - .50 | - 7.36 | - .06 | .100 | - .07 |
| 11 | Cleveland, Ohio | - .28 | - 3.69 | - .11 | .091 | - .15 |
| 12 | Baltimore, Maryland | - .31 | - 4.47 | - .14 | .117 | - .16 |
| 14 | Minneapolis-St. Paul, Minnesota | - .04 | - 2.35 | - .03 | .053 | - .04 |
| 15 | Houston, Texas | - .12 | - 1.84 | - .09 | .058 | - .12 |
| 16 | Buffalo, New York | - .42 | - 4.93 | - .26 | .190 | - .25 |
| 17 | Milwaukee, Wisconsin | - .30 | - 5.51 | - .24 | .276 | - .24 |
| 18 | Cincinnati, Ohio | - .11 | - 3.06 | - .09 | .147 | - .11 |
| 19 | Louisville, Kentucky | - .07 | - 1.74 | - .18 | .029 | - .08 |
| 20 | Dallas, Texas | - .02 | - .79 | - .01 | .012 | - .02 |
| 21 | Seattle-Everett, Wash. | - .18 | - 3.21 | - .07 | .052 | - .09 |
| 22 | Kansas City, Missouri | - .05 | - 2.84 | - .06 | .063 | - .09 |
| 23 | San Diego, Calif. | + .04 | - .37 | + .02 | -.019 | + .02 |
| 24 | Atlanta, Georgia | + .02 | - 1.27 | - .07 | .079 | - .11 |
| 25 | Indianapolis, Indiana | - .31 | - 6.28 | - .17 | .162 | - .25 |
| 26 | Miami, Florida | - .02 | - .74 | - .09 | .095 | - .12 |
| 27 | Denver, Colorado | - .02 | - 1.43 | - .04 | .083 | - .05 |
| 28 | New Orleans, Louisiana | - .04 | - 1.47 | - .01 | .003 | - .01 |
| 29 | Portland, Oregon | - .20 | - 5.36 | - .07 | .041 | - .09 |
| 30 | Providence-Pawtuckett, Rhode Island | + .01 | - 1.70 | + .04 | -.135 | + .07 |
| 31 | Phoenix, Arizona | - .12 | - .99 | - .05 | .064 | - .06 |
| 32 | Tampa, Florida | - .08 | - 1.89 | + .00 | -.033 | + .00 |
| 33 | Columbus, Ohio | - .11 | - 2.41 | - .04 | .030 | - .06 |
| 34 | San Antonio, Texas | - .22 | - 2.32 | - .03 | .030 | - .05 |
| 35 | Dayton, Ohio | - .05 | - 1.38 | - .05 | .080 | - .08 |
| 36 | Birmingham, Alabama | -1.18 | -12.77 | - .53 | .358 | - .78 |
| 37 | Toledo, Ohio | - .32 | - 4.39 | - .21 | .200 | - .29 |
| 38 | Steubenville-Weirton, Ohio/ Wheeling, West Virginia | -2.56 | - 7.06 | -2.12 | .629 | -1.90 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. In-vest-ment | Reg. Per-sonal Inc. | Reg. Unem-mnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 39 | Chattanooga, Tenn. | - .27 | - 3.46 | - .19 | .109 | - .23 |
| 40 | Memphis, Tennessee | - .05 | - 2.61 | - .02 | .009 | - .02 |
| 41 | Salt Lake City, Utah | - .12 | - 1.56 | - .04 | .051 | - .05 |
| 42 | Oklahoma City, Oklahoma | - .30 | - 3.87 | - .07 | .077 | - .10 |
| 43 | Omaha, Nebraska | - .12 | - 3.12 | - .08 | .144 | - .11 |
| 44 | Honolulu, Hawaii | - .04 | - 1.82 | - .01 | .013 | - .02 |
| 45 | Beaumont-Port Arthur-Orange, Texas | -1.08 | - 5.26 | + .43 | -.439 | + .43 |
| 46 | Charlotte, N. C. | - .09 | - .86 | - .05 | .856 | - .08 |
| 47 | Portland, Maine | - .17 | - 1.76 | - .13 | .163 | - .25 |
| 48 | Albuquerque, N. M. | - .02 | - 1.50 | - .00 | .002 | - .00 |
| 50 | El Paso, Texas | + .04 | - .72 | + .01 | -.005 | + .01 |
| 51 | Las Vegas, Nevada | - .03 | - .58 | + .00 | -.001 | + .00 |
| 52 | Fargo-Moorhead, N.D., Minnesota | - .78 | - 6.88 | - .11 | .172 | - .10 |
| 53 | Boise, Idaho | - .24 | - 6.01 | - .11 | .120 | - .15 |
| 54 | Billings, Montana | -1.70 | -11.96 | - .40 | .447 | - .46 |
| 55 | Sioux City, Iowa | - .61 | -25.40 | - .08 | .084 | - .11 |
| 61 | Allentown-Bethlehem-Easton, Pa. | - .53 | - 3.49 | - .26 | .215 | - .42 |
| 63 | Bakersfield, Calif. | -2.95 | -19.51 | - .26 | .462 | - .18 |
| 64 | Davenport-Rock Island-Moline, Iowa, Illinois | - .30 | - 1.98 | - .18 | .130 | - .24 |
| 66 | Grand Rapids/Muskegon-Muskegon Heights, Migh. | - .38 | - 3.42 | - .21 | .135 | - .21 |
| 67 | Greensboro, N. C. | - .12 | - 2.12 | - .03 | .095 | - .14 |
| 68 | Harrisburg, Pa. | - .12 | - 8.44 | - .20 | .178 | - .29 |
| 69 | Jacksonville, Florida | - .61 | - 5.49 | - .10 | .103 | - .17 |
| 70 | Knoxville, Tenn. | - .38 | - 5.02 | - .16 | .144 | - .21 |
| 71 | Nashville, Tenn. | - .11 | - 1.76 | - .03 | .029 | - .04 |
| 72 | Peoria, Illinois | - .35 | - 2.88 | - .20 | .155 | - .31 |
| 73 | Richmond, Virginia | - .22 | - 2.62 | - .07 | .066 | - .12 |
| 74 | Rochester, New York | - .00 | - .96 | - .01 | .016 | - .01 |
| 75 | Saginaw/Bay City, Mich. | - .44 | - 1.02 | - .24 | .245 | - .31 |
| 76 | Scranton/Wilkes Barre-Hazelton, Pa. | - .93 | -15.15 | - .44 | .509 | - .78 |
| 77 | Syracuse, New York | - .38 | - 4.77 | - .19 | .196 | - .17 |
| 78 | Tulsa, Oklahoma | - .39 | - 7.29 | - .10 | .086 | - .16 |
| 80 | Youngstown-Warren, Ohio | - .81 | - 9.96 | - .52 | .322 | - .80 |
| 81 | Albany-Schenectady-Troy, New York | - .31 | - 3.66 | - .11 | .113 | - .12 |

