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ENVIRONMENTAL IMPACT ANALYSIS BASED UPON  
INPUT-OUTPUT TABLES WITH REFERENCE TO THE  
STRIP-MINING OF COAL IN KANSAS

BY

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CHAPTER I  
INTRODUCTION

Man has always influenced and been influenced by his environment.<sup>1</sup> All civilizations so far have been built on an orderly system of relationships linking man to nature, but these relations are being disrupted all over the world by technological forces.<sup>2</sup> As man becomes more scientific, an individual detachment from nature takes place. Then the human being becomes a unit, a discrete thing with a mind of its own, operating in a vast universe. When nature becomes antagonistic to man, man must conquer nature to survive.<sup>3</sup> Now that society has allowed the environment to be abused, society will have to suffer the consequences. The answer does not lie in a return to an imaginary Arcadia or in the search for a static Utopia, but in an attempt to insure that the

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<sup>1</sup>John A. Baker, "Man and His Environment," Environmental Improvement (Washington, D.C.: Department of Agriculture Graduate School, 1965), p. 1.

<sup>2</sup>Ibid., p. 5.

<sup>3</sup>Leslie L. Roos, Jr., ed., The Politics of Ecosuicide (New York: Holt, Rinehart, and Winston, Inc., 1971), p. 25.

environmental changes that society brings about do not outstrip its adaptive potentialities; and furthermore, govern his adaptive responses in such a manner that they do not decrease the qualities of his life.<sup>4</sup>

Clearly, environmental pollution is a social problem, and while man individually may help to reduce the contamination of his environment, needed and effective control can only be achieved by concerted social action.<sup>5</sup> Control of environmental pollution is a major concern to many people. But what are the pollutants of air, water, or food that are really significant?<sup>6</sup> What are the sources of these pollutants? What is the relationship between the amount of wasteload generated and the amount of units produced? The answers to these questions must involve an evaluation of both the types and quantities of air, water, and land pollutants which are now being generated by industries.

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<sup>4</sup>Rene Jules Dubos, "Air, Water, and Earth," Environmental Improvement, p. 15.

<sup>5</sup>John T. Middleton, "Control of Environment," Environmental Improvement, p. 53.

<sup>6</sup>Rene Jules Dubos, "Man and His Environment, Adaptations and Interactions," The Fitness of Man's Environment (Washington, D.C.: Smithsonian Institution Press, 1968), p. 232.

Since a concern for the environment has emerged, and is becoming a social issue, economics, as one of the social sciences, is one of the academic fields which is responding to the concern. One very important tool at the economist's disposal is an Input-Output Systems Analysis which shows the economic interdependence of industries and from this the environmental impact of an industry may be assessed.

In this thesis a model will be developed, using Input-Output Analysis, to assess the environmental impact of an industry; specifically, the coal mining industry in Kansas. Briefly, the model will be presented in three stages. First, the basic model is formulated and applied to the strip-mining of coal industry in Kansas to assess the environmental effects of this industry. Second, the model will be applied to include the environmental effects of all industries economically linked with the strip-mining of coal in Kansas. Finally, the environmental effects of reclamation will be examined. Detailed descriptions of both an Input-Output Systems Analysis and the model developed from this system are presented in Chapter 3.

## HISTORICAL BACKGROUND

Prior to the emergence of the environmental quality movement in the nineteen sixties, concern for the environment was made evident by the establishment of voluntary, privately financed organizations to promote specific objectives. Illustrations of this movement include the establishment of the American Fisheries Society in 1870 and the American Forestry Association in 1875. Similar groups were established to promote the conservation of other natural resources. To strengthen the effectiveness of all these organizations, the Natural Resources Council was established in 1946.<sup>7</sup>

The environmental quality movement gained impetus partially as a public response to the publication, in 1962, of the book Silent Spring by Rachel Carson. This book was written in opposition to the extensive use of the pesticide, DDT. In the long run, the real contribution of Silent Spring was the stimulation of research efforts by scientists concerning the secondary effects of pesticides. DDT applied to crops or trees in one area may affect fish, birds, and possibly man, hundreds of miles away. The culmination of the interest voiced by Ms. Carson's book was a coalition of scientists and

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<sup>7</sup> Lynton Keith Caldwell, Environment, "A Challenge to Modern Society" (New York: Natural History Press, 1970), p. 39, 40.

citizens who joined forces to conduct a conference titled, "Pesticides--A Special Review," in April of 1966 in Madison, Wisconsin. The specific aim of this conference was to investigate DDT in relation to the ecosystem. This resulted in the identification of DDT as a water pollutant. Perhaps a much more significant outcome of this examination was the water quality legislation which defined a pollutant as, "any material that may be damaging to fish, game, or wildlife in state waters,"<sup>8</sup> and delegated authority to the Department of Natural Resources to control pollutants introduced into Wisconsin's lakes and streams. This provided not only an avenue for implementating the concern evidenced by the public, but also marked an entrance of government intervention into the area of water quality control.<sup>9</sup>

Entrance of the environmental quality movement into the area of air quality control was brought about by a dramatic episode in New York City in 1966. This event is commonly referred to as the "Thanksgiving episode." During a period of four or five days the level of sulfur

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<sup>8</sup> John Harte and Robert H. Socolow, Patient Earth (New York: Holt, Rinehart and Winston, Inc., 1971), p. 90.

<sup>9</sup> Ibid., pp. 88-90.

dioxide rose to 0.51 ppm\* daily resulting in more than 170 deaths. Because of its impact on the general public, the "Thanksgiving episode" marks the awareness of large segments of the general population that the condition of the air in major cities across the United States could lead to a major tragedy.<sup>10</sup>

To meet his requirements for daily sustenance, man has also misused another natural resource--land. The land has provided man with such products as; lumber, fuelwood, agricultural products, and a food supply for livestock. Each of these products was extracted, without concern for replenishment.<sup>11</sup>

The mining of minerals, such as coal, was often undertaken without concern for the environment. The primary objective governing this process was to extract the minerals as cheaply as possible. This is a short term goal, which ignores the long term effects of silted streams and wasteland left by surface mining.<sup>12</sup> Misuse

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\*According to Chapter 28, Article 19, Amendments, "Ambient Air Quality Standards and Air Pollution Control Regulations," p. 4, the Maximum annual arithmetic mean of SO<sub>2</sub> is 0.02 ppm, ppm is parts per million.

<sup>10</sup>Harte, Patient Earth, pp. 44, 45.

<sup>11</sup>U. S. Department of the Interior, Surface Mining and Our Environment (Washington, D.C.: U.S. Government Printing Office, 1967), p. 3.

<sup>12</sup>Ibid., p. 4.

of land has now become a serious challenge to the environmental quality movement.

The environmental quality movement provided the catalyst for a coordinated approach to natural resources policy. It is evident that public outcry and concern alone is not enough to halt the increasing amounts of contaminants that are being spewed into the environment-- air, land, and water. It is also true that pollution controls, implemented by individual private industries, would often place these industries in an unfair competitive economic advantage. One alternative whereby mass pollution control measures might be undertaken by all private industries is through government control. To obtain this objective, Public Law 91-190 was passed by Congress on January 1, 1970. The purposes of this Act are:

"To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality."<sup>13</sup>

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<sup>13</sup>Environmental Quality, "The First Annual Report of the Council on Environmental Quality" (Washington, D.C.: Government Printing Office, 1970), p. 243.

Government legislation and public concern play a vital role in curbing misuse of natural resources. There is still a great need for investigation to determine the sources of pollutants; also, the relationship between the amount of wasteload generated and the number of units produced. Both of these questions need to be answered to estimate both the types and quantities of air, water, and land pollutants which are now being generated by industries. The answers to these questions are a step towards evaluating the environmental effect of any industry. And with this information to develop a methodology to assess more fully the environmental effects of an industry, which would allow better policy-making and planning decisions regarding the location of industries.<sup>14</sup>

#### REASONS FOR THE STUDY

When people think of the environmental effects of an industry, they generally remember such obvious

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<sup>14</sup>For Example, if a decision was to be made to encourage either the location of industry A or industry B in the same area; and, they had the same economic effect and the same direct environmental effect, they would be equally attractive. However, if the indirect and induced environmental effects were assessed and the quantities of pollutants were greater for B than for A, then planners could encourage industry A to locate, rather than industry B.

incidences, as the "Thanksgiving episode." However, there are additional environmental effects which follow because of various linkages an industry may have. The obvious thought here might be the natural or biological ramifications. There is another cycle--the economic cycle which through the economic interdependence of industries, which also may generate additional impact on the environment. In order to illustrate this possibility the economic cycle of an industry merits attention. The industry to be used is the strip-mining of coal industry in Kansas.

To illustrate the obvious environmental effects, a description of the mining process itself will be discussed; these will be referred to as direct environmental effects. To illustrate other environmental effects, the economic cycle will be presented; these will be indirect or induced environmental effects.

The direct environmental effects follow from the technique most often used. In Kansas, this is strip-mining, which consists of removing the topsoil, rock and other strata that lie above the mineral deposits in order to recover these deposits.<sup>15</sup>

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<sup>15</sup>Interior Department, "Surface Mining," p. 33.

This method has been placed in an advantageous position relative to other mining techniques, such as deep shaft mining, for a number of reasons. With technological advances it has been possible to almost double the total coal production in Kansas from 900,000 tons mined in 1960, to 1,600,000 tons mined in 1970.<sup>16</sup> The operating costs are 25 to 30 percent lower, and the production per man is 100 percent higher, when comparing strip-mining to deep shaft mining.<sup>17</sup> Also, with the passage of the 1969 Federal law,<sup>18</sup> which established new requirements for the health and the safety of underground miners, the disparity between the two methods was increased.<sup>19</sup> According to research prepared by the Office of Business Economics, U.S. Department of Commerce, which examined the extent to which other industries depend on the coal industry, 76 percent of all the coal mined is used directly by 56 industries (out of a total of 82 industries) to produce other products. The remaining 24 percent represents exports and consumer

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<sup>16</sup>U.S. Bureau of Mines, Yearbook, Area Report (Washington, D.C.: U.S. Government Printing Office, 1970).

<sup>17</sup>Wichita Beacon, August 25, 1971, p. 14A.

<sup>18</sup>Public Law 91-173, Title V, sec. 501-513, U.S. Statutes at Large (1970), pp. 798-804.

<sup>19</sup>"Beacon," p. 14A.

consumption.<sup>20</sup> With all these advantages, and with the supplies of gas and oil dwindling and delays in producing nuclear power, the demand for coal is likely to remain.<sup>21</sup>

Strip mining consists of the removal of the layers of earth lying over the mineral deposits. This process displaces the layer of top soil. The resulting destruction of the protective vegetative cover speeds up erosion. Further, the massive piles of soil and rock left behind are sources of erosion, and may be displeasing to the eye. These are all examples of the direct environmental impact of the strip mining of coal industry in Kansas.

2) There are two sources of indirect environmental effects, which follow because of the economic interdependence of this industry. To illustrate, the coal company must purchase inputs, such as electricity, to operate machinery. This would be a direct purchase of an input. When electrical companies generate the power to meet this demand, they simultaneously produce air and water pollutants. These wastes would be classified as indirect environmental effects (see diagram, page 14). If the dollar the coal company pays to the electrical company is traced, it might eventually be spent by the

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<sup>20</sup>Interior Department, "Surface Mining," p. 42.

<sup>21</sup>"Beacon," p. 14A.

electrical company for inputs to be used to generate the electricity originally demanded by the coal company. This would be an indirect purchase of inputs (see diagram on following page). If the electrical company purchases oil (another indirect purchase of an input) to burn in order to produce electricity for the coal mining industry the wasteload generated by the oil company in meeting this demand can be traced back to the coal mining industry through the market structure of inputs. These wastes would also be classified as indirect environmental effects (see diagram).

2b) The income paid to the coal laborers enables them to spend money and generate demand for the output of various industries. This would be an induced economic effect. When these industries meet this demand, they also generate environmental effects; these are induced environmental effects. For example, if a laborer purchases food commodities, such as bread, with his dollars this will mean that the agricultural sector will need to produce wheat. The contaminants which may be by-products, such as nutrient loss, would be classified as induced environmental effects (see diagram, page 14).

The criteria involved in placing environmental effects in the categories described on the previous page, are different than those which may be used to identify environmental effects according to the biological cycle of organisms. This would involve an investigation of ecological systems or the study of the interactions of organisms and the environment.<sup>22</sup> This method was used by Isard<sup>23</sup> in a study done of the Philadelphia economy, and is discussed in detail in Chapter 2. For example, assume an industrial process results in an increase in the turbidity of water, a direct environmental effect. This is the same criteria used to classify effects on the previous page; however, according to the biological interdependence of light and phytoplankton, an indirect environmental effect would be a reduction in the amount of phytoplankton output from photosynthesis. This in turn affects the supply of plankton, algae production, and so on, and finally fish production.<sup>24</sup> In order to use these criteria, extensive and valid models of

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<sup>22</sup>Ian L. McHarg, Environmental Improvement, p. 100.

<sup>23</sup>Walter Isard and Thomas W. Langford, Regional Input-Output Study: "Recollections, Reflections, and Diverse Notes on the Philadelphia Experience" (Massachusetts: MIT Press, 1971).

<sup>24</sup>Ibid., p. 12.

ecological systems are necessary.<sup>25</sup> "At present, this kind of theoretical approach to ecological problems is not well developed."<sup>26</sup> It would also be "prohibitively expensive for most regional development agencies."<sup>27</sup>

An alternative approach to environmental effect classification utilizes the "Direct, Indirect, and Induced Requirements Matrix" developed in the Kansas Interindustry Structure publication.<sup>28</sup> This matrix illustrates the direct and indirect purchases of inputs by an industry, and the induced changes in income which results in consumer purchases for each dollar output generated by every Kansas industry. These will be referred to as "Total Purchases and Consumer Effects," Table A-1, column 3. A detailed explanation of the

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<sup>25</sup> Charles G. Wilber, The Biological Aspects of Water Pollution (Springfield: Charles C. Thomas, 1969), p. 276.

<sup>26</sup> Wilber, "Biological Aspects," p. 276.

<sup>27</sup> Geoffrey J. D. Hewings, "Aggregation for Regional Impact Analysis," 47 Centre for Research in Social Sciences, 17: W. Isard, T. W. Langford, Jr., with E. Romanoff, Revised Direct Coefficient Table and Complete Working Papers of the Philadelphia Region Input-Output Study (Philadelphia: Regional Science Research Institute, 1970).

<sup>28</sup> M. Jarvin Emerson, with Leonard D. Atencio, Phillip D. Brooks, and J. David Reed, The Interindustry Structure of the Kansas Economy (Manhattan: Kansas Office of Economic Analysis and Planning Division, Kansas Department of Economic Development, 1969).

derivation of this matrix and table is presented in Chapter 3.

#### OUTLINE OF THE MODEL

To derive the basic model, the "Kansas Direct, Indirect, and Induced Requirements Matrix" is used. It gives the list of the industries, along with their input coefficients, which are economically linked to the strip-mining of coal in Kansas. To calculate the direct and indirect purchases of inputs and the induced economic effects of consumer spending, multiply the input-output coefficients, Table A-1, column 2, by the total industrial output of the strip-mining of coal industry, Table A-1, column 3. To convert this figure to production units, divide the output by the average wholesale price per unit of the particular product, Table A-1, column 5. To calculate the total wasteload generated by all industries, multiply the total production units, Table A-1, column 6, by the industries' respective pollution generated per unit of product. The like effluents may be summed and their environmental impact expressed as population equivalents (Appendix D). If reclamation occurs, the pollution quantities will need to be re-evaluated (Appendix E). After this adjustment, the like pollution quantities are summed and evaluated according to population equivalents (Appendix E).

## METHODOLOGY

This thesis uses an Input-Output Systems Analysis to develop quantitative measures of the environmental effects of the strip-mining of coal industry in Kansas. Two sources of environmental effects are important in such an assessment--the environmental effects relevant to the mining process itself and the environmental effects which follow because of the economic interdependence of this industry. The first of these will be in the category of direct environmental effects; and the latter will be either indirect or induced environmental effects.

For example, with the removal of the layers of earth lying over the mineral deposits, the protective vegetative cover is destroyed, which leads to increased erosion. This is a direct environmental effect of the strip-mining process.

The indirect environmental effects result from the indirect purchases of inputs. As previously explained, when these industries meet the coal companies demand, they simultaneously generate waste products. The induced environmental effects occur when consumers spend their income, since industries upon meeting this demand also produce waste products at the same time.

## CONTENT & SCOPE OF THE THESIS

This thesis develops a quantitative method for measuring the environmental impact of industrial activities. This method will be applied to the strip-mining of coal industry in Kansas, to assess the direct, indirect, and induced environmental effects. A table has been constructed to summarize these environmental effects. Adjustments will be made to incorporate the reclamation law. The revised figures will be evaluated according to population equivalents.

CHAPTER II  
PREVIOUS STUDIES

One of the important advances in modern economic theory has been Input-Output Systems Analysis. This has provided a useful tool in projecting supply and demand of economic commodities. A new direction that has recently been undertaken is the application of Input-Output Methodology to problems relating to environmental quality. This would allow projections to be made concerning the supply and demand of environmental commodities--resources and pollutants.

Two studies applying Input-Output Methodology to environmental quality analysis should be mentioned. One, a study of the Philadelphia 496 region by Walter Isard;<sup>1</sup> and another of the Colorado River Basin by William H. Mierynk.<sup>2</sup>

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<sup>1</sup>Walter Isard and Thomas W. Langford, Regional Input-Output Study: "Recollections, Reflections, and Diverse Notes on the Philadelphia Experience" (Massachusetts: MIT Press, 1971).

<sup>2</sup>William H. Mierynk, Systems Analysis for Great Lakes Water Resources, "Proceedings of the Fourth Symposium on Water Resources Research of the Ohio State University Water Resources Center" (Ohio State University 1969), pp. 49-58.

These studies are available as theoretical guides for environmental quality analysis, although they have not as yet been empirically tested. A detailed presentation of both studies may be found in Appendices B and C.