| AQCR Code | AQCR | % change Mfg. Prd. (value added) | % change Mfg. Investment | Reg. Personal Inc. | Reg. Unemmnt. Rate | Local Govt. Revenue |
|---|---|---|---|---|---|---|
| 82 | Binghamton, New York | - .20 | - 3.91 | - .13 | .156 | - .10 |
| 83 | Charleston, S. C. | - .67 | - 3.79 | - .06 | .076 | - .10 |
| 84 | Charleston, W. Va. | - .38 | - 2.75 | - .37 | .233 | - .57 |
| 85 | Des Moines, Iowa | - .61 | - 7.25 | - .26 | .235 | - .33 |
| 86 | Fresno, Calif. | - .53 | - 4.55 | - .12 | .157 | - .06 |
| 87 | Fort Wayne, Indiana | - .25 | - 4.21 | - .10 | .062 | - .18 |
| 88 | Jackson, Mississippi | - .51 | - 6.50 | - .12 | .103 | - .14 |
| 89 | Johnstown, Pa. | - .46 | - 3.09 | - .19 | .214 | - .25 |
| 90 | Lancaster, Pa. | - .32 | - 5.65 | - .21 | .154 | - .35 |
| 91 | Mobile, Alabama | - .41 | - 4.54 | - .12 | .106 | - .15 |
| 92 | Norfolk-Portsmouth/Newport News-Hampton, Va. | - .49 | - 6.35 | - .07 | .075 | - .09 |
| 93 | Raleigh/Durham, N. C. | - .41 | - 3.42 | - .11 | .178 | - .14 |
| 94 | Reading, Pa. | - .68 | -10.11 | - .34 | .254 | - .56 |
| 95 | Rockford, Illinois | - .22 | - 3.06 | - .15 | .082 | - .24 |
| 96 | Sacramento, Calif | - .25 | - 3.40 | - .05 | .046 | - .04 |
| 97 | South Bend, Indiana | - .22 | - 2.61 | - .16 | .189 | - .20 |
| 98 | Utica-Rome, New York | - .41 | - 5.57 | - .25 | .247 | - .23 |
| 99 | Wichita, Kansas | - .03 | - 4.70 | - .04 | .045 | - .04 |
| 100 | York, Pa. | - .12 | - 2.30 | - .08 | .074 | - .08 |

# APPENDIX C

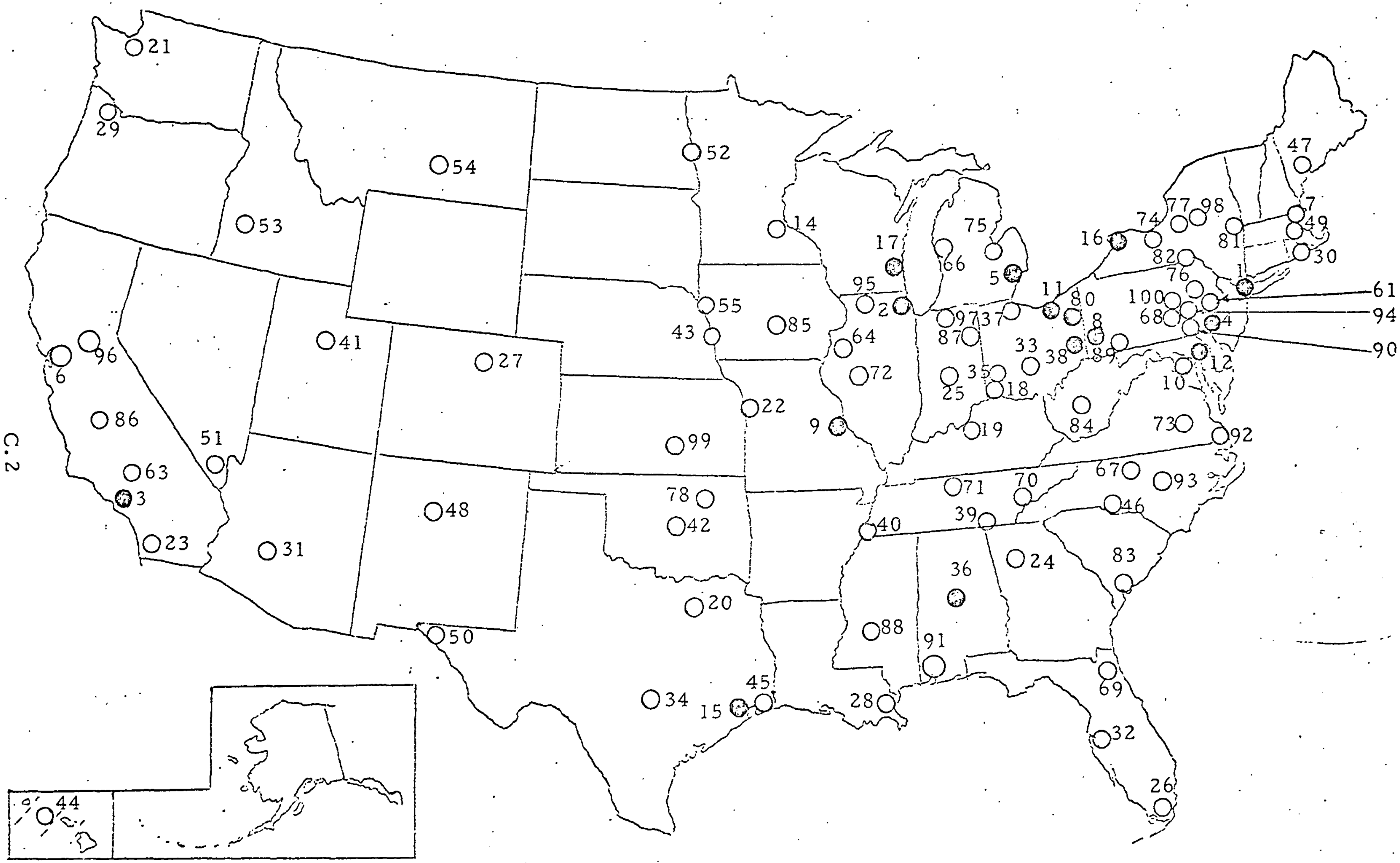
## REGIONS OF CONCENTRATION OF KEY HIGH EMISSION INDUSTRIES

Regions With 1% or More of National Production of Primary Metal Industries *

| AQCR | | % |
|---|---|---|
| 1 | New York, N.Y. | 1.06 |
| 2 | Chicago, Ill. | 5.17 |
| 3. | Los Angeles, Cal. | 2.31 |
| 4 | Philadelphia, Pa. | 2.93 |
| 5 | Detroit, Mich. | 4.16 |
| 8 | Pittsburgh, Pa. | 8.59 |
| 9 | St. Louis, Mo. | 1.86 |
| 11 | Cleveland, Oh. | 3.11 |
| 12 | Baltimore, Md. | 2.56 |
| 15 | Houston, Tx. | 1.12 |
| 16 | Buffalo, N.Y. | 2.30 |
| 17 | Milwaukee, Wis. | 1.35 |
| 36 | Birmingham, Al. | 1.78 |
| 38 | Steubenville - Weirton/Wheeling, Oh./W.V. | 2.09 |
| 80 | Youngstown - Warren, Oh. | 2.50 |

*SIC 33, Primary Metal Industries, includes SIC's 3321, Gray Iron Foundries; 3323, Steel Foundries; 3331, Primary Copper; 3323, Primary Lead; 3333, Primary Zinc; 3334, Primary Aluminum; and 3341, Secondary Nonferrous Metals. These are the codes under which Gray Iron Foundries; Iron and Steel; Primary Copper, Lead, and Zinc; Primary Aluminum; and Secondary Nonferrous Metals were classified.

Regions with % or More of National Production of Primary Metal Industries



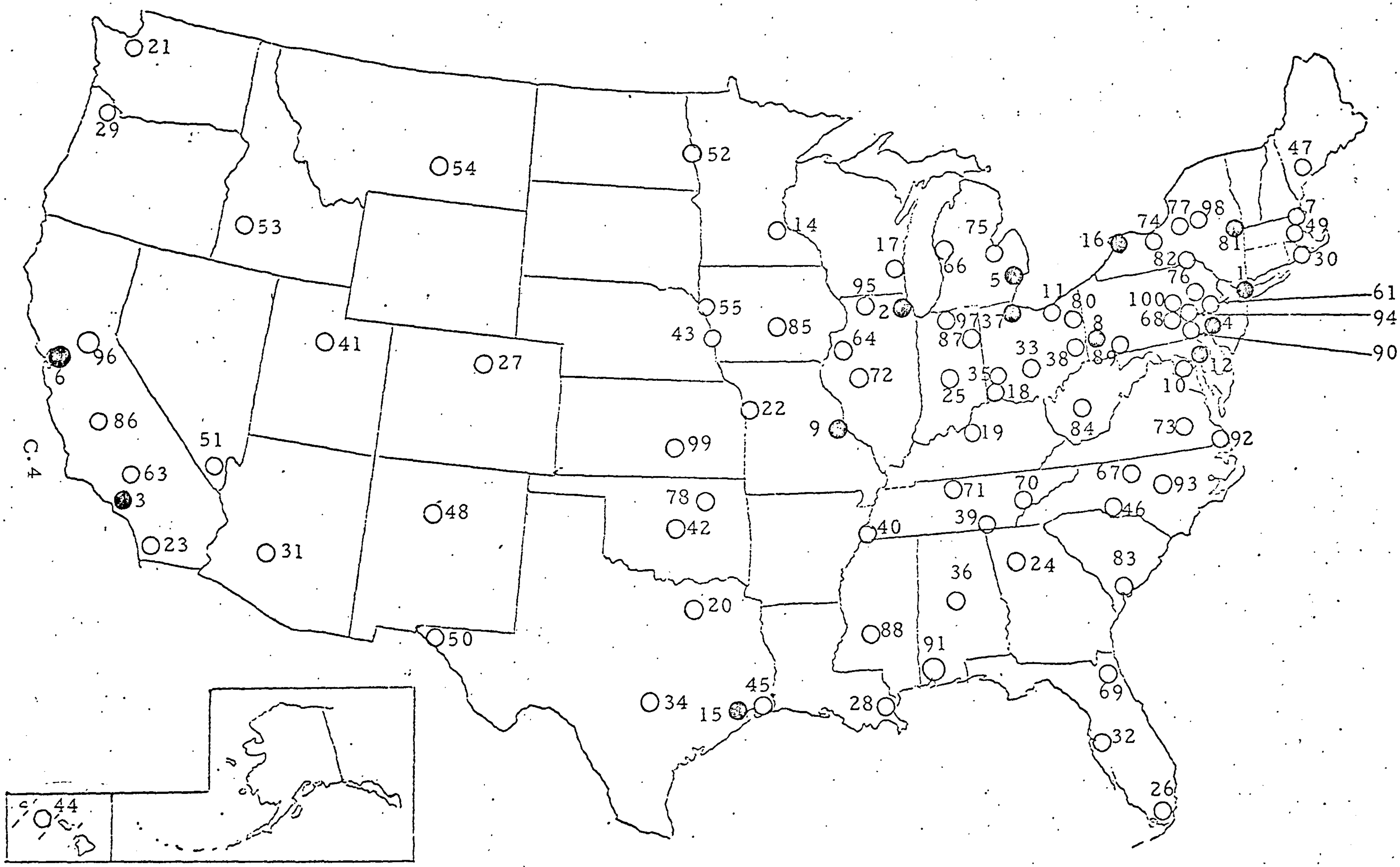

C.2

Regions with 1% or More of National Production of Stone, Clay, and Glass Products *

| AQCR | | % |
|---|---|---|
| 1 | New York, N. Y. | 1.90 |
| 2 | Chicago, Ill. | 3.29 |
| 3 | Los Angeles, Ca. | 2.88 |
| 4 | Philadelphia | 2.23 |
| 5 | Detroit, Mich. | 2.31 |
| 6 | San Francisco, Ca. | 1.30 |
| 8 | Pittsburgh, Pa. | 2.54 |
| 9 | St. Louis, Mo. | 1.71 |
| 12 | Baltimore, Md. | 1.19 |
| 15 | Houston, Tx. | 1.04 |
| 16 | Buffalo, N. Y. | 1.26 |
| 37 | Toledo, Oh. | 2.06 |
| 81 | Albany - Schenectady - Troy, N. Y. | 1.10 |