#### STUDY OF THE PHILADELPHIA 496 REGION

The study developed by Walter Isard, at the University of Pennsylvania, involves an extension of the input-output framework to simultaneously cover both economic and ecologic systems. This involved the addition of ecologic commodities, such as biological oxygen demand (BOD(5-day)), sulfur dioxide (SO<sub>2</sub>), and water of a specified content, to the rows of an input-output table. Parallel to these commodities the set of columns can be extended to cover ecologic processes; such as photosynthesis, replenishment of oxygen supply in water, and codfish production. This results in the extension of the inputs and the outputs from the ecologic systems. The inputs and outputs of each ecologic process cover commodities that are not only ecologic, but also those commodities, such as codfish, corn, and grass, that have come to be designated economic commodities. In short, the Philadelphia 496 order table is to be extended to cover many more commodities and processes, and thereby to

expose basic interrelations between the economic and ecologic subsystems.

Both Isard's study and this thesis have a common end--an assessment of the environmental effects of industries. The methods followed differ, however. Isard's theoretical approach to ecological problems requires extensive and valid models of ecological systems. At present, such models have not been developed. In Isard's study this lack of data required a change of industries investigated to complete his illustration. He used the petroleum refining industry to show the non-economic commodities which are produced, such as water pollutants discharged. This allowed the extension of the rows to cover both economic and ecologic commodities. However, to show the ecologic inputs from the ecologic system to the economic system, such as fish and the ecological process necessary to produce these inputs, he used recreational activities. As data on the ecological inputs and processes related to the petroleum refining industry was not available, it was necessary to use the industry of sport fishing from boats with outboard motors as an illustration.

Although research is being undertaken to develop models of ecological systems, it has been suggested that "perhaps ecological interactions are too complex and have

too great a degree of variability to permit satisfactory model construction."<sup>3</sup> There would be formidable difficulties, both conceptual and empirical, involved in estimating this data, since it would necessitate a sophisticated understanding of biological processes. When classifying these noneconomic commodities, researchers may find it necessary to make arbitrary decisions. Their findings might be accurate enough to approximate future needs regarding supply and demand of environmental commodities--resources and pollutants.

Another difference between Isard's study and this thesis involves the role played by the Input-Output model. Isard has suggested extending the columns and the rows of the matrix itself to derive the basis interrelationships between the economic and ecologic systems. In this thesis, it was used as a base for calculations, assuming that the quantity of demand created by the dollar output of an industry was constant or directly proportional to the quantity of waste products generated. One of the shortcomings of this method in comparison to Isard's is that since coefficients regarding water use and water pollutants were not developed, projections relevant to

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<sup>3</sup>Charles G. Wilber, The Biological Aspects of Water Pollution (Springfield: Charles C. Thomas, 1969), p. 276.

this resource could not be obtained, while in Isard's model the ramifications of increased demand on this resource could be evaluated.

A third area where Isard's model differs from this thesis regards the cycle of pollution relevant to ecological processes. For example, a part of the oxygen depleted in water is replenished naturally, and there are natural processes, such as rain and air movement that remove particulates from the air. These processes employed as inputs, the diverse pollutants that are generated, and yielded as outputs water and air of specified quality. This thesis quantifies the amount of pollutants generated and is not involved in evaluating the ecological interdependence of commodities and processes that exist in the ecologic realm as it does in the economic realm.

Implementation of Isard's method will provide a systematic method of projecting conditions of both supply and demand regarding environmental commodities such as, resources and pollutants. The advocacy of this classification of ecologic processes would require expertise in various fields. Educational training in economics alone would not suffice, as an understanding of biological and chemical processes would be useful. An alternative approach that may be used would be a coordination of the efforts of biologists, chemists, and economists.

## STUDY OF THE COLORADO RIVER BASIN

The forecasting model developed by William H. Mierynk for the water resources of the Colorado River Basin is concerned with how a change in water quality might effect water users; and thus industrial outputs. The "economic value"<sup>4</sup> of water quality has gained importance with the current trends of urbanization, industrial growth, and higher standard of living. Water is being used in greater quantities for household equipment, air conditioning (both in office buildings and homes), and in public places, such as swimming pools and parks.<sup>5</sup>

The method developed by William Mierynk was used to make long-range projections of economic activity in the Colorado River Basin subject to water quantity and quality constraints. The conventional open Leontief Input-Output model with changing input coefficients was the forecasting model. Separate transactions tables were derived for each sub-basin and linked together balancing import rows and export columns to form a "pure" interregional model. A set of sectoral water input coefficients were

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<sup>4</sup>Allen V. Kneese, Water Pollution, "Economic Aspects and Research Needs" (Baltimore: John Hopkins Press, 1962), p. 25.

<sup>5</sup>W. A. Hardenbergh and Edward B. Rodie, Water Supply and Waste Disposal (Scranton: International Textbook Company, 1966), pp. 40-45.

introduced to determine the relationship between the future water demanded and the future supply. This relationship determined how water quality would influence industrial output. If the quality of water demanded exceeded the available supply, Mierynk assumed the market would allocate the available supply to the "highest value-added" or "most profitable" uses (this basic assumption is a point of contention, and will be discussed later). This meant that the decision was made in advance that lesser quantities of water would be used in those sectors where each gallon of water consumed yielded the lowest rates of return to the users. Water quality then became a constraint on the water users. To allow quality-constrained projections to be made, it was necessary to estimate the total dissolved solids in parts per million which would result from the increased use of water to meet the projected levels of total gross output in each sub-basin. After the water quality constraints were derived, the results were analyzed in relation to the industrial (economic) realm, rather than the environmental (noneconomic) realm.

Both Mierynk's study and this thesis have used a Leontief Input-Output matrix as a base for calculations. Both inquiries were concerned with the wasteloads being generated by industries, which involves calculating a

pollution figure per product unit produced. However, after assessing the quantities of wasteloads generated by industries, Mierynk returned to the industries themselves to evaluate the effect the environment (decreased water quality) may have in the economic realm. Conclusions could then be drawn concerning the interdependence of the environment and industry, i.e. the relationship between economic output and water inputs of a specified quality. The primary concern of this thesis was not the economic ramifications of pollution generated; rather the noneconomic (environmental) effects of the pollution generated by industries.

In order to derive the quantities of resources necessary for production, it is vital to develop input coefficients of the resources being used. The form of these coefficients should be the number of units of the resources required per dollar of output of the industry. This was the method used by Mierynk. A knowledge of these coefficients would have expanded the conclusions of this thesis; however, sufficient data were not available on water use. In integrating the water input coefficients and the Input-Output Matrix, Mierynk made some previous decisions concerning the allocation of water. He assumed the market structure will cause adjustments as water becomes scarce. This, in effect,

classified water as a private rather than a public good, which is a question still unsettled. If water is a private good, then what Mierynk projected is valid. As water becomes more scarce and a need is brought about to reuse the water, if the price of water rises, marginal businesses (farms in this study) will be driven out and no shortage of water will exist. This means that the more capital intensive enterprises will survive. If, however, water quality is a public good, which Samuelson defines as one which satisfies the following relationship:

$X_2 = X_2^i$ , and  $(i=1, \dots, n)$ , where,  $X_2$ =quantity of public good where,  $X_2$ =quantity of public good produced,  
 $X_2^i$ =quantity of public good consumed by  $i^{\text{th}}$  consumer<sup>5</sup>

supplying the good to one individual is not possible without simultaneously supplying it to other individuals. There is a joint supply constraint.

Production of higher quality water requires either a rise in water prices or the investment of water purification equipment, but the water cannot be supplied selectively to some users and not to all users. In effect, the joint supply constraint prevents market mechanisms from determining the quantity of water produced

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<sup>5</sup>Paul Samuelson, "The Pure Theory of Public Expenditure," Review of Economics and Statistics, Vol. 36 (November 1954), p. 387.

of a specified quality.<sup>6</sup> Mierynk assumed that if a scarcity of water existed the market would allocate the available supply to the "most profitable" uses, which is not true unless water is considered a private good.

Mierynk's study does project future conditions concerning water demand and water supply relative to industrial needs. And water input coefficients are vital in an environmental quality analysis. This requires available water use information and an acceptance of his initial assumption that water is a private good. The main thrust of Mierynk's study was the effect of water quality constraints on production, and other changes in environmental quality were not evaluated.

#### CONCLUSIONS

These two studies illustrate two recent attempts to assess the environmental effect of an industry using Input-Output methodology. Data is not yet available to empirically test Isard's theory. Mierynk's was primarily concerned with changes in water quality. In relating the concept of these studies, i.e., using Input-Output methodology for an environmental quality analysis,

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<sup>6</sup>Allen V. Kneese and Blair T. Bower, Managing Water Quality: "Economics, Technology, Institutions" (Baltimore: Johns Hopkins Press, 1968), pp. 202, 203.

in conjunction with data currently available, the methodology presented in Chapter 3 was developed.

### CHAPTER III METHODOLOGY

Adam Smith and his immediate successors approached the economy as a whole, which is defined today as macroeconomics. Later economists changed the focus to the household and the firm, microeconomics. The Neoclassical economists analyzed the forces leading to economic equilibrium, specifically partial equilibrium, looking at one variable at a time, such as interest rates. John Maynard Keynes returned to aggregative economics, primarily the determinants of income and employment. None of these economists were directly concerned with economic interdependence, or the structure of the economy and the manner in which the sectors fit together.

There were a few departures from these early analyses, including Francois Quesnay in 1758, who published his Tableau Economique, which emphasized the interdependence of economic activities. Quesnay's study was concerned with the successive rounds of spending, a forerunner of the modern multiplier. Later economists' work added to the development of this model, including,

Leon Walras, whose theory of production utilized "production coefficients," and Gustav Cassel and Vilfredo Pareto who contributed to the theory of general equilibrium. The final step in the development of the Input-Output methodology came in 1930, when Wassily Leontief developed a general theory of production based on the notion of economic interdependence, and subsequently published the first Input-Output table for the American economy.<sup>1</sup>

Input-Output analysis has now become an integral part of modern economics. It is being applied to such problems as the allocation of resources and distribution of income, to the development of underdeveloped countries, and more recently to the measurement of environmental impact.

#### OUTLINE OF THE MODEL

As technology advances and becomes more specialized, there comes a greater degree of economic interdependence among industries. Therefore to assess the total effect of an industry, it becomes necessary to look at all firms in which this industry generates a greater demand for goods and services.

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<sup>1</sup>William H. Miernyk, The Elements of Input-Output Analysis (New York: Random House, 1965), pp. 3-6.

A list of industries which are economically linked with the strip-mining of coal industry in Kansas is the starting point for assessing the environmental impact resulting from these industries when they produce their output. This list was compiled from the "Kansas Direct, Indirect, and Induced Requirements Matrix;" and is the final matrix of the Kansas Interindustry Study.<sup>2</sup>

DEVELOPMENT OF THE KANSAS DIRECT, INDIRECT, AND  
INDUCED REQUIREMENTS MATRIX

An Input-Output model divides the economy into a number of industries or sectors and then derives the magnitude of the flows of products and services among these industries. There are three tables which are basic to an Input-Output system; the Transactions Matrix, the Direct Requirements Matrix, and the Direct and Indirect Requirements Matrix. A simple illustrative Input-Output system from Dr. Emerson's study explains this analysis.<sup>3</sup>

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<sup>2</sup>M. Jarvin Emerson with Leonard D. Atencio, Phillip D. Brooks, and J. David Reed, The Interindustry Structure of the Kansas Economy (Manhattan: Kansas Office of Economic Analysis and Planning Division, Kansas Department of Economic Development, 1969), Appendix C, Input-Output Tables, "Kansas Direct, Indirect, and Induced Requirements Matrix."

<sup>3</sup>Ibid., pp. 20-23.

SIMPLE ILLUSTRATIVE INPUT-OUTPUT SYSTEM

ILLUSTRATION 3-A

Input-Output Transactions Matrix--this shows the typical transactions undertaken in the Kansas economy.

IN MILLIONS OF DOLLARS

PURCHASING SECTORS	SELLING SECTORS				
	Farm- ing	Manu- factur- ing	Trade	Final Demand	Total Output
Farming	4	8	2	16	30
Manufacturing	7	15	6	22	50
Trade	6	5	4	10	25
Final Payments	13	22	13	0	48
Total Inputs	30	50	25	48	153

Each column represents the purchases and payments made by that column sector. For example, the farming sector, to produce its \$30 million output, purchased \$4 million from the farming sector, \$7 million from the manufacturing sector, and \$6 million from the trade sector, and made \$13 million of payments to the final payments sector. The final payments sectors represent expenditure categories of industries other than purchases of goods and services from Kansas industries. These include Households (wages, salaries, interest, profit, and rent), Gross Savings (retained earnings and depreciation), Federal Government (primarily taxes), State Government, Local Government, and Imports (out-of-state purchases.)<sup>4</sup> Conversely, each row indicates the sales of that row sector to the column sectors. Further, the farming row sector sells \$4 million to farming, \$8 million to manufacturing, \$2 million to trade, and \$16 million to final demand, for a farming row sector total of \$30 million of output. The final demand sector includes eight sectors which are Kansas households, gross private investment, change in finished goods inventory, federal government-defense, federal government-nondefense, state government,

<sup>4</sup>Ibid., p. 95.

local government, and exports.<sup>5</sup> For each sector, total inputs (purchases and payments) equal total outputs (sales).

#### ILLUSTRATION 3-B

Direct Requirements Matrix--this indicates for each column industry what proportions of purchases it makes of each row industry to produce one dollar of output.

	Farm- ing	Manu- factur- ing	Trade
Farming	.13	.16	.08
Manufacturing	.23	.30	.24
Trade	.20	.10	.16
Final Payments	.44	.44	.52
TOTAL	1.00	1.00	1.00

In each column entry in the Transactions Matrix is divided by the corresponding column total, the result will be a Direct Requirements Matrix, as shown above. The sum of each column is one, and thus, each column entry indicates the direct purchases from each row sector necessary to produce one dollar of output for the column sector. For example, the manufacturing column indicates that in order to produce one dollar of manufacturing output, manufacturing must purchase \$.16 from farming, \$.30 from manufacturing, \$.10 from trade, and \$.44 from final payments. These dollar fractions are referred to as input-output coefficients.

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<sup>5</sup>Ibid., p. 107.

## ILLUSTRATION 3-C

Direct and Indirect Requirements Matrix--this measures the multiple indirect effects of a change in output of a particular industry.

	Farm- ing	Manu- factur- ing	Trade
Farming	1.2844	.3242	.2149
Manufacturing	.5493	1.6360	.5174
Trade	.3712	.2710	1.3031

The information contained in the hypothetical Direct Requirements Matrix (on previous page) indicates an additional \$10 million of manufacturing requires \$1.6 million purchases from farming, \$3 million purchases from manufacturing, and \$1 million purchases from trade. In order to supply these additional requirements each of these industries must increase its production. These sectors, in turn, must purchase more from their suppliers in the proportions indicated in the Direct Requirements Matrix. For instance, for trade to produce the additional \$1 million which the manufacturing sector requires to produce its extra \$10 million output, the trade sector must purchase \$80,000 from farming, \$240,000 from manufacturing, and \$160,000 from trade. This requires an output increase from each of the sectors supplying trade, and in turn these sectors must purchase additional inputs from other sectors. As the illustration suggests, these indicate requirements diminish rapidly as they are traced through several "rounds." Nevertheless, these are critical in ascertaining the total requirements of all industries made necessary by additional output in a particular industry. In the Direct and Indirect Requirements Matrix (on this page), a column shows the requirements from each industry in order for the column industry to make a one dollar delivery to final demand, or roughly, to increase its output by one dollar.

Direct, Indirect, and Induced Requirements Matrix-- this includes both the household row and column and is similar in interpretation to the Direct and Indirect Requirements Matrix. Included in the expanded matrix, however, are the effects of additional consumer income and expenditures, households were previously in the final demand sector. Not only, are there the effects of additional purchases from other industries, but also the additional income to households which enables consumers to spend more. This represents additional demand for the output of most state industries.<sup>6</sup>

#### DEVELOPMENT OF THE ENVIRONMENTAL IMPACT TABLE

Coal mining, which in Kansas is limited to the strip-mining of bituminous coal is classified in the Kansas Direct, Indirect, and Induced Requirements Matrix as Other Mining, column 16.<sup>7</sup> This column represents the total direct, indirect, and induced effects on each industry resulting from a change in one dollar delivery to final demand by the Other Mining Industry. All Kansas industries will experience some impact. The list of all these industries along with their respective coefficients is the starting point for the assessment of the environmental effects of the strip-mining of coal industry in Kansas (see Table 3-1).

From the initial list, industries were eliminated for one of three reasons. Either because their environmental effects were minimal; a duplication of the source

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<sup>6</sup>Ibid., p. 149.

<sup>7</sup>Ibid., Appendix C, Input-Output Tables.