* SIC 32, Stone, Clay, and Glass Products, includes SIC's 3214, Hydraulic Cement, and 3274, Lime, under which cement and Lime were classified.

Regions with 1% or More of National Production of Stone, Clay, and Glass, Products



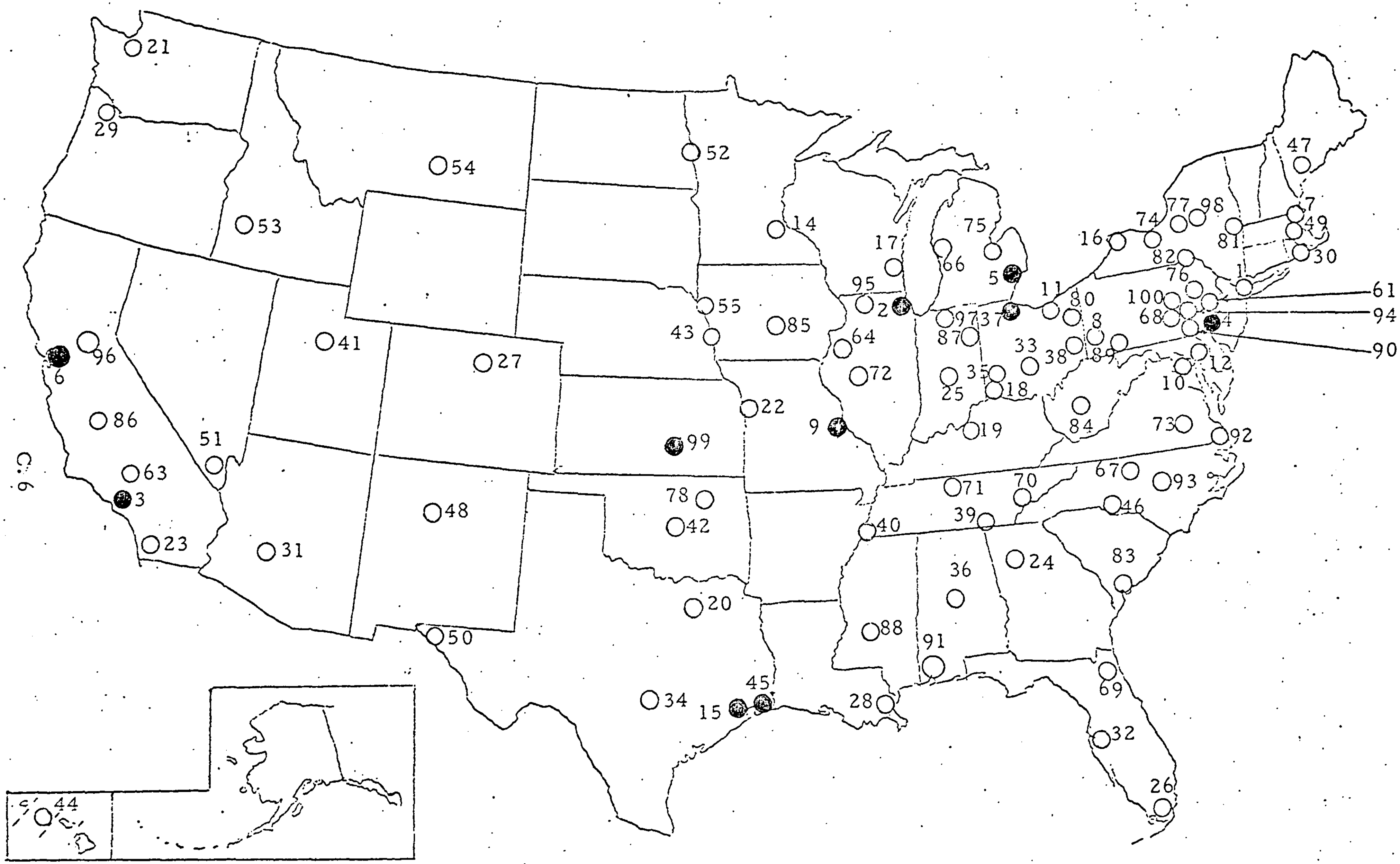

C.4

Regions with 1% or More of National Production of Petroleum and Coal Products *

| AQCR | | % |
|---|---|---|
| 2 | Chicago, Ill. | 2.73 |
| 3 | Los Angeles, Ca. | 5.67 |
| 4 | Philadelphia, Pa. | 5.35 |
| 5 | Detroit, Mich. | 1.26 |
| 6 | San Francisco, Ca. | 4.24 |
| 9 | St. Louis, Mo. | 3.59 |
| 15 | Houston, Tx. | 10.12 |
| 37 | Toledo, Oh. | 2.00 |
| 45 | Beaumont - Port Arthur - Orange, Tx. | 14.32 |
| 99 | Wichita, Kansas | 1.54 |

* SIC 29, Petroleum and Coal Products, includes SIC's 2911, Petroleum Refining, and 2951, Asphalt Mixtures and Blocks, under which Petroleum Refining and Storage and Asphalt Batching were classified.

Regions with 1% or More of National Production of Petroleum and Coal Products

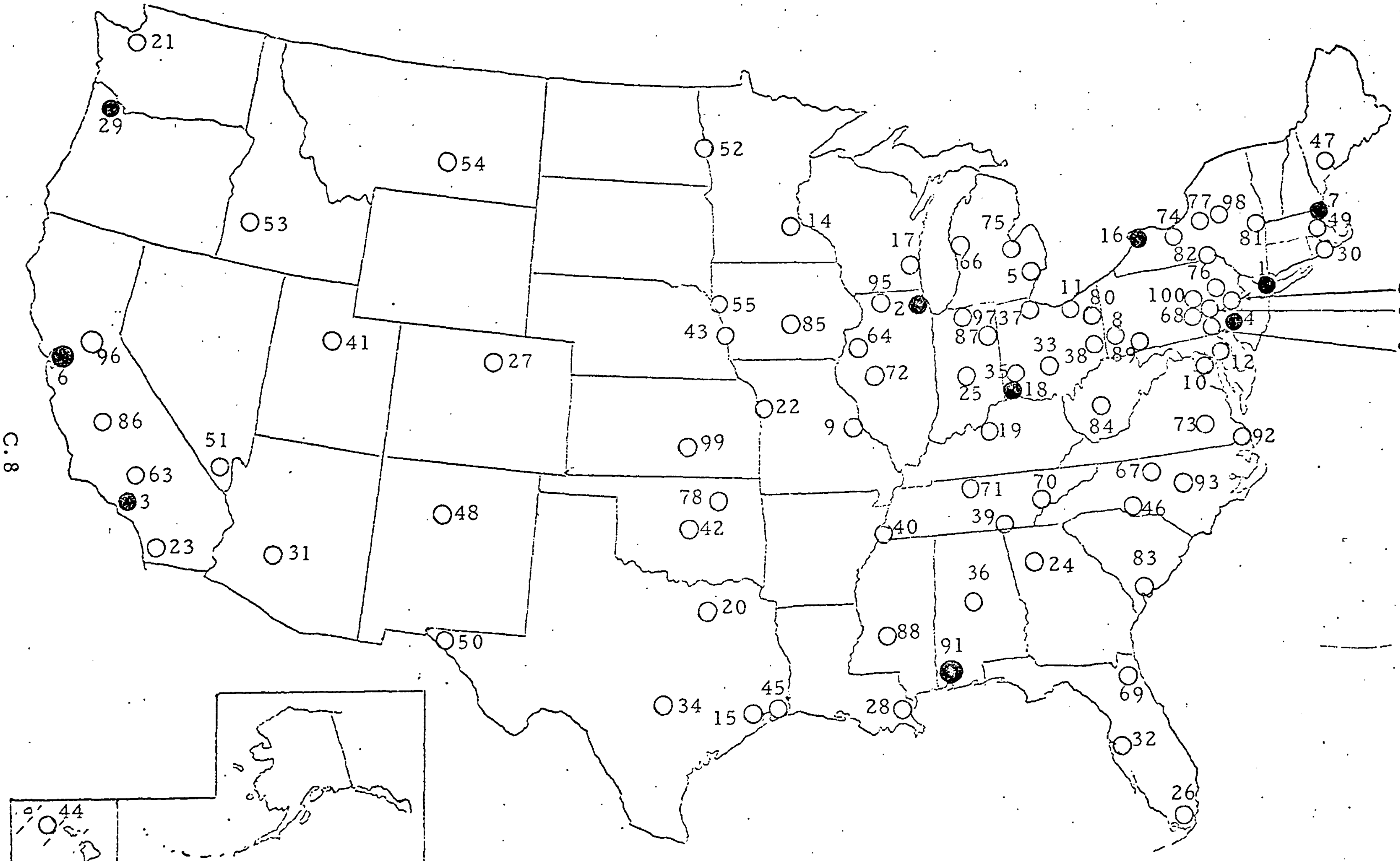


Regions with 1% or More of National Production of Paper and Allied Products *

| AQCR | | % |
|---|---|---|
| 1 | New York, N. Y. | 3.15 |
| 2 | Chicago, Ill. | 4.31 |
| 3 | Los Angeles, Calif. | 2.21 |
| 4 | Philadelphia, Pa. | 3.46 |
| 6 | San Francisco, Ca. | 1.08 |
| 7 | Boston, Mass. | 1.33 |
| 16 | Buffalo, N. Y. | 1.04 |
| 18 | Cincinnati, Oh. | 1.00 |
| 29 | Portland, Or. | 1.32 |
| 91 | Mobile, Al. | 1.33 |

* SIC 26, Paper and Allied Products, includes SIC 2611, Pulpmills, under which Kraft (Sulfate) Pulp was classified.