TABLE 3-1

ALL INDUSTRIES AND THEIR RESPECTIVE COEFFICIENTS ECONOMICALLY LINKED WITH THE  
STRIP-MINING OF COAL INDUSTRY IN KANSAS

	<u>INDUSTRY</u>	<u>COEFFICIENT</u>
FARMING:	Corn	.000659
	Sorghum	.001148
	Wheat	.000465
	Other Grains	.000039
	Soybeans	.000844
	Hay	.001074
	Dairy Products	.002359
	Poultry & Poultry Products	.000222
	Cattle	.005439
	Hogs	.001221
	Other Agricultural Products	.000799
	Agricultural Services	.000594
MINING:	Crude Oil & Natural Gas	.017475
	Oil & Gas Field Services	.002139
	Nonmetallic Mineral Mining	.000625
	Other Mining	1.293407
CONSTRUCTION:	Maintenance & Repair	.009000
	Building Construction	.000001
	Heavy Construction	.000252
	Special Trade Construction	.043791
MANUFACTURING:	Meat Products	.007667
	Dairy Products	.004184
	Grain Mill Products	.001247
	Other Food & Kindred Products	.005199
	Apparel	.000315
	Paper & Allied Products	.004660
	Printing & Publishing	.004241
	Industrial Chemicals	.000538
	Agricultural Chemicals	.000282
	Other Chemicals	.007321
	Petroleum & Coal Products	.026066
	Rubber & Plastics	.082643
	Cement & Concrete	.001131
	Other Stone & Clay	.002786
	Primary Metals	.004237
	Fabricated Metals	.001436
	Other Fabricated Metal Products	.007933
	Farm Machinery	.000465
	Construction Machinery	.000521
	Food Products Machinery	.000522
Electrical Machinery	.006248	
Other Machinery	.004860	

TABLE 3-1 (Cont'd)

	<u>INDUSTRY</u>	<u>COEFFICIENT</u>
MANUFACTURING	(Cont'd):	
	Motor Vehicles	.000020
	Aerospace	.002019
	Trailer Coaches	.000810
	Other Transportation Equipment	.000251
	Other Manufacturing	.006673
TRANSPORTATION:		
	Railroad Transportation	.010084
	Motor Freight	.006219
	Other Transportation	.001729
UTILITIES:		
	Communications	.011150
	Electric Gas & Sanitary Service	.050661
WHOLESALE:		
	Groceries	.002458
	Farm Products	.001287
	Machinery & Equipment	.031171
	Other Wholesale Trade	.021215
RETAIL:		
	Farm Equipment Dealers	.000222
	Gasoline Service Stations	.007017
	Eating & Drinking	.017360
	Other Retail Trade	.040941
F. I. R. E.:		
	Banking	.014050
	Other Finance	.016727
	Insurance and Real Estate	.045494
SERVICES:		
	Lodging Services	.003947
	Personal Services	.014184
	Business Services	.009127
	Medical & Health Services	.017712
	Other Services	.007934
	Education	.002391
	Households	.355007

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Source: M. Jarvin Emerson, with Leonard D. Atencio, Phillip D. Brooks, and J. David Reed, The Interindustry Structure of the Kansas Economy, Manhattan, Kansas, January, 1969 (Topeka, Kansas: Office of Economic Analysis and Kansas Department of Economic Planning Division, 1969), Appendix C, Kansas Direct, Indirect, and Induced Requirements Matrix.

of environmental effects would result; or, information on their environmental influence was not available. In the first category are primarily the wholesale and finance sectors, the services sector, and the maintenance and repair sectors. Information is not available for three industries in the mining sector; the crude oil and natural gas industry, the oil and gas field services industry, the non-metallic mineral mining industry, and the rubber and plastics industry. In the second category was the agricultural services sector. Since this sector's environmental influences are due to the application of fertilizers to farm crops, and the amount of fertilizer is counted when looking at the individual agricultural sectors; such as corn, sorghum, wheat, etc., the environmental effect of fertilizers would have been counted twice. Table 3-2 summarizes the industries and the consideration each was given in relation to the environment.

In quantifying the environmental effects, industries are either evaluated separately, or similar industries are assessed collectively. The numerical quantities applicable are presented in Table A-1. Even though industries are dissimilar in their manufacturing processes, like pollutants may be summed, see Table D-1 and D-3 to determine the total environmental effect.

TABLE 3-2  
SUMMARY OF THE ENVIRONMENTAL CONSIDERATION GIVEN TO THE INDUSTRIES ECONOMICALLY  
LINKED WITH THE STRIP-MINING OF COAL INDUSTRY IN KANSAS

<u>INDUSTRY</u>	<u>ENVIRONMENTAL IMPACT ASSESSED</u>	<u>ENVIRONMENTAL IMPACT NOT ASSESSED</u>		<u>DUPLICAT</u>
		<u>INFORMATION NOT AVAILABLE</u>	<u>HAD MINIMAL ENVI- RONMENTAL INFLUENCE</u>	
Corn	X			
Sorghum	X			
Wheat	X			
Other Grains	X			
Soybeans	X			
Hay	X			
Dairy Products	X			
Poultry & Poultry Products	X			
Cattle	X			
Hogs	X			
Other Agricultural Products	X			
Agricultural Services				X
Crude Oil & Natural Gas		X		
Oil & Gas Field Services		X		
Nonmetallic Mineral Mining		X		
Other Mining	X			
Maintenance & Repair			X	
Building Construction			X	
Heavy Construction			X	
Special Trade Construction			X	
Meat Products	X			
Dairy Products	X			
Grain Mill Products	X			
Other Food & Kindred Products	X			
Apparel			X	
Paper & Allied Products	X			
Printing & Publishing			X	
Industrial Chemicals	X			
Agricultural Chemicals	X			
Other Chemicals	X			
Petroleum and Coal Products	X			
Rubber & Plastics		X		
Cement & Concrete	X			
Other Stone & Clay	X			
Primary Metals	X			
Fabricated Metals			X	
Other Fabricated Metal Products			X	
Farm Machinery			X	
Construction Machinery			X	
Food Products Machinery			X	
Electrical Machinery			X	
Other Machinery			X	
Motor Vehicles			X	
Aerospace			X	
Trailer Coaches			X	
Other Transportation Equipment			X	
Other Manufacturing			X	

### BASIC PROCEDURE

The same basic procedure is followed for each industry to convert the Total Direct and Indirect Purchases and the Induced Effects of Consumers, to be referred to as Total Purchases and Consumers' Effect, which expressed in dollars to units of products in each industry. This involved two variables and one constant.

The formula used was:

$$\frac{\text{Coefficient} \times \text{Coal Industry Output}}{\text{Average Dollar Price per Unit}} = \text{Total Purchases and Consumers' Effects}$$

Variables used were:

1. Input-Output Coefficient--taken from column 16 of the Kansas Direct, Indirect, and Induced Requirements Matrix. This represents the total direct, indirect, and induced effects on each industry resulting from a change in one dollar delivery to final demand (excluding households) by the Other Mining Industry. All Kansas industries were subject to some impact.

2. Average Wholesale Dollar Price per Unit--taken from the Wholesale Price Index.<sup>8</sup> This was either the single average price of the product produced by an industry or a representative price; computed if more than one product was represented by an industry sector. This was a simple average. For example, the price of \$1.008 per bushel of Other Grains was computed by summing the average price per bushel of; Oats, \$.711 per bushel; Barley, \$1.130 per bushel; and Rye, \$1.184 per bushel, and then dividing by three. An indirect assumption made is that the Total Industrial Output of a sector is divided equally among representative products. Wholesale prices are used in lieu of retail prices since all

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<sup>8</sup>U.S. Department of Labor, Wholesale Prices and Price Indexes, January and February, 1965 (Washington, D.C.: Government Printing Office, 1965), pp. 6-21.

transactions are valued in producer's prices, rather than in purchaser's prices. The difference between the former and the latter are marketing and related costs. Individual marketing costs are charged to the purchaser as a direct purchase from those sectors rather than as part of the purchase price of the commodity.<sup>9</sup>

Constant used was:

\$6,072,000, which represents the Total Coal Industry Output for 1965 demanded by the remaining final demand sectors, after households is removed.<sup>10</sup>

The following example is taken from Table A-1 and illustrates the method.

<u>INDUS- TRY</u>	<u>COEFFI- CIENT</u>	<u>COAL INDUSTRY OUTPUT</u>	<u>AVERAGE WHOLE- PRICE</u>	<u>UNITS OF PRODUCT</u>
Corn	.000659	x \$6,072,000	÷ \$1.289	= 3,104 bu.

There is one basic assumption underlying all calculations, which is that the wasteload generated per unit produced is constant, therefore the marginal rate would be equal to the average rate. It is possible to compute a Marginal Propensity to Pollute per unit produced. However this measure should be used with extreme caution. As more research is done pertaining to wasteloads generated, then the MPP statistic will have more practical

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<sup>9</sup>This was the accounting characteristic used by Dr. Emerson in the Kansas Interindustry Study, refer to page 28 in the printed book.

<sup>10</sup>Ibid., p. 56.

value as an environmental and planning tool. An example is listed in the following example.

PROCEDURE:

$\beta W$ =Total Wasteload Generated, where,

$\beta$ = $\frac{\text{Pollution}}{\text{Output}}$ ; or, Marginal Propensity to Pollute (MPP)/Product Unit Produced; and,

$W$ = $\frac{\text{Direct, Indirect, \& Induced Coefficient} \times \text{Final Demand (excluding households)}}{\text{Wholesale Price}}$

ILLUSTRATION, USING THE CORN INDUSTRY:

Nitrogen loss=65 lbs./acre  
 Corn output=74 bu./acre  
 Direct, Indirect, and Induced Coefficient=.000659  
 Final Demand (excluding households)=\$6,072,000 (Coal Industry Output)  
 Wholesale Price=\$1.29/bu.

$\beta W$ =2,730 lbs. of nitrogen loss, where,

$\beta = \frac{65 \text{ lbs./acre}}{74 \text{ bu./acre}} = 1.54 \text{ (MPP) in lbs./bu.}$

$W = \frac{.000659 \times \$6,072,000}{\$1.29} = 3,102 \text{ bu.}$

$\beta W = 3,102 \text{ bu.} \times 1.54 \text{ (MPP)} = 2,730 \text{ lbs. of nitrogen loss.}$

The procedure used to quantify the environmental effects varied slightly with each industry. Even though the calculations made are presented in Appendix A, to illustrate the procedure used the following two industries will be presented in detail. These are the agricultural sector and the strip-mining of coal industry.

#### AGRICULTURAL SECTOR

In the agricultural sector, the Kansas industries of corn (1)<sup>11</sup>, sorghum (2), wheat (3), other grains (4), soybeans (5), hay (6), and other agricultural products (11), experience an increase in final demand (excluding households) from each dollar's output from the strip-mining of coal industry in Kansas. Since agricultural effluents differ only in amounts, according to the growing method, these seven industries are evaluated collectively when assessing their environmental effects.

As a result of man's farming activities there is an acceleration of eutrophication, the natural process of enrichment of water with nutrients. Although the increase of crop yields after fertilization is desirable in terrestrial situations, the effects of eutrophication

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<sup>11</sup>Indicates the Industry Code used in Dr. Emerson's study.

of waters is often undesirable.<sup>12</sup> The nutrients which are most important in this process are nitrogen and phosphorus, and to a lesser degree, potassium. The first two are vital in the greatest amounts for the production of green plants.<sup>13</sup>

These three nutrients influence water quality through two processes; leaching and erosion. Leaching, caused by the percolating of water through layers of soil, carries amounts of these dissolved nutrients to the water table. Erosion, the wearing away of soil by water action, occurs faster if the top layer of soil is disturbed. Cultivating or tilling of crops intensifies this process. The amounts of nutrients lost because of leaching and erosion are in Table 3-3.

To utilize this table it is necessary to classify the crops according to their respective production methods. There are three types of crops: 1) intertilled crops 2) annual crops not intertilled 3) biennial and perennial crops. The intertilled crops are those which require cultivating or tilling between rows. In this

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<sup>12</sup>Ted L. Willrich and George E. Smith, eds., Agricultural Practices and Water Quality (Ames: Iowa State University Press, 1970), p. 314.

<sup>13</sup>Ibid., p. 315.

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LOSS OF PLANT NUTRIENTS FROM HARVESTED CROPS IN THE U.S.A., 1930  
POUNDS PER ACRE PER YEAR

<u>TYPE OF CROP &amp; SOURCE</u>	<u>NITROGEN</u>	<u>PHOSPHORUS</u>	<u>POTASSIUM</u>
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Intertilled crops

Leaching	17.1		39.1
Erosion	48.1	21.0	280.7

Annual crops, not intertilled

Leaching	32.5		37.6
Erosion	11.1	4.9	65.0

Biennial & Perennial Crops

Leaching	23.0		
Erosion	24.2	10.6	141.1

Source: Lipman and Conybeare (1936) as reported by Biggar & Corey (1969) in Ted L. Willrich and George E. Smith, eds., Agricultural Practices and Water Quality (Ames: Iowa State University Press, 1970), p. 321.

category the Kansas industries would be corn, sorghum, and soybeans. Annual crops, not intertilled would be crops which are sown each year, and do not require cultivating of tilling between rows. Wheat, oats, barley, rye, potatoes, and beans would be in this category. The last category, biennial and perennial crops, are generally cool season grasses which require neither sowing nor cultivating, such as hay.<sup>14</sup>

After grouping the seven Kansas industries, the next step is to determine the amount of acres necessary to produce the "Total Purchases and Consumers' Effects."<sup>15</sup> By dividing this number by its respective average crop yield in the United States, the number of acres required is obtained (452 acres). The number of acres required is then multiplied times the amount of nutrients taken from Table 3-3. The final step is to sum the quantities of nitrogen, phosphorus, and potassium. The resulting amounts then become the environmental effects from plant nutrients of the agricultural sector. Since these occur as a result of an economic link with the strip-mining of coal industry in Kansas, they are included in the coal industry's environmental effects.

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<sup>14</sup>Verlin Peterson, Kansas State University Extension Agronomist, telephone call, October 15, 1971.

<sup>15</sup>See page 37.

The other source of environmental effect from the agricultural sector is the loss of sediment, which may reduce the carrying capacities of streams. Sediment loss is calculated according to the following assumptions:

(1) The average estimated sediment yield for the Arkansas-White-Red Region is 2,200 tons/square mile/year under the following conditions:

(a) Relief--rolling with average slopes of 5 to 10 percent.

(b) Soil Infiltration--normal, deep loom with infiltration about equal to that of typical prairie soil.

(c) Vegetal Cover--fair to good; about 50 percent of the drainage area in good grassland, woodland, or equivalent cover; not more than 50 percent of the area in clean, cultivated crops.<sup>16</sup>

(2)  $\frac{2,200 \text{ tons/square mile}}{640 \text{ acres/square mile}} = 3.5 \text{ tons/acre/year}$

(3) 452 acres x 3.5 tons/acre = 155.5 tons of sediment loss which is again an environmental effect of the strip-mining of coal industry in Kansas.

If all the like pollutants are summed, the amounts of effluents from the agricultural sector in Kansas which occur because of the Total Purchases and Consumers' Effects of the strip-mining of coal industry would be 25,000 pounds of nitrogen, 5,000 pounds of phosphorus, 104,000 pounds of potassium, and 156 tons of sediment loss.

<sup>16</sup> David Keith Todd, ed., The Water Encyclopedia (New York: Water Information Center, 1970), pp. 77-80.

B64  
 USGS PROF PAPER - 427B  
 INFLUENCES OF STRIP MINING ON THE HYDROLOGIC ENVIRONMENT  
 OF PARTS OF BEAVER CREEK BASIN, KY 1945-59  
 $\frac{20,000 \text{ tons/yr}}{640} = 46.9 \text{ tons/acre/yr}$

### STRIP-MINING OF COAL INDUSTRY

In the other mining industry of the Kansas economy, of immediate concern is the strip-mining of bituminous coal industry. In 1965 the industrial output of this industry was more than \$6 million,<sup>17</sup> representing the extraction of over 1.3 million tons of coal<sup>18</sup> and destruction of approximately 500 acres.<sup>19</sup>

As a result of this mining activity there are three environmental effects to be measured. These are air emissions from diesel engines used on the site; visual degradation of the landscape; and an acceleration of erosion from the loss of vegetal cover.

The main use of diesel engines is the transporting of coal from the mining site to the tipple to be cleaned. The following assumptions are made to determine the amount of driving hours this would entail:

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<sup>17</sup> Op. Cit., Emerson, "Interindustry Study," p. 56.

<sup>18</sup> U.S. Bureau of Mines, Yearbook Area Report, 1970 (Washington, D.C.: U.S. Government Printing Office, 1970).

<sup>19</sup> See Appendix A, p. 62.

- (1) 1,310,000 tons of coal were mined.
- (2) A 50-ton truck was used for hauling.\*
- (3) Hauling trips were 15 minutes long.\*\*

Therefore 26,200 trips or  $\frac{1,310,000}{50}$ , are made requiring 6,550 hours or  $\frac{26,200}{4/\text{hr.}}$  of driving.

The amounts of air emissions resulting from the diesel engines are determined by using the table in Table A-1. After consulting with a mechanical engineer,<sup>21</sup> maximum emissions were determined to be the appropriate measure. The reasons being the brevity of the trips implies numerous starts and stops; and, the majority of the hauling takes place on dirt roads which implies poor traction. Since the Foley Tractor Company engine output figures were in flywheel horsepower, no conversion factor was necessary from flywheel horsepower figure into BHP (Brake Horsepower Hours), because flywheel horsepower measures the actual output of the engine as does brake

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\*The size of the truck bed is the middle capacity of trucks bought by the mining companies from the Foley Tractor Company.<sup>19</sup>

\*\*The length of the trips is the average time given by a person familiar with the strip-mining activity.<sup>20</sup>

<sup>19</sup>Salesman, Foley Tractor Company, Wichita, Kansas, telephone conversation, September 5, 1971.

<sup>20</sup>Frank Fox, Mined Land Redevelopment Office, Girard, Kansas, October 10, 1971.

<sup>21</sup>J. B. Severt, Faculty Member of the Engineering Department, Wichita State University, personal interview, August 10, 1971.

horsepower hours. This is not the same figure as the horsepower a car manufacturer might advertise. (The latter would be less due to power lost due to friction.)

To derive the total number of BHP hours, it is necessary to multiply the hours driven, 6,550, by the BHP of the diesel engine, 600, which equals 3,930,000 BHP hrs. To determine the total wasteload generated, multiply this number by the grams of air emissions per BHP hr. resulting in 38,121,000 grams of carbon monoxide, 27,903,000 grams of hydrocarbons, and 28,530,000 grams of nitrogen oxide.

Following the strip-mining process, the watershed characteristics would be as follows. The relief is hilly, with average slopes of 10-30%. The soil infiltration is high, because there is no effective soil cover, only rocks or a thin soil mantle of negligible infiltration capacity. The vegetal cover is sparse.<sup>22</sup> Using these assumptions the sediment yield is 8,210 tons of soil per square mile.

To convert these tons of sediment per square mile to cubic feet of soil lost, divide this figure by the number of acres in a square mile, 640, or  $\frac{8,210 \text{ tons/sq.mi.}}{640 \text{ acres/sq.mi.}}$ , which is 12,83 tons of sediment yield per acre annually,

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<sup>22</sup>Op. Cit., David Todd, "Water Encyclopedia," p. 77-80.

or 25,660 pounds. The weight of a cubic foot of clay-earth type soil is 110 pounds<sup>23</sup> and  $\frac{25,660 \text{ lbs.}}{110 \text{ lbs.}} = 233$  cubic feet of sediment yield per acre annually. Therefore, 493 acres of soil barren of vegetal cover may lose 12,650,000 lbs. of sediment annually.

The environmental effects accruing from the strip-mining of coal process would be over 6,000 tons of sediment loss, 38,121,000 grams of carbon monoxide, 27,903,000 grams of hydrocarbons, and 28,530,000 grams of nitrogen oxide.

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<sup>23</sup>Robert Peele, ed., Mining Engineer's Handbook (Vol. II, New York: John Wiley and Sons, Inc., 1956), p. 3-30.

CHAPTER IV  
SUMMARY AND CONCLUSIONS

When the methodology described in Chapter 3 is applied to the Kansas Coal Mining Industry and its economically related industries, the total water and air pollutants generated annually, by type, are shown in Table 4-1 and Table 4-2, respectively.<sup>1</sup> A point should be made that these wasteloads do not represent the total amount of wasteload generated by all Kansas industries, but only for the Coal Mining Industry and that portion of industrial output which is produced in meeting the demand generated in other Kansas industries by the Coal Mining Industry in Kansas.

Knowledge of the absolute amounts of industrial pollutants generated does not enable one to reach conclusions as to the environmental effects or importance of these contaminants. Therefore it is necessary that these absolute values be compared to other measures or related to the current wasteloads being processed.

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<sup>1</sup>For detailed calculations refer to Appendix D.

## WATER QUALITY

For the area of water quality two of the twenty effluents, Biological Oxygen Demand (BOD) and Suspended Solids (SS) are equivalent to 4,800 persons and 3,600 persons.<sup>2</sup> The amounts of nitrogen, phosphorus, BOD, and SS may be compared to the average daily amounts of like pollutants received by the Sewage Treatment Plant in Wichita. In an average day the Wichita Sewage Treatment Plant receives 10,216 lbs. of nitrogen, 3,002 lbs. of phosphorus, 62,550 lbs. of BOD, and 68,850 lbs. of SS.<sup>3</sup> The amounts of water pollutants generated by the Coal Mining Industry and the production economically linked to Coal (see Table 4-1) are 99,405 lbs. of nitrogen, 33,806 lbs. of phosphorus, 298,930 lbs. of BOD, and 258,266 lbs. of SS. Therefore, the annual wasteload generated by the Coal Mining Industry in Kansas and those industries economically linked to it (this is not a total amount, see previous page) would be equal to ten times the daily amount of nitrogen received by the Wichita Sewage Treatment Plant, eleven times that of phosphorus, five times that of BOD, and four times that of SS. It should be pointed out that the environmental effect of these

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<sup>2</sup>For detailed calculations refer to Appendix D.

<sup>3</sup>Otis Harder, engineer, Wichita Sewage Treatment Plant, telephone interview between writer and respondent, June 27, 1972.

TABLE 4-1  
 1970 WATER QUALITY EFFECTS OF THE DEMAND GENERATED  
 BY THE STRIP-MINING OF COAL INDUSTRY  
 AND ECONOMICALLY RELATED INDUSTRIES IN KANSAS

<u>POLLUTANT</u>	<u>POUNDS PER YEAR(1970)</u>
Sediment Yield	25,302,400
Nitrogen	99,405
Phosphorus	33,806
Potassium	167,701
Total Solids	1,456,496
B.O.D.	298,930
Suspended Solids	258,266
Grease	198
Dissolved Solids	231,365
Phenol	125
Sulfide	14
Cyanide	34
Fluoride	37
Solid Garbage	1,811,282
Ammonia	91
Ferric Sulfate	3,190
Lube Oils	4,152
Sulfuric Acid	15,482
Emissions	485
Soluble Metals	93

TABLE 4-2  
 1970 AIR QUALITY EFFECTS OF THE DEMAND GENERATED BY THE STRIP-MINING  
 OF COAL INDUSTRY AND ECONOMICALLY RELATED INDUSTRIES IN KANSAS

<u>POLLUTANT</u>	<u>POUNDS PER YEAR (1970)</u>
Particulates	23,510
Hydrocarbons	294,058
Organics	460,023,125
Nitrogen Oxides	2,140,349,766
Sulfur Oxides	46,097,778
Sulfur Dioxide	145,200
Sulfur Trioxide	3,005
Carbon Monoxide	1,271,578
Ammonia	139,999,792
Aldehydes	306,662,613
Aerosols	1,002
Dust	92,109
Acids	380,036,656
Solids	273,856

pollutants dispersed in water depend on several variables such as, the rate and amount of water flow, the temperature of the water, the distribution in time, and the geographical distribution of these effluents. All of these variables will determine the magnitude of the detrimental effects of the pollutants. However, a comparison with the wasteload received at the Wichita Sewage Treatment Plant will enable one to get a "feeling" for the pollutants.

#### AIR QUALITY

As in water quality there are several variables which should be taken into consideration when translating the amount of air emissions into environmental effects. An attempt was made initially to convert the air emissions (Table 4-2 to Parts Per Million (PPM). Since PPM can be any measure such as, parts per million ounces or parts per million pounds, an effort was made to calculate the weight of air over some geographical area. However, as in water quality, this amount will be influenced by several variables such as, wind movement, rainfall, and temperature.<sup>4</sup> Further, when and if these

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<sup>4</sup>Robert J. Chanslor, Assistant Chief of the Program Support Branch (Air), Environmental Protection Agency, Kansas City, Missouri, telephone interview between writer and respondent on June 4, 1972.

air emissions are released into the atmosphere there are additional conditions one must know such as stack parameters, time and rate of emissions, and the geographical distribution of these emissions.<sup>5</sup>

#### IMPACT OF THE MINING LAW<sup>6</sup>

The environmental effects of the reclamation law were estimated.<sup>7</sup> Reclamation as required by law should reduce sediment yield from 6,325 tons per year to 379 tons. There would be an increase in other pollutants (see Table 4-3) produced by the cattle grazing industry and the portion of industrial output which is produced by other Kansas industries in meeting the demand of the cattle grazing industries, or in those industries to which cattle grazing is economically linked. It is essential to note that whereas the cattle grazing industry and other industries which might utilize this reclaimed land do decrease the amount of sediment yield, a loss in this type of pollutant may be replaced by others. The total sediment loss will not be completely eliminated,

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<sup>5</sup>Ibid.

<sup>6</sup>Mined-Land Conservation and Reclamation Act, sec. 49-406, K.S.A. Supplement (1968).

<sup>7</sup>For detailed calculations refer to Appendix E.

## POLLUTANTS GENERATED AFTER MINING, WITH RECLAMATION AND WITHOUT RECLAMATION

Annual Pollutants Generated  
Without ReclamationAnnual Pollutants Generated by  
Reclamation to Grassland

## Water Quality:

<u>Effluent</u>	<u>Amount</u>	<u>Amount</u>
Sediment Yield	6,325.00 tons	-5,946.00 tons
Nitrogen		20,406.00 lbs.
Phosphorus		6,674.00 lbs.
Potassium		29,536.00 lbs.
Suspended Solids		472,936.00 lbs.
Biological Oxygen Demand		46,736.00 lbs.
Grease		8.00 lbs.
Phenol		.14 lbs.
Sulfide		.04 lbs.
Ferric Sulfate		1.00 lbs.
Lube Oils		1.00 lbs.
Sulfuric Acid		5.00 lbs.
Soluble Metals		.03 lbs.
Cyanide		.01 lbs.
Fluorides		.01 lbs.
Ammonia		.03 lbs.
Emissions		.17 lbs.

## Air Quality:

<u>Effluent</u>	<u>Amount</u>	<u>Amount</u>
Particulates		7,474.00 lbs.
Hydrocarbons		718.00 lbs.
Organics		808.00 lbs.
Nitrogen Oxides		592.00 lbs.
Sulfur Oxides		49.00 lbs.
Sulfur Dioxide		400.00 lbs.
Sulfur Trioxide		8.00 lbs.
Carbon Monoxide		5,162.00 lbs.
Ammonia		77.00 lbs.
Aldehydes		78.00 lbs.
Aerosols		3.00 lbs.
Dust		168.00 lbs.
Acids		1,122.00 lbs.

<sup>1</sup>For detailed calculations, refer to Appendix E.

but reduced with the possibility there might be a replacement with industrial contaminants. Unfortunately, there presently does not exist a methodology to relate the environmental effects of different types of pollutants. For this evaluation, maybe the biological sciences could provide the expertise necessary.

#### CONCLUDING REMARKS

This methodology presented in Chapter 3 is especially important, because it brings into an environmental quality analysis those industries which are economically linked to the industry under consideration. The environmental analyses currently being undertaken by federal agencies are concerned primarily with primary or "obvious" environmental effects. For example, in the Coal Mining Industry the "obvious" environmental effect might be the degradation of land.

In Industry A, is being evaluated only in terms of primary environmental effects, and these are negative, it may be an undesirable industry because of the environmental effects in those industries on which Industry A is economically dependent.

In short, the methodology used in this thesis offers a more complete picture of the economic interrelationships and therefore environmental effects of industries, than

does the current methodology based on primary environmental effects.

## CHAPTER V LIMITATIONS AND FUTURE RESEARCH

Inherent in any new research project are numerous possible avenues for investigation. More often than not, however, good research depends on a thorough examination of the individual avenues, to prevent digression and cursory treatment of important areas. In order to circumvent these pitfalls, it was decided to assess the environmental impact of an industry using only an Input-Output Methodology. During the course of this investigation, new areas of desirable research have presented themselves, as have limitations of the Input-Output Methodology itself. By the same token, new areas of possible application of conclusions drawn have also come to light.

Some limitations of this thesis follow from the selection of an Input-Output Methodology as a tool. Since this type of analysis assumes constant technical coefficients the forecasting model is static. Although these coefficients are not subject to frequent changes, they are likely to vary with advances made in technologies, with changes in relative prices of inputs, and with the

appearance of new industries. It would be possible to make allowances for these changes with a dynamic model; however, this thesis was not sufficiently comprehensive to make this allowance.

Even though long-term forecasting might not be advisable, an Input-Output study lends itself well to "impact" analyses. Two areas of possible application of "impact" analyses are presented in Appendices D and E.

In Appendix D, the total environmental effects of the strip-mining of coal industry are viewed relative to their non-economic impact. For example, the "Direct, Indirect, and Induced Requirements Matrix," states that for every dollar of industrial output of the strip-mining of coal industry, .000659 worth of produced will be generated by the corn industry in Kansas. By translating this into non-economic terms this would result in 2,730 lbs. of nitrogen, 882 lbs. of phosphorus, and 13,440 lbs. of potassium. This may be taken one step further by assessing the potential impact of these nutrients on the environment, i.e., speaking of this nutrient losses in terms of possible plant destruction, harm to humans, changes in water quality, or changes in air quality. By the addition of the non-economic impact of industries to the economic impact of industries another dimension might

be given to the decision making process of future planners and policy makers.

In order to illustrate the effectiveness of "impact" analysis relative to policy making, Appendix E is a presentation of one possible impact of the current reclamation law.<sup>1</sup> It was assumed that the acres stripped were reclaimed and cattle were grazed on this land. The economic impact of this venture was traced through the "Kansas Direct, Indirect, and Induced Matrix" (the procedure was identical to the one used for the strip-mining of coal industry environmental quality analysis), and the conclusions were translated into non-economic terms. This analysis may either enhance the desirability of this law, or it may detract from the desirability of this law.

With the timeliness of the concern for environmental quality, data is still being collected. While pollution characteristics are readily available for general industrial processes, information on individual firms has not as yet been analyzed. This necessitated the assumption that the wasteload generated by Kansas' industries is identical to general industrial effluents. If in fact, the wasteloads generated by Kansas' industries is greater than or less than these general effluent amounts the

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<sup>1</sup>Mined-Land Conservation and Reclamation Act, sec. 49-406, K.S.A. Supplement (1968).

conclusions of this thesis will need to be adjusted. Another indirect assumption contained in the methodology, was that the wasteload per unit produced is constant. Although these assumptions may or may not prove true, they are the best possible estimates given the data currently available.

Though the possibilities for inquiry which exist within the area of environmental quality analysis are enticing, this thesis directs itself to one basic assumption. This assumption, stated simply, is that the economic impact of an industry reflects the non-economic impact as well. And further, by tracing the economic impact of an industry, it may also be possible to uncover non-economic ramifications. If credence is given to these basic assumptions, then as future research is undertaken in the area of environmental quality analysis the sophistication of this tool will enhance the usefulness of this methodology.

APPENDIX A  
ENVIRONMENTAL EFFECTS OF THE STRIP-MINING OF COAL  
INDUSTRY IN KANSAS

TABLE A-1  
ENVIRONMENTAL EFFECTS OF THE COAL MINING INDUSTRY & ITS ECONOMICALLY RELATED INDUSTRIES  
IN KANSAS

Loss of Plant Nutrients<sup>6</sup>  
from Harvested Crop  
Areas--lbs/acre/year  
Loss--Direct, Indirect  
& Induced Effect on the  
Strip Mining of Coal--  
lbs/year.<sup>6</sup>

Industry and Code from Input-Output Matrix <sup>1</sup>	Direct, <sup>2</sup> Indirect, Induced Co-efficient per \$ Final Demand	Coal <sup>3</sup> Industry Output \$	Total Purchases and Consumer Effects, in \$'s <sup>4</sup>	Average <sup>4</sup> Wholesale Price per Unit \$	Total Purchases and Consumer Effects in units of product <sup>5</sup>	Average <sup>5</sup> Crop Yields per Acre	Acres Required for Total Purchases and Consumer Effects <sup>6</sup>	Cause	Loss of Plant Nutrients <sup>6</sup>			Loss--Direct, Indirect & Induced Effect on the Strip Mining of Coal-- lbs/year. <sup>6</sup>		
									Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Corn (1)	.000659	6,072,000	4,002	1.29/bu.	3,102 bu.	74 bu.	42	Leaching Erosion	17 48	— 21	39 251	714 2,016	— 982	1,638 11,502
Sorghum (2)	.001148	6,072,000	6,971	1.76/100 bu. <sup>7</sup> 1 bu. sorghum 56 lbs <sup>5</sup> .985/bu. <sup>F</sup>	7,077 bu.	52 bu.	137	Leaching Erosion	17 48	— 21	39 281	2,329 6,576	— 2,877	5,343 38,497
Wheat (3)	.000465	6,072,000	2,824	1.62/bu.	1,743 bu.	27 bu.	66	Leaching Erosion	33 11	— 5	38 65	2,178 726	— 330	2,508 4,290
Other Grains (4)	.000039	6,072,000	237	1.01/bu. <sup>F</sup>	235 bu.	37 bu. <sup>I</sup>	6	Leaching Erosion	33 11	— 5	38 65	198 66	— 30	228 390
Soybeans (5)	.000544	6,072,000	5,125	2.85/bu.	1,798 bu.	27 bu. <sup>10</sup>	66	Leaching Erosion	17 48	— 21	39 251	1,122 3,168	— 1,386	2,594 18,546
Hay (6)	.001074	6,072,000	6,521	26.25/ton <sup>F</sup>	248 tons	1.85 tons	134	Leaching Erosion	23 24	— 11	— 141	3,082 3,216	— 1,474	— 18,894
Other Agricultural Products (11)	.000799	6,072,000	2,571 <sup>E</sup> 340 <sup>E</sup> 1,941 <sup>E</sup> 4,852	grain 10.05/100 lbs <sup>F</sup> wool 122.83/100 lbs <sup>F</sup> sheep 21.75/100 lbs <sup>F</sup>	255 lbs <sup>G</sup> 270 lbs <sup>G</sup> 8,900 lbs <sup>H</sup>	186 lbs <sup>I</sup>	1	Leaching Erosion	33 11	— 5	38 65	33 11	— 5	38 65
TOTALS:								452				25,435	6,994	104,813

- A. Coefficient (Column 2) x Coal Industry Output (Column 3) = Total Purchases and Consumer Effects in \$'s.  
 B. Total Purchases and Consumer Effects in \$'s (Column 4)/Average Wholesale Price per unit (Column 5) = Total Purchases & Consumer Effects in product units.  
 C. Total Purchases & Consumer Effects in units of product (Column 6)/Average Crop Yields (Column 7) = Acres Required.  
 D. Acres Required (Column 8) x Loss of Plant Nutrients (Column 9) = Total Pounds of Nutrients Lost.  
 E. For detailed calculation, refer to Table A-2  
 F. For detailed calculation, refer to Table A-3  
 G. Pollution characteristics not available.  
 H. Treated as Cattle.<sup>9</sup>  
 I. For detailed calculation, refer to Table A-4

TABLE A-1 (Cont'd)

Industry and Code from Input-Output Matrix	Direct, Indirect, Induced Co-efficient per \$ Final Demand	Coal Industry Output \$	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price per Unit \$	Total Purchases and Consumer Effects in units of product	
(Agricultural Products, cont'd.)						Sediment loss is calculated according to the following assumptions:
						(1) The average estimated sediment yield for the Arkansas-White-Red Region is 2,200 tons/sq. mile/year under the following conditions: (a) <u>Relief</u> —rolling with average slopes of 5 to 10 percent. (b) <u>Soil Infiltration</u> —normal, deep loam with infiltration about equal to that of typical prairie soil. (c) <u>Vegetal Cover</u> —fair to good; about 50 percent of the drainage area in good grassland, woodland, or equivalent cover; not more than 50 percent of the area in clean, cultivated crops. <sup>11</sup>
						(2) $\frac{2,200 \text{ tons/sq. mile}}{640 \text{ acres/sq. mile}} = 3.5 \text{ tons/acre/year}$ .
						(3) $452^A \text{ acres} \times 3.5 \text{ tons/acre} = 1,582 \text{ tons of sediment}$ which is the direct, indirect, and induced effect of the strip mining of coal.
Dairy Products (7)	.002359	6,072,000	14,324	.26/qt. <sup>C</sup>	55,092 qts.	An average dairy cow produces 10,000 lbs. of milk annually, <sup>12</sup> and milk weighs 8.6 lbs/gal. <sup>13</sup> $\frac{10,000}{8.6} = 1,160 \text{ gals/yr}$ . $\frac{55,092 \text{ qts.}}{4} = 13,773 \text{ gals.}$ , $\frac{13,773}{1,160} = 11.9$ dairy cows would be required for the milk production; an average dairy cow weighs 1,700 lbs. <sup>14</sup> , $11.9 \times 1,700 = 20,230 \text{ lbs}$ .
Poultry & Poultry Products (8)	.000222	6,072,000	256B <u>1,092B</u> 1,348	.17/lb. <sup>C</sup> .33/doz. <sup>C</sup>	1,506 lbs. 3,309 doz.	An average hen lays 200 eggs annually, <sup>15</sup> a chicken weighs 3.5 lbs. <sup>16</sup> $3,309 \text{ doz.} \times 12 = 39,708 \text{ eggs}$ , $\frac{39,708}{200} = 198.5$ chickens would be required for the egg production. To convert the number of chickens to pounds of chicken: $198.5 \times 3.5 \text{ lbs.} = 694.8$ . $\frac{694.8}{5} = 139 \text{ units}$ .