Regions with 1% or More of National Production of Paper and Allied Products



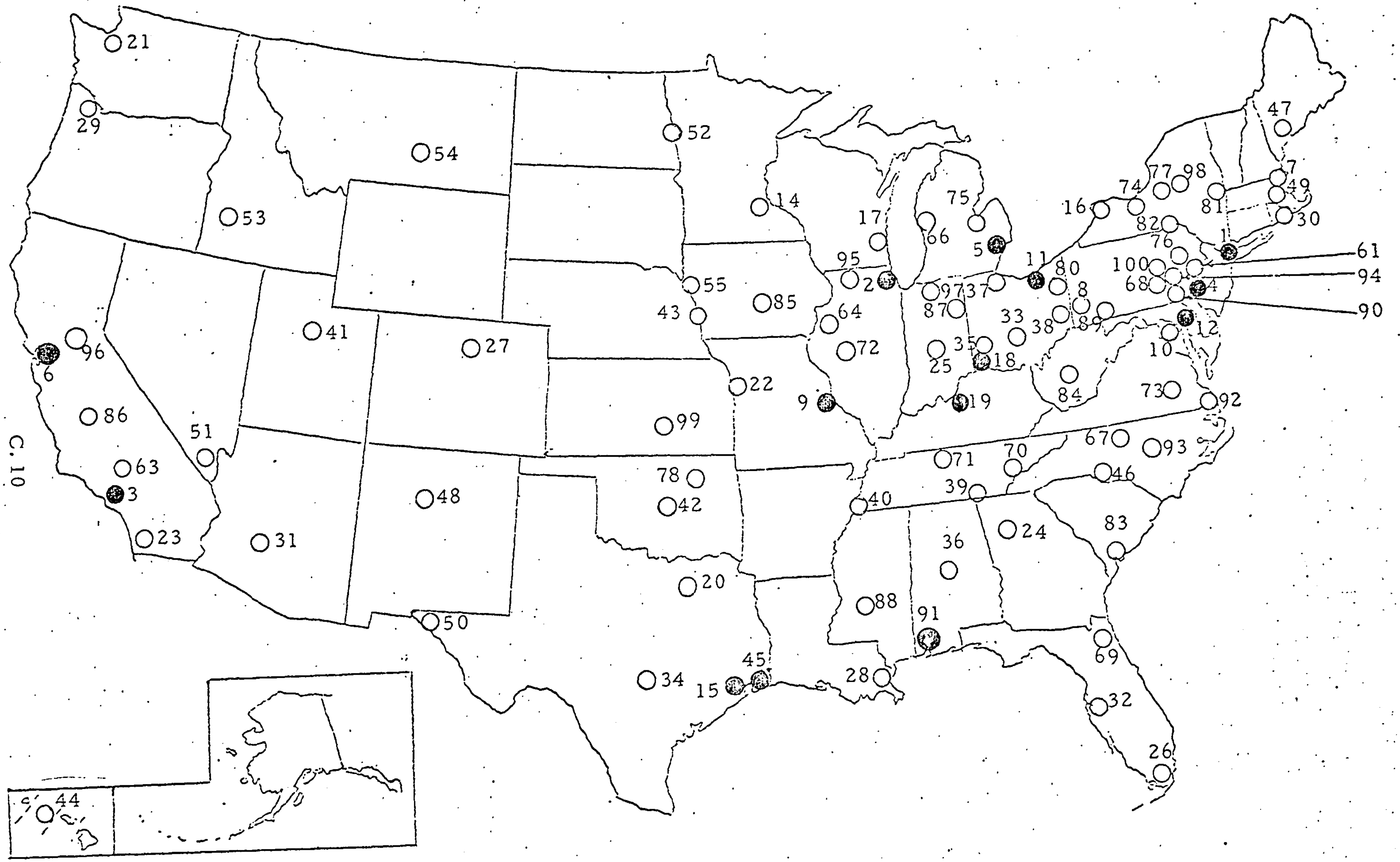

C.8

Regions with 1% or More of National Production
Of Chemicals and Allied Products *

| AQCR | | % |
|---|---|---|
| 1 | New York, N.Y. | 3.78 |
| 2. | Chicago, Ill. | 4.95 |
| 3 | Los Angeles, Ca. | 2.64 |
| 4 | Philadelphia, Pa. | 4.33 |
| 5 | Detroit, Mich. | 1.36 |
| 6 | San Francisco, Ca. | 1.22 |
| 9 | St. Louis, Mo. | 2.07 |
| 11 | Cleveland, Oh. | 1.28 |
| 12 | Baltimore, Md. | 1.36 |
| 15 | Houston, Tx. | 3.55 |
| 18 | Cincinnati, Oh. | 2.26 |
| 19 | Louisville, Ky. | 1.34 |
| 45 | Beaumont - Port Arthur - Orange, Tx. | 1.14 |
| 91 | Mobile, Al. | 1.22 |

* SIC 28, Chemicals and Allied Products, includes SIC's 2819 Industrial Inorganic Chemicals, and 2871, Fertilizers, under which Nitric Acid, Sulfuric Acid, and the Phosphate Industry are classified.

Regions with % or More of National Production of Chemical and Allied Products




C. 10

# APPENDIX D

## Convergency Test for 15 AQCRs

A test of actual vs. estimated values has been conducted to test the speed of convergency of the use of non-linear solution of the model. Results of these comparisons are provided here for the largest 15 AQCRs.

The symbols shown in the following pages stand for:

| | | |
|---|---|---|
| Y | = | Regional personal income |
| G | = | Regional government expenditures |
| C | = | Regional consumption |
| N-T | = | Total regional employment |
| L | = | Regional labor force |
| W | = | Wage rate |
| U | = | Regional employment rate |
| SUMN | = | Total manufacturing employment |

AQCR 1 NEW YORK, N.Y.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 53712.00 | | 5944.00 | | 32945.00 | |
| ITERATION- 1 | 55507.33 | 0.03342 | 6065.98 | 0.02052 | 34171.32 | 0.05321 |
| ITERATION- 2 | 55507.98 | 0.00001 | 6068.26 | 0.00038 | 34178.59 | 0.00021 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 5123.71 | | 5337.20 | | 7.08 | | 0.04 | | 1144.00 | |
| ITERATION- 1 | 5160.15 | 0.00711 | 5362.70 | 0.00478 | 6.85 | 0.03268 | 0.04 | 0.05816 | 1181.39 | -0.03268 |
| ITERATION- 2 | 5162.46 | 0.00045 | 5364.73 | 0.00038 | 6.85 | 0.00012 | 0.04 | 0.00075 | 1182.80 | 0.00119 |

ITERATIONS TO CONVERGE= 2

AQCR 2 CHICAGO, ILL.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 30251.00 | | 1941.00 | | 18709.00 | |
| ITERATION- 1 | 26899.35 | 0.11079 | 1851.19 | 0.04627 | 16638.37 | 0.11068 |
| ITERATION- 2 | 26890.69 | 0.00032 | 1851.19 | 0.00000 | 16628.98 | 0.00056 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 3099.43 | | 3178.90 | | 7.28 | | 0.02 | | 981.50 | |
| ITERATION- 1 | 3114.44 | 0.00484 | 3236.29 | 0.01805 | 7.17 | 0.01538 | 0.04 | 0.51679 | 996.41 | 0.01519 |
| ITERATION- 2 | 3114.79 | 0.00011 | 3236.68 | 0.00012 | 7.17 | 0.00003 | 0.04 | 0.00689 | 996.86 | 0.00045 |