A. 452 acres was the total amount of acreage required to produce the ( Column 6 ) , and is the sum of Column 8.  
 B. For detailed calculation, refer to Table A-2  
 C. For detailed calculation, refer to Table A-3

TABLE A-1 (Cont'd)

Industry and Code from Input-Output Matrix	Direct, Indirect, Induced Co-efficient per \$ Final Demand	Coal Industry Output \$	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price per Unit \$	Total Purchases and Consumer Effects in units of product
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(Poultry & Poultry Products, cont'd.)

Since waste measurements are per 5 lbs.,  $\frac{17,506 \text{ lbs. (TPCE)}^A}{5} = 3,501$  units.

Also, 13,694 lbs. from Kansas Sector 21  $\frac{13,694 \text{ lbs.}}{5} = 2,739$ .

The total number of chickens required would be 139 for egg laying + 301 for poultry processing + 2,739 from Sector 21 = 3,179.

Cattle (9) .005439 6,072,000 33,026 .22/lb.<sup>B</sup> 150,118 lbs.

The wastes from cattle, hogs, and chickens are as follows:

Pollutional Characteristics of Untreated Animal Wastes<sup>17</sup>

Animal	Animal Weight	Solids lbs/day	BOD lbs/day	Nitrogen lbs/day	Phosphorus lbs/day
Cattle	1,000	10.0	1.0	0.3	0.1
Dairy Cow	1,000	10.0	1.2	0.4	0.1
Swine	100	0.9	0.25	0.06	0.02
Poultry	5	0.06	0.015	0.003	0.003

Hogs (10) .001221 6,072,000 7,414 .13/lb. 57,031 lbs.

Kansas production resulting from the coal industry in numbers of animals are:

Animal	Number of Animals	Solids lbs/day	BOD lbs/day	Nitrogen lbs/day	Phosphorus lbs/day
Cattle	159 <sup>C</sup>	1,590	159	48	16
Dairy Cows	20	200	24	8	2
Swine	570	513	142	34	11
Poultry	3,179	191	48	10	10
		2,494	373	100	39

Total Wastes Annually (x 365): 910,310 136,145 36,500 14,235

Crude Oil & Natural Gas (13) .017475 6,072,000 106,108 2.97/brl. 35,727 brls.

Pollution characteristics not available.

A. Total Purchases and Consumer Effects

B. For detailed calculation, refer to Table A-3

C. Cattle 150,118 lbs.

Sheep 8,900 lbs.

$\frac{159,018}{1000} = 159$ .

Industry and Code from Input-Output Matrix	Direct, Indirect, Induced Co-efficient Per \$ Final Demand	Coal Industry Output \$	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price per Unit \$	TABLE A-1 (Cont'd)	
					Total Purchases and Consumer Effects in units of product	Pollution characteristics not available.
Nonmetallic Mineral Mining (15)	.000625	6,072,000	3,795	1.56/ton	2,402 tons	Pollution characteristics not available.
Other Mining (16)					1,310,000 <sup>18</sup>	A. SEDIMENT YIELD

Yield of 2,656 tons<sup>18</sup>/acre =  $\frac{1,310,000}{2,661} = 493$  acres.

Based on the following assumptions the sediment yield would be Arkansas-White-Red: 5,210 tons/sq. mile estimated yield.<sup>19</sup>

Assumptions—use high yield (watershed characteristics)

- (1) Relief—hilly average slopes 10-30%.
- (2) Soil Infiltration—no effective soil cover, either rock or thin soil mantle of negligible infiltration capacity.
- (3) Vegetal Cover—no effective plant cover; bare or very sparse cover.

To convert tons of sediment/sq. mile into cubic feet of soil:

(1)  $\frac{5,210 \text{ tons/sq. mile}}{640 \text{ acres/sq. mile}^{20}} = 12.53 \text{ ton of sediment yield/acre/yr.}$

(2)  $12.53 \text{ tons of sediment yield/acre/yr.} \times 2,000 \text{ lbs/ton}^{21} = 25,660 \text{ lbs. of sediment yield/acre/yr.}$

(3) Weight of cubic foot of soil, clay-earth type = 110 lbs/cu. ft.<sup>22</sup>

$\frac{25,660 \text{ lbs of sediment yield/acre/yr.}}{110 \text{ lbs/cu. ft. of clay soil}} = 233 \text{ cu. ft. of yield/acre/yr.}$

<sup>18</sup> Thickness of Coal Seam x sq. ft. in an acre = cubic feet of coal per acre;  $1.5^{23} \times 43,645^{24} \text{ sq. ft.} = 65,467.5 \text{ cu. ft.}$ , and 1 ton of coal = 24.6 cubic ft.<sup>25</sup>  $\therefore \frac{65,467.5}{24.6} = 2661 \text{ tons of coal/acre.}$

TABLE A (Cont'd)

Other Mining (cont'd.)

493 acres x 12.83 ton/acre sediment yield =  
6,325 tons of sediment yield x 2,000 lbs = 12,650,000 lbs.

The diesel transportation used in transporting the coal from the mining site to the tippie would not appear in the Motor Freight sector because this sector is representative of public transportation. Therefore, this amount is figured in addition and is presented below.

a. AIR EMISSIONS FROM DIESEL ENGINES USED IN MINING PROCESS.<sup>26</sup>

Diesel engines used in transporting coal:

(a) carbon monoxide 1.7 - 9.7)  
hydrocarbon .5 - 7.1) Grams/Brake Horsepower Hour (BHP)  
nitrogen oxides 3.9 - 21.0)

(b) at city cycle which represents a load factor of 32% of the truck's maximum carrying capacity.

Assumptions

- (1) Use the maximum figure for the city cycle because:
  - a. short haulage trips; implying frequent starts and stops.
  - b. majority of hauling will be off of public roads; implying poor traction.
- (2) BHP implies output hp so, the horsepower figure from the diesel company would be the correct variable to use.

Truck No.	Tonnage Capacity	Flywheel H = (BHP) <sup>27</sup>
769B	35 tons	415
773	50 tons	600
779	85 tons	960

Assumptions:

- (1) 1,310,000 tons of coal were mined.
- (2) Using a 50-ton truck this would require  $\frac{1,310,000}{50} = 26,200$  trips.
- (3) Trips are 15 minutes in length,<sup>28</sup> ∴ 4 an hour could be made ∴  $\frac{26,200 \text{ trips}}{4/\text{hr.}} = 6,550$  hours driven.
- (4) Emissions from diesel engine:
  - 9.7 grams C/P/hr. carbon monoxide.
  - 7.1 grams BHP/hr. hydrocarbons
  - 21.0 grams BHP/hr. nitrogen oxides
  - 600 h.p. x 6,550 hrs. driven = 3,930,000 BHP hours.
- (5) 9.7 grams x 3,930,000 = 38,121,000 grams carbon monoxide  
7.1 grams x 3,930,000 = 27,903,000 grams hydrocarbon  
21.0 grams x 3,930,000 = 82,530,000 grams nitrogen oxide
- (6) 454 gr. = 1 lb.<sup>29</sup> ∴ 83,967 lbs. carbon monoxide  
61,460 lbs. hydrocarbons  
181,784 lbs. nitrogen oxide.

TABLE A-1 (Cont'd)

Industry and Code from Input-Output Matrix	Direct, Indirect, Induced Co-efficient Per \$ Final Demand	Coal Industry Output \$	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price per Unit \$	Total Purchases and Consumer Effects in units of product																																														
Meat Products (21)	.007667	6,072,000	43,295 Cattle <sup>A</sup>	.36/lb. <sup>B</sup>	120,264 lbs.																																														
			931 Hogs <sup>A</sup>	.37/lb. <sup>B</sup>	2,516 lbs.																																														
			2,328 Chickens <sup>A</sup>	.17/lb. <sup>B</sup>	13,694 lbs. <sup>C</sup>																																														
A. WATER QUALITY																																																			
MEAT PRODUCTS																																																			
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The major consideration would be odor which is an aesthetic value which cannot be quantified.																																																			
Dairy Products (22)	.004184	6,072,000	22,103 Milk <sup>A</sup>	.26/qt <sup>B</sup>	85,011 qts. or																																														
			1,270 Ice Cream <sup>A</sup>	1.77/gal <sup>B</sup>	21,253 gal.																																														
			2,032 Condensed Milk <sup>A</sup>	8.20/case of 48 <sup>31</sup>	717 gal.																																														
		25,402			248 cases																																														
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A. For detailed calculation, refer to Table A-2.  
 B. For detailed calculation, refer to Table A-3.  
 C. Summed with wasteload generated in Sector 8, Poultry & Poultry Products.

TABLE A-1 (Cont'd)

Industry and Code from Input-Output Matrix	Direct, Indirect, Induced Co-efficient per \$ Final Demand	Coal Industry Output \$	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price per Unit \$	Total Purchases and Consumer Effects in units of product
--	--	-------------------------	---	-------------------------------------	--

Dairy Products (cont'd.)

To convert 21,253 gal. of fluid milk to pounds, multiply by 8.614 lbs.<sup>33</sup>, or 183,073 lbs.

To convert 248 cases of condensed milk to pounds, there are 48 cans/case,<sup>34</sup> and they contain 14.5 oz. of condensed milk/can<sup>34</sup>. Therefore, 248 cases x 48 cans = 11,904 cans; and 11,904 cans x 14.5 oz. = 172,608 oz. or 10,788 lbs ( $\frac{172,608 \text{ lbs.}}{16 \text{ oz.}}$ )

Total wasteload generated by 183,073 lbs. of fluid milk, 719 gal. of ice cream and 10,788 lbs. of condensed milk.

	BOD (lbs)	Soap & Chemical BOD (lbs)	Wastewater (gal)
Fluid Milk	183.0	18.3	1,189,974.5
Ice Cream	2.4	.2	5,752.0
Condensed Milk	49.6	5.4	37,758.0
Totals:	235.0	23.9	1,233,484.5

B. AIR QUALITY

The major consideration would be odor, which is an aesthetic value which cannot be quantified.

Grain Mill Products (23) .001247 6,072,000 7,572 .06/lb. 124,530 lbs. or 62.3 tons

A. AIR QUALITY

GRAIN MILL PRODUCTS

	Particulates (lbs)	Hydro-Carbons (lbs)	Organics (lbs)	Nitrogen Oxides (lbs)	Sulfur Oxides (lbs)
Wasteload per ton processed, <sup>35</sup>	.8	3.0	3.6	5.0	1.4
Total Wasteload generated by 62.3 tons.	49.8	186.9	224.3	311.5	87.2

B. WATER QUALITY

no data referring to water quality changes.

TABLE A-1 (Cont'd)

Industry and Code from Input-Output Matrix	Direct, Indirect, Induced Co-efficient per \$ Final Demand	Coal Industry Output \$	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price per Unit \$	Total Purchases and Consumer Effects in units of product
Other Food and Kindred Products (24)	.005199	6,072,000	31,568	1.65/doz. cans <sup>A</sup>	19,132 doz. cans or 797 cases <sup>B</sup>
A. WATER QUALITY					
OTHER FOOD & KINDRED PRODUCTS					
		Plant BOD (lbs)	Suspended Solids (lbs)	Total Dissolved Solids (lbs)	Wastewater Vol. MGD
Wasteload per case produced. <sup>37</sup>		.7	.8	.75	.000075
Total wasteload generated by 797 cases.		557.9	637.6	597.75	.059
B. AIR QUALITY					
No data referring to air quality changes.					
Paper & Allied Products (26)	.004660	6,072,000	28,296	.20/lb. <sup>A</sup>	141,400 lbs. or 70.7 tons
A. WATER QUALITY					
PAPER & ALLIED PRODUCTS					
		Suspended Solids (lbs)	Dissolved Solids (lbs)	BOD (lbs)	Wastewater
Wasteload per ton of finished product. <sup>38</sup>		120	550	135	40,000 gal.
Total wasteload generated by 70.7 tons.		8,464.0	38,885.0	9,544.5	2,828,000.0

A. For detailed calculation, refer to Table A-3.

B. Assuming 24 #303 cans = 1 case of vegetables and 24 #202 cans = 1 case of fruit.<sup>36</sup>

TABLE A-1 (Cont'd)

Industry and Code from Input-Output Matrix	Direct, Indirect, Induced Co-efficient per \$ Final Demand	Coal Industry Output \$	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price per Unit \$	Total Purchases and Consumer Effects in units of product																		
Industrial Chemicals (28)	.000538	6,072,000	3,267	1,606.86/ton <sup>A</sup>	2 tons																		
Agricultural Chemicals (29)	.000282	6,072,000	1,712	52.38/ton <sup>A</sup>	33 tons																		
Other Chemicals (30)	.007321	6,072,000	44,453	.13/lb. <sup>A</sup>	341,946 lbs. or 171 tons																		
TOTAL:					206 tons.																		
A. AIR QUALITY																							
INDUSTRIAL, AGRICULTURAL, & OTHER CHEMICALS																							
<table border="1" style="width: 100%;"> <thead> <tr> <th></th> <th>Particulate Matter (lbs)</th> <th>Saturated Hydrocarbons (lbs)</th> <th>Organics (lbs)</th> <th>Nitrogen Oxides (lbs)</th> <th>Sulfur Oxides (lbs)</th> </tr> </thead> <tbody> <tr> <td>Wasteload per ton produced.<sup>40</sup></td> <td>4.7</td> <td>4.6</td> <td>7.6</td> <td>.6</td> <td>.6</td> </tr> <tr> <td>Total wasteload generated by 206 tons.</td> <td>968.0</td> <td>948.0</td> <td>1,566.0</td> <td>124.0</td> <td>124.0</td> </tr> </tbody> </table>							Particulate Matter (lbs)	Saturated Hydrocarbons (lbs)	Organics (lbs)	Nitrogen Oxides (lbs)	Sulfur Oxides (lbs)	Wasteload per ton produced. <sup>40</sup>	4.7	4.6	7.6	.6	.6	Total wasteload generated by 206 tons.	968.0	948.0	1,566.0	124.0	124.0
	Particulate Matter (lbs)	Saturated Hydrocarbons (lbs)	Organics (lbs)	Nitrogen Oxides (lbs)	Sulfur Oxides (lbs)																		
Wasteload per ton produced. <sup>40</sup>	4.7	4.6	7.6	.6	.6																		
Total wasteload generated by 206 tons.	968.0	948.0	1,566.0	124.0	124.0																		
Petroleum & Coal Products (31)	.026066	6,072,000	158,273	.12/gal. <sup>A</sup>	1,314,294 gal. or 31,293 bbl. <sup>B</sup>																		
A. WATER QUALITY																							
PETROLEUM & COAL PRODUCTS																							
<table border="1" style="width: 100%;"> <thead> <tr> <th></th> <th>BOD (lbs)</th> <th>Phenol (lbs)</th> <th>Sulfide (lbs)</th> <th>Wastewater</th> </tr> </thead> <tbody> <tr> <td>Wasteload per barrel produced<sup>41</sup></td> <td>.1</td> <td>.001</td> <td>.0003</td> <td>100 gal.</td> </tr> <tr> <td>Total wasteload generated by 31,293 bbl.</td> <td>3,129.3</td> <td>31.3</td> <td>9.4</td> <td>3,129,300</td> </tr> </tbody> </table>							BOD (lbs)	Phenol (lbs)	Sulfide (lbs)	Wastewater	Wasteload per barrel produced <sup>41</sup>	.1	.001	.0003	100 gal.	Total wasteload generated by 31,293 bbl.	3,129.3	31.3	9.4	3,129,300			
	BOD (lbs)	Phenol (lbs)	Sulfide (lbs)	Wastewater																			
Wasteload per barrel produced <sup>41</sup>	.1	.001	.0003	100 gal.																			
Total wasteload generated by 31,293 bbl.	3,129.3	31.3	9.4	3,129,300																			

A. For detailed calculation, refer to Table A-3.

B. 42 gal. of oil = 1 bbl.<sup>39</sup>

TABLE A-1 (Cont'd)

Industry and Code from Input-Output Matrix	Direct, Indirect, Induced Co-efficient per \$ Final Demand	Coal Industry Output \$	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price per Unit \$	Total Purchases and Consumer Effects in units of product
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Petroleum & Coal Products (cont'd.)

B A. AIR QUALITY

PETROLEUM & COAL PRODUCTS

Wasteload per Barrel Produced <sup>42</sup>	Total Wasteload Generated by 31,293 bbl.
Hydrocarbons (lbs.) 2.0	62,586
Nitrogen Oxides (lbs.) .08	2,503
Sulfur Dioxide (lbs.) 2.9	90,750
Sulfur Trioxide (lbs.) > .06	1,878
Carbon Monoxide (lbs.) 4.4	137,689
Particulate Matter (lbs.) .28	8,762
Ammonia (lbs.) < .02	626
Aldehydes (lbs.) < .02	626
Organic Acids (lbs.) < .02	626
Aerosols (lbs.) < .02	626

Cement & Concrete (33)

.001131 6,072,000 6,867

3.34/bbl. 2,056 bbls.

A. AIR QUALITY

CEMENT & CONCRETE

	Dust	Alde- hydes	Nitrogen	Acids	Organic	Sulfur Oxides	Solids
Wasteload per bbl. processed <sup>43</sup>	28.00	.1320	.5280	1.98	1.32	4.62	13.2
Total wasteload generated by 2,056 bbl.	57,568.00	271.00	1,085.00	4,071.00	2,714.00	9,499.00	27,139.00

TABLE A-1 (Cont'd)

Industry and Code from Input-Output Matrix	Direct, Indirect, Induced Co-efficient per \$ Final Demand	Coal Industry Output \$	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price per Unit \$	Total Purchases and Consumer Effects in units of product
Other Stone & Clay (34)	.002786	6,072,000	16,917	5.43/50 sq. ft.	3,115-50 sq. ft. or 234 tons <sup>B</sup>

A. AIR QUALITY

OTHER STONE & CLAY—GLASS

	Particulate Matter	Sulfur Oxides
Wasteload per ton processed <sup>46</sup>	21	3.8
Total wasteload generated by 234 tons.	4,914	889.2

Primary Metals (35)	.004237	6,072,000	25,727	46.02/gr ton <sup>A</sup>	559 gr. tons or 773 ingot tons. <sup>C</sup>
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A. WATER QUALITY

PRIMARY METALS

	Wasteload per Ingot Ton Processed <sup>47</sup>	Total Wasteload Generated by 733 Ingot Tons
Suspended Solids (lbs)	125.00	91,625.00
Ferric Sulfate (lbs)	2.72	1,993.76
Lube Oils (lbs)	3.54	2,594.82
Sulfuric Acid (lbs)	13.2	9,675.60
Soluble Metals (lbs)	.079	57.91
Phenols (lbs)	.064	46.91
Cyanides (lbs)	.028	20.52
Fluorides (lbs)	.031	22.72
Ammonia (lbs)	.078	57.17
Emissions (lbs)	.414	303.46

A. For detailed calculation, refer to Table

B. To convert 3,115-50 sq. ft. to tons, first change to number of square feet or 155,750 sq. ft., then multiply by 3 lbs. <sup>44</sup> which equals 467,250 lbs. or 234 tons.