ITERATIONS TO CONVERGE= 2

AQCR 3 LOS ANGELES, CALIF.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 30815.00 | | 2867.00 | | 20057.00 | |
| ITERATION- 1 | 31811.58 | 0.03234 | 2831.05 | 0.01254 | 19649.40 | 0.02032 |
| ITERATION- 2 | 31807.75 | 0.00012 | 2831.03 | 0.00001 | 19644.30 | 0.00026 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 2972.03 | | 3118.60 | | 7.73 | | 0.05 | | 856.10 | |
| ITERATION- 1 | 3009.74 | 0.01269 | 3127.63 | 0.00290 | 7.39 | 0.04423 | 0.04 | 0.19903 | 893.43 | 0.04361 |
| ITERATION- 2 | 3011.84 | 0.00070 | 3129.69 | 0.00066 | 7.39 | 0.00022 | 0.04 | 0.00026 | 895.89 | 0.00275 |

ITERATIONS TO CONVERGE= 2

AQCR 4 PHILADELPHIA, PA.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 18036.00 | | 1280.00 | | 11725.00 | |
| ITERATION- 1 | 16637.03 | 0.07757 | 1185.22 | 0.07404 | 10334.41 | 0.11860 |
| ITERATION- 2 | 16612.55 | 0.00147 | 1185.09 | 0.00011 | 10325.54 | 0.00086 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 1924.47 | | 1992.20 | | 7.22 | | 0.03 | | 580.70 | |
| ITERATION- 1 | 1940.82 | 0.00850 | 2016.53 | 0.01221 | 7.02 | 0.02796 | 0.04 | 0.10665 | 596.95 | 0.02798 |
| ITERATION- 2 | 1941.24 | 0.00021 | 2017.04 | 0.00026 | 7.02 | 0.00010 | 0.04 | 0.00117 | 597.47 | 0.00088 |

ITERATIONS TO CONVERGE= 2

AQCR 5 DETROIT, MICH.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 17890.00 | | 1459.00 | | 9962.00 | |
| ITERATION- 1 | 18036.79 | 0.00821 | 1335.39 | 0.08472 | 11199.02 | 0.12417 |
| ITERATION- 2 | 18050.45 | 0.00076 | 1334.90 | 0.00037 | 11207.49 | 0.00076 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 1531.20 | | 1600.00 | | 8.92 | | 0.04 | | 585.90 | |
| ITERATION- 1 | 1567.09 | 0.02344 | 1628.14 | 0.01758 | 8.37 | 0.06153 | 0.04 | 0.12988 | 621.95 | 0.06153 |
| ITERATION- 2 | 1569.80 | 0.00173 | 1631.03 | 0.00178 | 8.37 | 0.00032 | 0.04 | 0.00343 | 624.51 | 0.00411 |

ITERATIONS TO CONVERGE= 2

AQCR 6 SAN FRANCISCO, CALIF.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 14422.00 | | 1345.00 | | 9753.00 | |
| ITERATION- 1 | 12920.51 | 0.10411 | 1380.80 | 0.02661 | 8069.50 | 0.17261 |
| ITERATION- 2 | 12875.25 | 0.00350 | 1381.06 | 0.00019 | 8034.11 | 0.00439 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 1288.80 | | 1355.20 | | 7.98 | | 0.05 | | 196.40 | |
| ITERATION- 1 | 1297.06 | 0.00642 | 1347.59 | 0.00561 | 7.64 | 0.04251 | 0.04 | 0.23391 | 204.75 | 0.04251 |
| ITERATION- 2 | 1297.55 | 0.00038 | 1348.06 | 0.00035 | 7.64 | 0.00019 | 0.04 | 0.00193 | 205.16 | 0.00200 |

ITERATIONS TO CONVERGE= 2

AQCR 7 BOSTON, MASS.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 13313.00 | | 958.00 | | 9174.00 | |
| ITERATION- 1 | 10932.73 | 0.17879 | 940.25 | 0.01853 | 6837.06 | 0.25473 |
| ITERATION- 2 | 10930.80 | 0.00018 | 940.13 | 0.00013 | 6841.35 | 0.00063 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 1291.83 | | 1337.30 | | 7.04 | | 0.03 | | 316.20 | |
| ITERATION- 1 | 1298.13 | 0.00487 | 1348.62 | 0.00846 | 6.90 | 0.01987 | 0.04 | 0.10269 | 322.48 | 0.01987 |
| ITERATION- 2 | 1298.26 | 0.00010 | 1348.79 | 0.00013 | 6.90 | 0.00005 | 0.04 | 0.00075 | 322.63 | 0.00044 |

ITERATIONS TO CONVERGE= 2

AQCR 8 PITTSBURGH, PA.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 8657.00 | | 600.00 | | 5162.00 | |
| ITERATION- 1 | 8253.34 | 0.04663 | 587.98 | 0.02004 | 5191.32 | 0.00568 |
| ITERATION- 2 | 8255.28 | 0.00023 | 587.77 | 0.00035 | 5200.45 | 0.00176 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | H-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 906.20 | | 938.10 | | 7.96 | | 0.03 | | 301.70 | |
| ITERATION- 1 | 913.22 | 0.00774 | 948.64 | 0.01124 | 7.77 | 0.02321 | 0.04 | 0.09795 | 308.70 | 0.02321 |
| ITERATION- 2 | 913.38 | 0.00018 | 948.73 | 0.00009 | 7.77 | 0.00002 | 0.04 | 0.00182 | 308.87 | 0.00055 |

ITERATIONS TO CONVERGE= 2

ANCR 9 ST. LOUIS, MO.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 8856.00 | | 624.00 | | 4715.00 | |
| ITERATION- 1 | 8471.20 | 0.04345 | 572.64 | 0.08231 | 5301.99 | 0.12449 |
| ITERATION- 2 | 8457.21 | 0.00165 | 571.76 | 0.00154 | 5323.61 | 0.00408 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 954.41 | | 988.00 | | 7.50 | | 0.03 | | 296.90 | |
| ITERATION- 1 | 965.61 | 0.01174 | 1003.15 | 0.01533 | 7.22 | 0.03711 | 0.04 | 0.09897 | 307.92 | 0.03711 |
| ITERATION- 2 | 965.90 | 0.00030 | 1003.33 | 0.00018 | 7.22 | 0.00018 | 0.04 | 0.00165 | 308.38 | 0.00151 |

ITERATIONS TO CONVERGE= 2

AQCR 10 WASHINGTON, D. C.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 11246.00 | | 1055.00 | | 7894.00 | |
| ITERATION- 1 | 7354.39 | 0.34604 | 935.28 | 0.11348 | 4648.34 | 0.41116 |
| ITERATION- 2 | 7397.63 | 0.00588 | 934.49 | 0.00085 | 4675.45 | 0.00583 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 1002.68 | | 1030.50 | | 7.41 | | 0.03 | | 56.80 | |
| ITERATION- 1 | 1003.72 | 0.00104 | 1042.64 | 0.01178 | 7.28 | 0.01734 | 0.04 | 0.38931 | 57.78 | 0.01734 |
| ITERATION- 2 | 1003.68 | 0.00004 | 1042.61 | 0.00003 | 7.28 | 0.00008 | 0.04 | 0.00483 | 57.81 | 0.00038 |

ITERATIONS TO CONVERGE= 2

AQCR 11 CLEVELAND, OHIO

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 8466.00 | | 613.00 | | 5048.00 | |
| ITERATION- 1 | 8647.33 | 0.02142 | 581.66 | 0.05112 | 5440.42 | 0.07774 |
| ITERATION- 2 | 8637.14 | 0.00118 | 581.18 | 0.00083 | 5434.61 | 0.00107 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 878.14 | | 905.30 | | 7.86 | | 0.03 | | 306.90 | |
| ITERATION- 1 | 890.33 | 0.01389 | 924.70 | 0.02143 | 7.55 | 0.03999 | 0.04 | 0.25137 | 318.70 | 0.03846 |
| ITERATION- 2 | 890.94 | 0.00068 | 925.40 | 0.00075 | 7.55 | 0.00003 | 0.04 | 0.00792 | 319.66 | 0.00302 |

ITERATIONS TO CONVERGE= 2

AQCR 12 BALTIMORE, MY.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 7438.00 | | 645.00 | | 4666.00 | |
| ITERATION- 1 | 7536.26 | 0.01321 | 637.73 | 0.01128 | 4760.88 | 0.02033 |
| ITERATION- 2 | 7543.09 | 0.00091 | 637.70 | 0.00003 | 4763.82 | 0.00062 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 812.75 | | 835.30 | | 7.08 | | 0.03 | | 209.80 | |
| ITERATION- 1 | 813.57 | 0.00102 | 844.98 | 0.01159 | 7.05 | 0.00399 | 0.04 | 0.38417 | 210.64 | 0.00401 |
| ITERATION- 2 | 813.59 | 0.00002 | 844.99 | 0.00001 | 7.05 | 0.00002 | 0.04 | 0.00575 | 210.64 | 0.00002 |

ITERATIONS TO CONVERGE= 2

AQCR 14 MINNEAPOLIS-ST. PAUL, MINN.

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 7154.00 | | 643.00 | | 4067.00 | |
| ITERATION- 1 | 7073.18 | 0.01130 | 569.38 | 0.11449 | 4475.66 | 0.10048 |
| ITERATION- 2 | 7052.10 | 0.00298 | 568.93 | 0.00079 | 4462.32 | 0.00298 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 757.85 | | 774.90 | | 7.49 | | 0.02 | | 203.80 | |
| ITERATION- 1 | 764.45 | 0.00870 | 793.99 | 0.02464 | 7.24 | 0.03236 | 0.04 | 0.71179 | 210.37 | 0.03224 |
| ITERATION- 2 | 764.66 | 0.00029 | 794.12 | 0.00016 | 7.24 | 0.00000 | 0.04 | 0.01524 | 210.62 | 0.00117 |
| ITERATION- 3 | 764.67 | 0.00001 | 794.12 | 0.00001 | 7.24 | 0.0 | 0.04 | 0.00010 | 210.62 | 0.00000 |

ITERATIONS TO CONVERGE= 3

AWCR 15 HOUSTON, TEXAS

CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 6279.00 | | -534.00 | | 4160.00 | |
| ITERATION- 1 | 6920.77 | 0.10221 | 465.69 | 0.12792 | 4385.45 | 0.05420 |
| ITERATION- 2 | 6934.05 | 0.00192 | 465.30 | 0.00084 | 4390.32 | 0.00111 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 740.65 | | 755.00 | | 7.77 | | 0.02 | | 148.70 | |
| ITERATION- 1 | 746.39 | 0.00774 | 775.36 | 0.02696 | 7.46 | 0.03935 | 0.04 | 0.99374 | 154.55 | 0.03935 |
| ITERATION- 2 | 746.75 | 0.00049 | 775.50 | 0.00019 | 7.46 | 0.00004 | 0.04 | 0.02149 | 154.80 | 0.00159 |
| ITERATION- 3 | 746.75 | 0.00000 | 775.49 | 0.00001 | 7.46 | 0.00000 | 0.04 | 0.00019 | 154.80 | 0.00000 |

ITERATIONS TO CONVERGE= 3

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CONVERGENCE PROCESS FOR ESTIMATED VALUES WITHOUT POLLUTION CONTROLS

SIMULTANEOUS SYSTEM NUMBER - 1

| ENDOGENOUS VAR. | Y | CONV | G | CONV | C | CONV |
|---|---|---|---|---|---|---|
| ACTUAL VALUE | 4804.00 | | 502.00 | | 3076.00 | |
| ITERATION- 1 | 6384.43 | 0.32898 | 499.27 | 0.00544 | 4067.92 | 0.32247 |
| ITERATION- 2 | 6412.20 | 0.00435 | 499.21 | 0.00012 | 4070.48 | 0.00063 |

ITERATIONS TO CONVERGE= 2

SIMULTANEOUS SYSTEM NUMBER - 2

| ENDOGENOUS VAR. | N-T | CONV | L | CONV | W | CONV | U | CONV | SUMN | CONV |
|---|---|---|---|---|---|---|---|---|---|---|
| ACTUAL VALUE | 518.12 | | 543.10 | | 7.69 | | 0.05 | | 176.60 | |
| ITERATION- 1 | 521.75 | 0.00701 | 541.52 | 0.00291 | 7.52 | 0.02143 | 0.04 | 0.20823 | 180.40 | 0.02152 |
| ITERATION- 2 | 522.00 | 0.00049 | 541.62 | 0.00019 | 7.52 | 0.00011 | 0.04 | 0.00551 | 180.49 | 0.00047 |

ITERATIONS TO CONVERGE= 2