C. To convert gross tons to ingot tons, multiply by 1.311.

TABLE A-1 (Cont'd)

Industry and Code from Input-Output Matrix	Direct, Indirect, Induced Co-efficient per \$ Final Demand	Coal Industry Output \$	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price per Unit \$	Total Purchases and Consumer Effects in units of product
Motor Freight (49)	.006219	6,072,000	37,762	.37 mi. driven <sup>48</sup>	102,059 miles 102,059 mi. ÷ 51.8 mph <sup>50</sup> = 1,970 hrs. Truck with 600 BHP x 1,970 hrs. = 1,182,000 BHP

Air Pollutant	Grams/BHP-Hour <sup>51</sup>	Total Wasteload Generated by 1,182,000 BHP
Carbon Monoxide:	5.7 =	6,737,400 grams or 14,840 lbs.
Hydrocarbons:	3.8 =	4,491,600 grams or 9,893 lbs.
Nitrogen Oxides:	12.4 =	14,655,800 grams or 32,254 lbs.

Electric, Gas & Sanitary Service (52)	.050661	9,712,000 <sup>49</sup>	492,020	NA
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ESTIMATED AIR CONTAMINANT EMISSIONS FROM FUELS<sup>52</sup>

Sources	Aldehydes	Nitrogen Oxides	Acids	Organics	Solids	Ammonia	Sulfur Oxides
Coal lb/ton	2.0	8.0	30.0	20.0	200.0	2.0	60.0
Oil lb/1000 gal.	8.6	93.0	108.0	36.0	1.8	7.2	215.0
Gas lb/100 CF	46.0	321.0	57.0	69.0	NA	21.0	6.9
Diesel lb/1000 gal.	17.0	166.0	34.0	180.0	116.0	NA	116.0 <sup>53</sup>

Wasteload per unit of fuel used.

Total Fuel Input for the Electric Industry <sup>54</sup>	Percentage of Total Fuel Inputs to Generation (TPCE) <sup>A</sup>	Amounts of Fuel Inputs Required
Coal: 356,568 tons	x .002 =	714 tons
Oil: 17,078 1000 gal.	x .002 =	34 1000 gal.
Gas: 2,083,275,300 100 CF	x .002 =	4,166,551 100 CF
Diesel: 4,907 1000 gal.	x .002 =	10 1000 gal.

A. Total Purchases and Consumer Effects.

TABLE A-1 (Cont'd)

Electric, Gas & Sanitary Service (cont'd.)

	Total lbs.				
	Coal	Oil	Gas	Diesel	Total
Total wasteload generated by 714 tons of coal, 34-1,000 gal. of oil, 4,166,551-100 CF of gas, and 10-1,000 gal. of oil used.					
Aldehydes	1,428	292	191,661,346	170	191,663,236
Nitrogen Oxides	5,712	3,162	1,337,462,871	1,660	1,337,473,405
Acids	21,420	3,672	237,493,407	340	237,518,839
Organics	14,250	1,224	287,492,019	1,800	287,509,323
Solids	142,800	61	NA	1,160	144,021
Ammonia	1,428	245	87,497,571	NA	87,499,244
Sulfur Oxides	42,840	7,310	28,749,202	1,160	28,800,512

THERMAL POLLUTION

Assumptions

1. 1 BTU raises 1 lb. of water 1° F.<sup>55</sup>
2. 80 gal. water required/KWH<sup>56</sup>
3. 1970 electrical industry output is \$207,957,000.<sup>57</sup>
4. 1970 industrial average price is \$.0103/KWH.<sup>58</sup>
5. 1 KWH = 3,410 BTU.<sup>59</sup>
6. 1 gal. water = 8.34 lb.<sup>60</sup>
7. Total Purchases & Consumer Effects resulting from each coal mining \$ output represented the total electrical industry output.

Calculations

1.  $\frac{\$207,957,000}{.0103}$  (1970 electrical output) = 20,190,000,000 KWH produced.
2.  $20,190,000,000 \text{ KWH} \times .002 = 40,380,000 \text{ KWH}$  (Total Purchases and Consumer Effects) resulting from coal mining \$ output.
3.  $80 \text{ gal. water/KWH} \times 40,380,000 \text{ KWH} = 3,230,400,000 \text{ gal. of water.}$
4.  $8.34 \text{ lb./gal. water} \times 3,230,400,000 \text{ gal.} = 26,941,536,000 \text{ lb. water required.}$
5. The heat to be dissipated is:  
 $40,380,000 \text{ KWH} \times 3,410 \text{ BTU/KWH} = 137,695,800,000 \text{ BTU,}$   
 which would raise 137,695,800,000 lbs. of water 1° F.,  
 but the heat will be absorbed in 26,941,536,000 lbs.  
 of water, or 1/5 as much, so the rise in temperature  
 will be 5° F.<sup>61</sup>

- A. Refer to Chapter 3 for detailed calculations.
- B. Represents a conservative average, according to the Water Resource Council, who estimate that fossil-fueled electric power plants raise the water temperature 15° F.<sup>61</sup>

TABLE A-1 (Cont'd)

Industry and Code from Input-Output Matrix	Direct, Indirect, Induced Co-efficient per \$ Final Demand	Coal Industry Output \$	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price per Unit \$	Total Purchases and Consumer Effects in units of product
Households	.355077	6,072,000	2,156,028	2,639/capita income <sup>62</sup>	617 persons

A. WATER QUALITY

1. HOUSEHOLD WASTES

State of Solids	Mineral (grams)	Organic (grams)	Total (grams)	BOD
Suspended	25	65	90	42
(a) setttable	(15)	(39)	(54)	(19)
(b) non-settable	(10)	(26)	(36)	(23)
Dissolved	50	80	160	12
Total	105	145	250	54

Wasteload per capita per day<sup>63</sup>

Suspended	16,425	42,705	59,130	27,594
(a) setttable	(9,855)	(25,623)	(35,478)	(12,453)
(b) non-settable	(6,570)	(17,082)	(23,652)	(15,111)
Dissolved	52,560	52,560	105,120	7,554
Total	65,955	95,265	164,250	35,475

Total wasteload generated by 617 persons in pounds per year, multiplier used was 657.<sup>64</sup>

2. GARBAGE--SOLID WASTES LBS/DAY<sup>64</sup>

	Urban	Rural
Households and Commercial:	4.01	3.3

Population breakdown in 1960:<sup>65</sup> Urban 69.9% Rural 30.1%  
 617 x .699 = 571 and 617 x .301 = 246.

	lbs/day	day/yr	total lbs.
Urban	571 x 4.01	x 365	= 535,744.15
Rural	246 x 3.30	x 365	= 296,307.00
Total			1,132,051.15

Total wasteload generated by 617 persons in pounds per year.

A.  $\frac{617 \text{ persons} \times 365 \text{ days}}{454 \text{ grams}} = 657$ , this number was used to convert the grams/day to pounds/year.

TABLE A-1 (Cont'd)

Households (cont'd.)

3. AUTOMOBILE EMISSIONS

Kansas cars and taxicabs  $\frac{1,013,705^{66}}{2,222,178^{67}}$  = .45 cars/person.

817 persons x .45 cars/person = 367.65 cars.

Automobile Emissions<sup>65</sup>

Type of Emission	Lbs/Car Day	No. of Cars	Days/Yr	Total Lbs/Yr
Carbon Monoxide	4.16	x 367.65	x 365	= 558,240
Nitrogen Oxides	.202	x 367.65	x 365	= 27,107
Hydrocarbons	.363	x 367.65	x 365	= 48,712
				<u>634,069</u>

## FOOTNOTES

- (1) M. Jarvin Emerson, with Leonard D. Atencio, Phillip D. Brooks, and J. David Reed, The Interindustry Structure of the Kansas Economy, Manhattan, Kansas, January, 1969 (Topeka, Kansas: Office of Economic Analysis and Kansas Department of Economic Planning Division, 1969), Appendix C, Kansas Direct, Indirect, and Induced Requirements Matrix.
- (2) Ibid., The Interindustry Structure of the Kansas Economy, Direct, Indirect, and Induced Coefficients Matrix.
- (3) Ibid., The Interindustry Structure of the Kansas Economy, p. 56.
- (4) U.S. Department of Labor, Wholesale Prices and Price Indexes, January and February, 1965 (Washington, D.C.: Government Printing Office, 1965), pp. 6-21, unless otherwise indicated.
- (5) Lee Foster, ed., The New York Times Encyclopedia Almanac (New York: New York Times Book and Education Division, 1970), p. 638, unless otherwise indicated.
- ✓ (6) Ted L. Willrich and George E. Smith, eds., Agricultural Practices and Water Quality (Ames: Iowa State University Press, 1970), p. 321.
- (7) Luman H. Longred, 1971 World Almanac (New York: Newspaper Enterprise Association, Inc., 1971), p. 131.
- (8) U.S. Department of Agriculture, Yearbook of Agriculture, 1935 (Washington, D.C.: Government Printing Office, 1935), p. 348.
- (9) "Sheep," Worldbook Encyclopedia, 1967, XVII, p. 307.
- (10) U.S. Department of Agriculture, Food for Us All, Yearbook of Agriculture, 1969 (Washington, D.C.: Government Printing Office, 1969), p. 12.

- (11) David Keith Todd, ed., The Water Encyclopedia (New York: Water Information Center, 1970), pp. 77-80.
- (12) "Dairy Cows," Worldbook Encyclopedia, 1967, V, p. 6.
- (13) Committee of Consumer and Marketing Service, Marketing Research Report, No. 701, Volume-Weight Conversion Factors for Milk (Washington, D.C.: U.S. Government Printing Office, 1965), p. 4.
- (14) Op. cit., Worldbook Encyclopedia, p. 6.
- (15) "Chickens," Worldbook Encyclopedia, 1967, III, p. 364.
- (16) U.S. Department of Agriculture, Agricultural Statistics, 1965 (Washington, D.C.: U.S. Government Printing Office, 1965), p. 414.
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- (63) Op. cit., Fair and Geyer, "Water Supply," p. 563.
- (64) Dan Golepaul, ed., Information Please Almanac, Atlas and Yearbook (New York: Dan Golepaul Assoc., 1970), p. 114.
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TABLE A-2  
PERCENTAGE DISTRIBUTION OF TOTAL INDUSTRY OUTPUT<sup>A</sup>

Sector	Component Industries	Component Industry Output in Dollars <sup>1</sup>	Component Classification <sup>2</sup>	Total Component Output	Percentage Distribution (Col.5/Col.3 Total)	
Other Agricultural Products (11)	Vegetables	663,000	Grains			
	Sweet Potatoes	794,000	"			
	Dry edible beans	825,000	"			
	Strawberries	111,000	"			
	Peaches	432,000	"			
	Apples	529,000	"			
	Lespedeza seed	232,000	"			
	Red clover seed	337,000	"			
	Sweet clover seed	91,000	"			
	Alfalfa seed	2,024,000	"			
	Sugar beets	3,588,000	"			
	Honey	570,000	"			
	Beeswax	29,000	"			
					10,225,000	.53
		Wool	1,471,000	Wool	1,471,000	.07
	Sheep	7,711,000	Sheep	7,711,000	.40	
	<b>Total Sector Output:</b>	<b>19,407,000</b>			<b>1.00</b>	
Poultry & Poultry Products (8)	Chickens	1,765,000	Poultry			
	Turkeys	2,560,000	Poultry	4,325,000	.19	
	Eggs	18,466,000	Eggs	18,455,000	.81	
	<b>Total Sector Output:</b>	<b>22,791,000</b>			<b>1.00</b>	
Meat Products (21)	Meat packing plants	584,893,000	Cattle	548,893,000	.93	
	Sausages	10,565,000	Hogs	10,565,000	.02	
	Poultry	31,180,000	Chickens	31,180,000	.05	
	<b>Total Sector Output:</b>	<b>590,638,000</b>			<b>1.00</b>	

<sup>1</sup>M. Jarvin Emerson with Leonard D. Atencio, Phillip D. Brooks, and J. David Reed, The Interindustry Structure of the Kansas Economy (Manhattan, Kansas: Department of Economic Development, 1969), p. 55.

<sup>2</sup>Ibid., p. 55.

<sup>A</sup>Total Sector Outputs were distributed among component industries, whenever the quantity of wasteload generated by production of the product varied significantly among the products produced.

TABLE A-2 (Cont'd)

Sector	Component Industries	Component Industry Output in Dollars	Component Classification	Total Component Output	Percentage Distribution (Col. 5/Col. 3 Total)
Dairy Products (22)	Condensed & evaporated milk	8,486,000	Condensed milk	8,486,000	.08
	Ice cream & frozen desserts	5,695,000	Ice cream	5,695,000	.05
	Fluid Milk	<u>98,530,000</u>	Milk	98,530,000	<u>.87</u>
Total Sector Output:		112,711,000			1.00

TABLE A-3

COMPUTATION OF AVERAGE PRICES<sup>A</sup>

Industry and Code <sup>2</sup>	Product <sup>2</sup>	Calculation		Average Price		Other Comments
		Dollar Amount	Unit	Dollar Amount	Unit	
Sorghum (2)		1.76	100 lbs.	.935 <sup>3</sup>	bu.	1 bu. sorghum = 56 lb. <sup>4</sup>
Other Grains (4)	Oats	.711	bu.			
	Barley	1.130	bu.			
	Rye	1.184	bu.			
		<u>3.025/3</u>			1.008	bu.
Hay (6)	Alfalfa	24.500	ton			
	Timothy	28.000	ton			
		<u>52.500/2</u>			26.250	ton
Other Agricultural Products (11)	Sweet potatoes	10.050	100 lbs.			
	Sweet potatoes, Chicago	9.750	100 lbs.			
	Beans, dried	8.750	100 lbs.			
	Clover seed	29.667	100 lbs.			
	Cabbage	4.250	100 lbs.			
	Carrots	7.236	100 lbs.			
	Onions	4.318	100 lbs.			
	Potatoes	6.375	100 lbs.			
	<u>80.396/8</u>			10.050	100 lbs.	of grain

1. U.S. Department of Labor, Wholesale Prices and Price Indexes, January and February, 1965 (Washington, D.C.: U.S. Government Printing Office, 1965), pp. 6-21, unless otherwise indicated.
  2. M. Jarvin Emerson, with Leonard D. Atencio, Phillip D. Brooks, and J. David Reed, The Interindustry Structure of the Kansas Economy (Manhattan, Kansas: Department of Economic Development, 1969), pp. 54-66.
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  4. U.S. Department of Agriculture, Yearbook of Agriculture, 1935 (Washington, D.C.: U.S. Government Printing Office, 1935), p. 348.
- A. Indirect Assumption: Total Sector Output is divided equally among representative products.

SOURCE: U.S. Department of Labor, Wholesale Prices & Indexes for Commodity Groups, Subgroups, Product Classes & Individual Items (Washington, D.C.: U.S. Government Printing Office, 1965), pp. 6-21; unless otherwise indicated

TABLE A-3 (Cont'd)

Industry and Code	Product	Calculation		Average Price		Other Comments	
		Dollar Amount	Unit	Dollar Amount	Unit		
Other Agricultural Products, Cont'd.	Good French Combing & Staple	1.325	lb.				
	Short French Combing & Staple	1.175	lb.				
	Good French Combing & Staple	1.295	lb.				
	Average French Combing & Staple	1.125	lb.				
	Good French Combing & Staple	1.275	lb.				
	Good French Combing & Staple	1.175	lb.				
		<u>7.370/6</u>			1.228	lb.	or \$122.833 per 100 lb.
Dairy Products (7)	Milk, Chicago	.265	qt.				
	Milk, San Francisco	.235	qt.				
	Milk, Washington, D.C.	.290	qt.				
	Milk, Dallas	.260	qt.				
	<u>1.050/4</u>			.2625	qt.	or \$.26 per qt.	
Poultry & Poultry Products (8)	<u>A. Chickens &amp; Turkeys</u>						
	Broilers & Fryers, Arkansas-Missouri	.131	lb.				
	Broilers & Fryers, North Georgia	.130	lb.				
	Turkeys, Fryers	.220	lb.				
	Turkeys, Toms	.210	lb.				
		<u>.691/4</u>			.1727	lb.	or \$.17 per lb.
	<u>B. Eggs</u>						
	Large, New England	.343	doz.				
	Extra large, Chicago	.273	doz.				
	Fancy Heavy Weights, NY	.320	doz.				
Grade A Large, San Francisco	.400	doz.					
	<u>1.336/4</u>			.334	doz.	or \$.33 per doz.	

TABLE A-3 (Cont'd.)

Industry and Code	Product	Calculation		Average Price		Other Comments	
		Dollar Amount	Unit	Dollar Amount	Unit		
Cattle (9)	Steers, Prime	25.375	100 lbs.				
	Steers, Choice	23.875	100 lbs.				
	Steers, Good	21.750	100 lbs.				
	Steers, Standard	18.875	100 lbs.				
		<u>89.875/4</u>		22.468	100 lbs.	or \$.22 per lb.	
Meat Products (21)	Beef, Prime	41.250	100 lbs.				
	Beef, Choice	40.429	100 lbs.				
	Beef, Utility	26.050	100 lbs.				
	Beef, Standard	33.000	100 lbs.				
	Beef, Good	38.643	100 lbs.				
			<u>179.372/5</u>		35.874	100 lbs.	or \$.36 per lb.
	Bacon	49.500	100 lbs.				
	Fatback	11.300	100 lbs.				
	Ham, Smoked	48.300	100 lbs.				
	Picnics, Smoked	28.600	100 lbs.				
	Pork Loins, Fresh	47.000	100 lbs.				
			<u>184.700/5</u>		36.940	100 lbs.	or \$.37 per lb.
Dairy Products (22)	A. Milk			.2625	qt.	previously calculated	
	B. Ice Cream, bulk	1.864	gal.				
	Ice Cream in $\frac{1}{2}$ gal.	1.671	gal.				
		<u>3.535/2</u>		1.767	gal.	or \$1.77 per gal.	
Other Food & Kindred Products	Applesauce	1.387	doz. cans				
	Peaches	2.399	doz. cans				
	Beans	1.710	doz. cans				
	Soup	1.120	doz. cans				
		<u>6.616/4</u>		1.654	doz. cans	or \$1.65 per doz. cans	
Paper & Allied Products (26)	Book Paper, A Grade	16.770	100 lbs.				
	Book Paper, #2 Plain Offset	17.967	100 lbs.				
	Wood Bond	17.614	100 lbs.				
	Writing Paper	27.685	100 lbs.				
		<u>80.036/4</u>		20.009	100 lbs.	or \$20.01 per 100 lbs. or \$.20 per lb.	

TABLE A-3 (Cont'd.)

Industry and Code	Product	Calculation		Average Price		Other Comments	
		Dollar Amount	Unit	Dollar Amount	Unit		
Industrial Chemicals (28) <sup>A</sup>	<u>A. Organic Chemicals</u>						
		High-Dye, Red	6,200.00	ton			
		Low-Coal, tar pitch	- 42.00	ton			
			$6,158.00/2 =$				
			$3,079.00 + 42.00 =$				
			3,121.00 per ton				
		<u>B. Inorganic Chemicals</u>					
		High-calcium Carbide	171.400	ton			
		Low-calcium Oxide	- 14.063				
			$157.337/2 =$				
			$78.668 + 14.063 =$				
			$92.731 \text{ ton} =$				
			$3,213.731/2 =$				
			1,606.865 ton or				
		\$1,606.86 per ton					
Agricultural Chemicals (29)	Ammonia, Anhydrous	92.00	ton				
	Ammonium Nitrate	70.00	ton				
	Ammonium Sulfate	32.00	ton				
	Nitrogen Solutions	130.00	ton				
	Sodium Nitrate	48.00	ton				
	Urea	96.00	ton				
	Nitrogenous process tankage	27.60	ton				
	Phosphate Rock	7.38	ton				
	Superphosphate	18.60	ton				
	Superphosphate, Triple	45.00	ton				
	Muriate, domestic	24.00	ton				
	Sulfate	38.00	ton				
			$628.58/12$		52.382 ton	or \$52.38 per ton.	

A. Due to lack of price information and a list of chemicals produced in Kansas, the best price estimate was the median of the range of those prices of industrial chemicals available.

TABLE A-3(Cont'd)

Industry and Code	Product	Calculation		Average Price		Other Comments	
		Dollar Amount	Unit	Dollar Amount	Unit		
Other Chemicals (30)	<u>Dynamites</u>						
	Ammonia Gelatine	23.20	100 lbs.				
	Ammonium Nitrate	3.50	100 lbs.				
		<u>26.70/2</u>		13.35	100 lbs.	or \$.13 per lb.	
Petroleum & Coal Products (31)	Gasoline, Tulsa 91-92, Octane Regular	.1130	gal.				
	Light Distillate, Tulsa, Kerosene	.1040	gal.				
	Middle Distillate, Tulsa #2	.0900	gal.				
	Residual Fuels, Tulsa #6, Ordinary	.0428	gal.				
	Lubricating Oil Materials, Neutral, Tulsa	.2400	gal.				
		<u>.5898/5</u>			.118	gal.	or \$.12 per gal.
Primary Metals (35)	Iron Ore, Mesabi, Bessemer	10.700	gross ton				
	Iron Ore, Non-Bessemer	10.550	gross ton				
	Iron Ore, Brazilian	10.400	gross ton				
	Steel #1, Heavy Melting	36.614	gross ton				
	Steel #2, Heavy Melting	30.563	gross ton				
	Steel Scrap #2, Bundle	23.602	gross ton				
	Steel, Melting, R.R. #1	41.810	gross ton				
	Steel Scrap #1, Bundles	39.310	gross ton				
	Steel, Stainless, Bundles	<u>210.665</u>	gross ton				
		<u>414.214/9</u>			46.024	gross ton	or \$46.02 per gross ton

TABLE A-4  
 REPRESENTATIVE AVERAGE CROP YIELDS

Industry	Representative Crops	Average Yields in Bushels/Acre	Representative Yield in Bushels/Acre (Col. 3 Total/the number of crops, 3)
Other Grains (4)	Oats	50.2	36.9 or 37
	Barley	37.8 <sup>1</sup>	
	Rye	22.6	
		<u>110.6/3</u>	
Industry	Representative Crops	Average Yields in Cwt <sup>A</sup> /Acre	Representative Yield in cwt/Acre (Col. 3 Total/the number of crops, 5)
Other Agricultural Products (11)	Potatoes	210.0	186.2 or 186
	Cabbage	201.0 <sup>2</sup>	
	Beans, dry edible	11.1 <sup>3</sup>	
	Carrots	220.0 <sup>4</sup>	
	Onions	<u>289.0<sup>5</sup></u>	
	931.1/5		

<sup>1</sup>Reader's Digest Association, Reader's Digest, Almanac and Yearbook, 1971 (Pleasantville: Reader's Digest Association, Inc., 1971), p. 175.

<sup>2</sup>U.S. Department of Agriculture, Agricultural Statistics, 1970 (Washington, D.C.: Government Printing Office, 1971), p. 166.

<sup>3</sup>Ibid., Agricultural Statistics, 1970, p. 284.

<sup>4</sup>Ibid., Agricultural Statistics, 1970, p. 168.

<sup>5</sup>Ibid., Agricultural Statistics, 1970, p. 180.

<sup>A</sup>cwt = Hundred weight, or 100 lbs.

APPENDIX B  
PRESENTATION OF WALTER ISARD'S STUDY OF THE  
PHILADELPHIA 496 REGION

APPENDIX B  
PHILADELPHIA 496 REGION STUDY  
by  
Walter Isard and Thomas W. Langford

The purpose of this summary is to provide a format for the systematic classification of ecologic commodities, such as the diverse water pollutants and air pollutants. It should be as detailed as the classes that now exist for economic commodities. Also needed, is a systematic classification of natural production processes. This section demonstrates the necessary procedures to achieve this goal, using both the petroleum refining industry and the sport fishing from boats with outboard motors activity.

BASIC TABLES NECESSARY<sup>1</sup>

- (1) A table of ecologic commodities--this might be a preliminary classification scheme for water and water pollutants as ecologic commodities.
- (2) A table of ecologic inputs--this might be an extended table of the main inputs for the processes involved in the basic food chain that produces both herring and cod as final products.

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<sup>1</sup>Walter Isard and Thomas W. Langford, Regional Input-Output Study: "Recollections, Reflections, and Diverse Notes on the Philadelphia Experience" (Massachusetts: MIT Press, 1971), pp. 18-20.

(3) A table of ecologic processes--this might be the processes involved in herring and cod production, such as the photosynthesis process in marine areas.

(4) A table of environmental regions--this might be regions such as air and land and water, which would include the set of relevant commodities and processes in the ecologic systems studied. The Philadelphia region would then function as a sub-region of each of these major regions, and an integration of all sub-systems would be the total ecologic-economic system.

### ECOLOGICAL COMMODITIES<sup>2</sup>

Technical production coefficients for any economic sector, for example the steel sector, must cover as inputs not only economic commodities such as coal, iron ore, professional services, and labor, but also ecologic commodities, such as water (for sanitary, production, cooling, boiler, irrigation, and other purposes), air, and land of diverse types. They should also cover the several outputs not only of economic commodities such as steel by type, slag and by-product gas, but also of ecologic commodities such as polluted water (from sanitary, production, cooling, and other uses), Biological Oxygen Demand (BOD), Ultimate Oxygen Demand (UOD), Chemical Oxygen Demand (COD), suspended solids, settleable solids, turbidity, alkalinity, acidity, and temperature (BTU).

Coefficients should also be developed for the outputs of the ecologic commodities, such as hydrogen sulfide, sulfur dioxide, particulates, and other air pollutants, diverse solid wastes, noise, and all other items of significance in terms of environmental quality and potential disturbance to the environment. For each sector of the economy, it will be necessary to have complete data for ecologic as well as economic commodities, as both inputs and outputs.

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<sup>2</sup>Ibid., pp. 201-204.

### ECOLOGICAL PROCESSES<sup>3</sup>

Once ecologic commodities are introduced into the framework, it also becomes important to encompass those processes that yield these commodities as outputs. Such processes may use some of these commodities as inputs. For example, the ecologic process that replenished the oxygen supply of water depleted by BOD and other oxygen demands must be included. The natural processes that remove particulates from the air, such as rain and wind movement should also be included. These processes employ as inputs the diverse pollutants that are generated and yield as outputs water and air of a specified quality. The relevant data on inputs and outputs are to be recorded in appropriately titled columns of an Input-Output Table.

### CONCEPTUAL FRAMEWORK<sup>4</sup>

The conceptual framework and the operational model must be extended further. Pollutants that are "exported" to the ecologic system at a given location interfere with processes going on there. For example, an increase in the turbidity of the water decreases the depth of penetration of light and thus reduces the phytoplankton output from photosynthesis in the marine area. This in turn, affects the supply of plankton, algae production, and so on, and finally fish production. A change in the supply of fish then affect the desirability and profitability of recreational fishing at any location for which that production represents a significant resource. Since these and other feedback effects upon recreation and other sectors of the economy are important, it is essential to examine the interrelationships between pollutants and the outputs of diverse environmental processes to the economy. This analysis requires a full and systematic collection of data on all the environmental processes involved. Table B-1 describes the quadrants of the conceptual framework.

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<sup>3</sup> Ibid., pp. 205, 206.

<sup>4</sup> Ibid., p. 207.

TABLE B-1  
MATRIX OF ECONOMIC AND ECOLOGIC PROCESSES

		ECONOMIC ACTIVITIES				ECOLOGIC PROCESSES		
		Agriculture	Textiles	Petroleum Refining	Sport Fishing			
						Plankton Production	Herring Production	Cod Production
ECONOMIC COMMODITIES	Wheat							
	Cloth							
	⋮	Economic System: Intersector Co- efficients				Ecologic Processes: Their Input and Out- put Coefficients regarding economic commodities		
	⋮							
	Crude Oil							
ECOLOGIC COMMODITIES	Water Intake							
	Alkalinity							
	⋮	Economic Sectors: Their Input and Output Coeffi- cients regarding ecologic commod- ities.				Ecologic System: Interprocess Coefficients		
	⋮							
	Detritus							
	Plankton					+	-	
	Herring						+	-
Cod							+	

Source: Walter Isard and Thomas W. Langford, Regional Input-Output Study: "Recollections, Reflections, and Diverse Notes on the Philadelphia Experience" (Massachusetts: MIT Press, 1971), p. 205.

## IMPLEMENTATION

The relevant coefficients to implement this model were developed for the petroleum refining industry. In Table B-2, the petroleum refining industry's typical inputs and outputs of economic commodities are listed in coefficient form. For example, the first coefficient,  $-.555848$ , is the dollar's worth of input of crude petroleum and natural gas per dollar output of the industry.

The petroleum refining industry also requires inputs of water and yields as output pollutants discharged via water to the environment. The water utilized has two categories of transactions as shown by a Water Balance Account, Table B-3. From this Water Balance Account, Table B-4, water pollutants are classified and coefficients for water use are estimated.

To derive these water use coefficients, a classification of water pollutants based on four-digit numbers is established. The first three digits describe the major group of pollutants and the fourth digit details the components of the three digit group, Table 3. To estimate water coefficients take the sum of the annual water flows and the waste flows, by kind, and divide this number by the corresponding sum of the value of shipments. Assuming the data for an individual industry is representative of all like industries, industrial coefficients are computed by taking the total of the summed flow data by kind for each source and dividing this grand total value of the shipments. This row must be added to the Input-Output Model. Examples of the water use coefficients are found in Table B-5.

The non-economic commodities listed in Table B-4 may be transferred to the lower half, along with their respective coefficients to Table B-5. This is the first step in linking the economic and ecologic systems. Petroleum refining involves other non-economic commodities, for example, air and air pollutants, and other economic activities involve still other non-economic commodities. Therefore, a need to extend the classification of non-economic commodities is necessary.

TABLE B-2  
 SAMPLE INPUT-OUTPUT COEFFICIENTS: RIS SECTOR 2911, PETROLEUM REFINING

<u>SECTOR (RIS NUMBER)</u>	<u>INDUSTRY</u>	<u>COEFFICIENT</u>
1311	Crude Petroleum and Natural Gas	-0.555848
1509	Construction, Maintenance, and Repair	-0.001410
2652	Set-Up Paperboard Boxes	-0.008054
.	.	.
.	.	.
2818	Industrial Organic Chemicals, n.e.c.*	-0.027180
2819	Industrial Inorganic Chemicals, n.e.c.	-0.009199
2911	Petroleum Refining	+0.954950
.	.	.
.	.	.
3599	Machinery & Parts, n.e.c.	-0.000002
4811	Telephone Communications	-0.001210
4890	Telegraph & Other Communications	-0.000100
.	.	.
.	.	.
4990	Sanitary & Other Systems	-0.000142
6020	Interest	-0.005088
6301	Insurance, Non-life	-0.001242
.	.	.
.	.	.
7310	Advertising	-0.002312
7400	Research & Development	-0.000390
7500	Automotive Repair	-0.001040
.	.	.
.	.	.
9826	Office Supplies	-0.000280
9842	Transportation Costs	-0.040831
9888	Wages & Supplies	-0.089378

\*Not elsewhere classified.

Designates an input of this economic sector.

+Designates an output of this economic sector.

Source: Walter Isard and Thomas W. Langford, Regional Input-Output Study: "Recollections, Reflections, and Diverse Notes on the Philadelphia Experience" (Massachusetts: MIT Press, 1971), p. 207

TABLE B-3  
WATER BALANCE ACCOUNT

INPUTS

Sanitary Use  
Production  
Cooling  
Boiler Feed  
Other  

---

Water Intake

OUTPUTS

Water Discharged:  
Sanitary Use  
Production  
Cooling  
Other  
Water Consumed:  
Embodied in produce  
Evaporated\*  
Seeped into ground  

---

Water Discharged + Water Consumed

\*An account to cover agricultural and residential locations should include transpiration of water by plant life.

Source: Walter Isard et. al., "On the Linkage of Socio-Economic and Ecologic System," Regional Science Association Papers, XXI (November, 1967), 86.

TABLE B-4  
 SAMPLE PROPOSED WATER POLLUTION CLASSIFICATION (WPC) CODES

<u>WPC CODE</u>	<u>WATER RELATED ITEM</u>	<u>UNITS</u>
1000	Water Intake, Total	1,000 gal./ \$ Output
1001	Sanitary Use	"
1002	Production Use	"
.	.	.
.	.	.
.	.	.
1010	Water Discharge, Total	"
1011	Sanitary Use	"
1012	Production	"
.	.	.
.	.	.
.	.	.
1020	Water Consumed	"
1031	Biological Oxygen Demand (BOD (5-Day))	1,000 lb./ \$ Output
1032	Ultimate Oxygen Demand (UOD)	"
1033	Chemical Oxygen Demand, (COD)	"
1040	Solids, Total	"
1041	Suspended Solids	"
1042	Settleable Solids	"
.	.	.
.	.	.
.	.	.
1051	Alkalinity	"
1052	Acidity	"
1061	Oils and Greases	"
.	.	.
.	.	.
.	.	.
1070	Pathogenic (Disease Causing) Organisms	"
1080	Temperature	BTU/ \$ Output
1090	Other Pollutants	1,000 lb./ \$ Output
.	.	.
.	.	.
.	.	.
1099	Not Classified	"

Source: Walter Isard and Thomas W. Langford, Regional Input-Output Study: "Recollections, Reflections, and Diverse Notes on the Philadelphia Experience" (Massachusetts: MIT Press, 1971), p. 208.

TABLE B-5  
WATER USE COEFFICIENTS

<u>SECTOR (WPC NUMBER) *</u>	<u>INDUSTRY</u>	<u>COEFFICIENT</u>
1001	Water Intake--Sanitary Use, 1,000 gal./\$ Output	-0.000455
1002	Water Intake--Production, 1,000 gal./\$ Output	-0.022827
1003	Water Intake--Cooling, 1,000 gal./\$ Output	-0.114861
.	.	.
.	.	.
.	.	.
1033	Chemical Oxygen Demand, (COD), 1,000 lb./ \$ Output	+0.000169
1041	Suspended Solids, 1,000 lb./ \$ Output	+0.000084
1042	Settleable Solids, 1,000 lb./ \$ Output	+0.000124
.	.	.
.	.	.
.	.	.
10951	Phenols, 1,000 lb./ \$ Output	+0.000003

\*Water Pollution Code.

Source: Walter Isard and Thomas W. Langford, Regional Input-Output Study: "Recollections, Reflections, and Diverse Notes on the Philadelphia Experience" (Massachusetts: MIT Press, 1971), p. 207.

Some further questions (as yet unanswered for the petroleum refining industry), what are the sources of the inputs from the ecologic system to the economic system? How are they produced? Since research is available on recreational activities, it will be used for illustration. One of these activities is sport fishing from boats with outboard motors. This economic-type activity is at the head of one of the columns with its inputs listed underneath, in the left-half of the Matrix, Table 5. For the economic activity, recreational sport fishing the relevant inputs per 1,000 man-days per season per day are listed in Table B-6.

One of the coefficients for this industry is fish, in the context of a particular area of New England studied, Plymouth Bay, the chief fish is cod. It has been estimated that per 1,000 man-days of sport fishing in outboards, 6,200 lbs. of cod are required to provide a satisfactory recreational outcome. That number may be written in the cell corresponding to the cod row and sport fishing column.

For cod to be an input in an activity of the economic system, it must be yielded as an output of a process, the cod production activity, a natural ecological process. The output of cod requires, as food inputs, herring, invertebrate carnivores, and small fish. In turn, the herring requires as food inputs plankton; and invertebrate carnivores; and small fish consume herbivorous invertebrates, which live on detritus. These activities are part of a basic food chain in the ecological system, and their input-output data are recorded in the lower right block of the matrix. Each of the production processes becomes a column heading relating to ecologic processes on the right-half of the matrix and each commodity required is listed among the ecologic commodities in the lower part of the left-hand stub of the matrix. The food chain is illustrated in Table B-7.

The food chain represents only one basic set of linkages in the ecologic system. A study of the entire ecologic system in relation to the economic system must cover various other basic linkages. Biogeochemical cycles, such as the phosphorus cycle, and photosynthesis are two examples of basic relationships that should be included. The photosynthesis cycle is necessary for herring production. Herring production requires 10 pounds of plankton

TABLE B-6

## RECREATIONAL SPORTFISHING: OUTBOARD, SEASONAL

<u>OUTPUT</u>	<u>QUANTITY</u>	<u>UNIT</u>
Man-Days per Season/Day	1,000	Man-Days
<u>INPUTS</u>		
1. Land Inputs--Parking	2.66	Acres
2. Land Inputs--Operational Facilities	0.72	Acres
Storage 28%	0.20	Acres
Repairs, Services 24%	0.17	Acres
Sales, Showroom 15%	0.11	Acres
Office 4%	0.03	Acres
Others 29%	0.21	Acres
3. Land Inputs--Additional Operational Facilities		
4. Land Inputs--Miscellaneous Land Space (Optional)	0.50	Acres
5. Land Inputs--Launching Ramps	3.30	Acres
6. Water Surface--Water Space Environmental Conditions	6.33	Acres
Coliform Index	5,000/100 ml. max.	
Dissolved Oxygen	3.0 ppm. min.	
pH	6.7-8.6 avg.	
Biochemical Oxygen Demand	5.0 ppm max.	
Turbidity	100,000 ppm avg.	
Color	30 units+	
7. Boat Input--Boats/Day	333.0	Boats/Day
8. Labor Input--Man-Days of Labor	80.0	Man-Days
9. Fuel Input--Fuel Consumed	3,762	Gal./Day
10. Fish Input--Winter Flounder	3,960	Lbs./Man-Day
11. Fish Input--Cod	6,633	Lbs./Man-Day

Source: Walter Isard, et. al, "On the Linkage of Socio-Economic and Ecologic Systems," Regional Science Association Papers, XXI (November, 1967), 85.

TABLE B-7  
FOOD CHAIN REQUIREMENT FOR COD PRODUCTION

Classification Number	Commodity	Units	MX 61-10 Plankton Production	MX 60 All Marine Plant Production	MX 6001 Detritus Production	MX 718 Production of Herbi- vorous Invertebrates	MX 719 Herring Production	MX 722 Small Fish Production	MX 721 Carnivorous Inverte- brates (Lgr. Gastropods) Proc.	MX 725 Cod Production
MX 61-10	Plankton	Lbs.	+1				-10			
MX 60	All Marine Plants	"	+1	-1						
MX 6001	Detritus	"		+1	-10					
MX 718	Herbivorous Invertebrates (Misc.)	"			+1		-10	-10		
MX 719	Herring	"					+1			-1.167
MX 722	Small Fish	"					+1			-1.167
MX 721	Carnivorous Invertebrates (Lrg. Gastro- pods)	"							+1	-8.333
MX 725	Cod	"								+1

Source: Walter Isard and Thomas W. Langford, Regional Input-Output Study: "Recollections, Reflections, and Diverse Notes on the Philadelphia Experience" (Massachusetts: MIT Press, 1971), p. 210.

per pound of herring. In the Plymouth Bay setting, 1 gram of plankton may be considered as a mixture consisting of 0.86 gram of phytoplankton and 0.14 gram of zooplankton. The zooplankton uses the phytoplankton as an input. The phytoplankton itself is produced via photosynthesis, which requires inputs of light, solar radiation at the ocean surface, and dissolved phosphate in seawater. All of the carbon fixed by phytoplankton photosynthesis is not available for consumption by zooplankton, because some is used by the phytoplankton's own respiration process, and this must be accounted for (refer to Table B-8).

All of the empirical materials presented will fill cells in three of the major blocks of the matrix, leaving the upper right quadrant. This problem is eliminated by an appropriate classification of commodities.

Reconsider the commodity, cod, (Table B-5) as an ecologic (non-economic) commodity in the lower half of the commodity classification. That is, as a commodity that is yielded as an output (designated by a +) by an ecologic process and used as an input (designated by a -) by an economic process. An alternative classification of cod could be an economic commodity or resource, just as land and labor are. This follows because the amount of cod that is produced by the natural environment, just as the amount of land and labor, represents the stock of a resource. This stock behaves as a constraint on the levels of economic activities that use these resources. Other resources, such as timber and grass, which are also yielded by natural processes, could also be classified as scarce economic resources. This would identify them as economic commodities, which are listed in the upper half of the left-hand stub. If these criteria are adhered to the positive cells in the upper-right quadrant of the matrix would represent outputs of ecologic processes that are provided as resources to the economic system; and negative entries would represent the use of these economic resources in natural production processes themselves. Illustrations of these natural production processes would be the consumption of herring by cod, or the consumption of grass by wildlife.

TABLE B-6

## PLANKTON AND RELATED PRODUCTION ACTIVITIES

Classification	Commodity	Units	PMX Gross Phytoplankton 61-14 Production by Photosynthesis	PMX Utilization of 61-15 Phytoplankton Matter by Respiration @2	P <sub>2</sub> MX Utilization of 61-15 Matter by Respiration @7	P <sub>3</sub> MX Utilization of 61-15 Phytoplankton Matter by Respiration @12	P <sub>4</sub> MX Utilization of 61-15 Phytoplankton Matter by Respiration @17	PMX Phytoplankton 61-11 in pounds (Dummy Unit Conversion Process)	PMX Plankton 61-10 Formation	PMX Zooplankton 117 Production
MX 11	Solar Radiation	G. Cal per cm <sup>2</sup> /min.	-1.79							
MX 420	Below 0.55mg/m <sup>3</sup> Phosphorus as Phosphate	MG. at/m <sup>2</sup>	-0.06							
MX 42	Above 0.55mg/m <sup>3</sup>	MG. at/m <sup>2</sup>	-0.00							
MX 44	Water Transparency t=i/k		-68.68					+1.00	-0.86	-1.7
MX 61-11	Phytoplankton @3.98 g.c./m <sup>2</sup>	pounds	-35.54	-.0201	-.0281	-.0400	-.0565			
MX 61-12	Phytoplankton Stock	grams carbon/m <sup>2</sup>	-1.00					-277		
MX 61-13	Phytoplankton	grams carbon/m <sup>2</sup>		+1.00	+1.00	+1.00	+1.00			
MX 61-14	Phytoplankton Gross Production by Photosynthesis	grams carbon/m <sup>2</sup> /day							+1.00	
MX 61-15	Loss of Phytoplankton matter due to Respiration	grams carbon/m <sup>2</sup> /day							-0.14	+1.00
MX 61-10	Plankton	pounds								
MX 711	Zooplankton @.68 g.c./m <sup>2</sup>	pounds								

Source: Walter Isard and Thomas W. Langford, Regional Input-Output Study: "Recollections, Reflections, and Diverse Notes on the Philadelphia Experience" (Massachusetts: MIT Press, 1971), p. 212.

A classification scheme (such as proposed on the previous page) would involve arbitrary decisions; Is land an economic commodity to be recorded in the upper half of the matrix, or an ecologic commodity to be recorded in the lower half? Similar queries may be posed regarding water, air, fish, livestock, etc. While this will require arbitrary decisions, the primary objective is to provide a full accounting of all inputs and outputs of all commodities relevant to the problem being examined. If a commodity can be used as both an economic input and as an ecologic input, a dummy process is necessary that would use the commodity as an ecologic input and transform and deliver it as an output to the economic system as an economic commodity. While a classification of processes as economic and ecologic clarifies understanding of the problem, it is not essential for analysis, provided all processes relevant for a problem are identified and accurately described in an empirical manner.

Another issue is the definition of relevant regions. When the problems under consideration involve air pollution, water pollution, solid waste disposal, or sonic pollution, the relevant region is the physical environment. The regional classification system adequate for studying an economy, is not extensive enough for studying the combination of an economic system and an ecologic system and their interrelations.

Three new major types of regions might be land, air, and marine. Each is composed of subsystems; an economic subsystem, an ecologic subsystem, and other subsystems. The traditional regions, which in this case are the Philadelphia metropolitan area or New England may be incorporated under both the economic and ecologic subsystems of the major region, land. A typical column in the set of columns representing the Philadelphia subsystem region would be the petroleum refining activity. In that column would be listed all of this industry's inputs and outputs, both economic and non-economic commodities. Some commodities, such as crude oil, gasoline, and solid wastes would be classified as land types; others such as clean water from a river system and water pollutants released into the marine area, would be classified as marine types. Others would be commodities of an air type, such as unpolluted air itself and particulates. Other subsystem regions could also be

classified. Table B-9 illustrates the use of these regions.

A change in the present conception of regions for planning purposes is necessary. This will involve investigation of new areas and major changes in the uses of Input-Output methodology as a tool.

TABLE B-9  
 SAMPLE SCHEME FOR ECONOMIC AND ECOLOGIC SYSTEMS ANALYSIS

		L A N D		A I R		M A R I N E	
		Economic	Ecologic	Economic	Ecologic	Economic	Ecologic
L A N D	Economic	Philadelphia	Philadelphia	Philadelphia	Philadelphia		
	Ecologic	Philadelphia	Philadelphia	Philadelphia	Philadelphia		
A I R	Economic						
	Ecologic						
M A R I N E	Economic						
	Ecologic						

Source: Walter Isard and Thomas W. Langford, Regional Input-Output Study: "Recollections, Reflections, and Diverse Notes on the Philadelphia Experience" (Massachusetts: MIT Press, 1971), p. 214.

## METHODOLOGY

The methodology employed in this study is a combination of traditional landscape analysis techniques and a derivation from Characteristic Supply and Demand and Equilibrium analysis of Regional Science.

## LANDSCAPE ANALYSIS (CLASSIFICATION AND EVALUATION)

After the Case Study area of the Beverly Harbor and Collins Cove in Salem, Mass. had been selected on the basis of combined visual/physical and economic factors, a landscape analysis was made by the research staff. This analysis (as illustrated on the accompanying maps A-1 through A-6) was the basis for classification of the Case Study area into separate Visual Landscape Zones (See Map A-6) which, for our present purposes we will consider to be separate environments.<sup>9</sup> Each zone was then evaluated in terms of the prescribed Visual Environmental Attributes (of Pleasure, Comfort, etc.) for empirical comparison with physical and economic parameters of the study (as described elsewhere in this report) for the purpose of selecting two alternative sites for further evaluation and comparison. The two zones (or sites 1 and 2 of Map A-7) finally selected were those considered for the development of a marina, namely:

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<sup>9</sup> An environment is made up on an almost infinite array of "things, objects, causes and causal relationships" - which are transferred through the "medium of the atmosphere" into information and never perceived in isolation (as in a laboratory experiment) and seldom from a stationary viewpoint. For purposes of visual analysis however, we can isolate and identify the primary or predominant elements which give a particular environment its landscape character which we can then classify into zones according to its general type as well as its environmental attributes (of pleasure, comfort, diversity, etc.), Ittelson, Gibson.

## Continuation of footnote 9

9 The following Visual elements in the case study area were located, identified and weighed:

- a. Primary and secondary visual zones (Map A-1)
- b. Visual landscape Character (Primary Visual Zone) (Map A-6)
  - 1. Predominantly natural
    - open water (anchorage, boats, rocks, apparency of sea)
    - coves (enclosure)
    - channels (major activity - movement)
    - beaches and intertidal zones (activities, swimming, tidal change)
    - hills, bluffs
    - headlands (prominent features)
    - marshes
    - rock out-croppings
  - 2. Predominantly man-made
    - primary use or activity (i.e. residential, industrial, etc.) and other activities, age, condition or other qualifying aspects.
- c. Visual Prominence (Map A-3)
- d. Movement patterns and rhythm (daily, annual, continual, sporadic, static) (Map A-2)
- e. Visual landscape elements (positive and negative) (Map A-4)
  - 1. Dominant zones
  - 2. Features and landmarks
- f. Texture (Map A-5)
  - 1. Urban form (horizontal and vertical densities - mass)
  - 2. Land form and vegetation

a. POINT SITE = a dump or fill site (Zone k) and a gas plant site (Zone l) (Map A-6).

A waterfront industrial complex consisting of steel gas storage tanks, a complex of picturesque, unused brick buildings, a stone pier, power towers and some derelict, flat open space - it is distinguished by its location and size, uniqueness in the landscape, visibility from the Salem entrance road, from Collins Cove and from Beverly Harbor and by its 'unnatural' character.

b. FORT LEE COVE SITE = a swimming beach in park on Collins Cove. (Subarea of Zone a) (Map A-6).

A sandy beach consisting of open beach, sloping gently from water's edge to the adjacent road, enclosed on either side by small tree and grass-covered hills - it is distinguished by its natural character and blending into the overall park environment.

The evaluation of the two sites is shown in Chart E-2. The numerical values (or ratings) are used here for convenience only and will be referred to in the following section.

#### VISUAL SUPPLY ANALYSIS

The resulting evaluations of each site in terms of high or low quantity of each of the prescribed attributes were assigned numerical values on a scale of 1 through 9 to provide an index of Existing Visual Supply.<sup>10</sup> (EXISTING SUPPLY INDEX)

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<sup>10</sup> The evaluation (high, medium or low) is the measure of the significance (in terms of each of the prescribed Visual Environmental Attributes) afforded to an observer by a given environment. Two ways of analyzing the degree of significance: i.e. very significant, significant, insignificant (high, medium, or low) as

(continued on next page)

The scale of 1 through 9 was used to allow a more precise evaluation than would have been possible with only 5 weights. The significance of a given Visual Environmental Attribute can thereby be rated medium, toward low or toward high and enables the observer to have a greater latitude of expression than if the ratings were confined to high, medium, and low.

1	2	3	4	5	6	7	8	9
low-low/low/high-low	low-med/med/high-med	med-high/high/high-high						

An even finer scale may prove to be desirable but was not attempted in this study. Another refinement was used in the study but was not developed or tested. Subratings were given to each qualification of the overall rating for each of the Visual Environmental Attributes (of pleasure, comfort, etc.) which, when divided by their number yield the overall rating. The use of such subratings in conjunction with well developed sub-qualifications should prove very useful.<sup>11</sup>

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10 (continued)

opposed to significant, insignificant or opposing significance (positive, neutral or negative) have not been differentiated here except that a low significance was considered neutral and received a medium evaluation whereas an opposing or negative significance received a low evaluation. The Cove Site, for example, was considered to have medium prominence as it was simply not prominent while the Point Site was considered to have low Continuity as it was detrimental to the continuity of the overall neighborhood.<sup>11</sup>

Qualifying the Point Site's rating of 2 (low) for the attribute of Pleasure, for example, the subratings of 3 (high-low) for frustration, 1 (low-low) for depressing image and 2 (low) for its irrelevancy clearly indicate the importance of its image of dirt, oppressive size and inhuman function. The subrating of the Point Site for the attribute of Meaning - 5 (med) for significance, 2 (low) for social context and 8 (high) for informational value indicate the high amount of visual information supplied and the lack of a meaningful social context.

In addition to the quantity of Visual Environmental Attributes provided by a given environment at a given point in time, a site developed or undeveloped has an inherent potential to provide a certain quantity of these attributes,<sup>12</sup> hence a Potential Visual Supply

(POTENTIAL SUPPLY INDEX) This potential was quantified in the same manner as the existing supply.<sup>13</sup>

CHART E-2 COMPARATIVE SITE RATING

POINT SITE	PLEAS.	COMF.	DIVERS.	CONTIN.	PROM.	MEAN.	INDEX
existing supply rating	2	2	4	2	7	5	22
POTENTIAL SUPPLY RATING	8	6	8	7	9	7	45
index of visual equilibrium	-6	-4	-4	-5	-2	-2	-25
COVE SITE	PLEAS.	COMF.	DIVERS.	CONTIN.	PROM.	MEAN.	INDEX
existing supply rating	7	7	4	8	5	5	36
POTENTIAL SUPPLY RATING	7	7	5	6	6	5	36
index of Visual equilibrium	0	0	-1	2	-1	0	0

<sup>12</sup> Due to intrinsic factors of its land form, location, relation, relation to other sites and activities, size, shape, etc.

<sup>13</sup> Example: DIVERSITY  
 Point Site: - high 8  
8/high choice - large size, location allow build-in of variety  
9/ excitement of: activity node(land-water), harbor, city entrance  
7/ challenge of participation  
 Cove Site: - medium  
3. choice of activity limited by size, too much activity could destroy existing environment

(continued)

## VISUAL EQUILIBRIUM ANALYSIS

The final evaluation or ratings for the two sites, which we will call Existing and Potential Supply Indexes [b],[c], were then compared to determine the INDEX OF VISUAL EQUILIBRIUM [d]; the difference between existing and potential Visual Quality in terms of the prescribed Visual Environmental Attributes.

The comparison (of existing vs. potential) yields a greater or lesser difference between the two - the lesser the difference the more the site's visual quality is consistent with its potential or is in Visual Equilibrium. The Index of Visual Equilibrium for the Point Site is -25 and for the Cove Site 0 - clearly the latter is in visual equilibrium while the former is not.

The resulting totals are meaningful in themselves but each attribute must be examined individually, thus while the totals for the Cove Site are in equilibrium, the site had potential for increased diversity and prominence but only at the cost of continuity. Similarly, for the Point Site, while all other attributes had great potential, prominence and meaning were relatively near equilibrium. Further, more meaningful analysis of resultant ratings can be derived from the examination of subratings which indicates basis for rating of each category. These subratings, which were not tested as described below, are found in Chart E-1, page A-21.

To test and evaluate the foregoing methodology a questionnaire was prepared and given to 18 people along with a presentation

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13 (continued)

- 6. controlled, pastoral lacks excitement (if not beauty)
- 6. limited challenge

of the study area, emphasizing the two sites. Presentation material consisted of a series of Visual Analysis maps (See Maps A-1 through A-6) and a photographic record of a trip through the study area around Collins Cove. The 18 participants were then asked to rate the two sites for existing and potential Visual Attributes (of pleasure, comfort, etc.). Questionnaire results showed that most participants (approximately 66%) reached conclusions substantially similar to those of the research staff thus indicating the general validity of the methodology. The majority of the participants understood the meaning and application of the terms (pleasure, comfort, etc.) in the same fashion, and had a clear appreciation of the relative equilibrium of the two sites.<sup>14</sup> There was wide agreement about the potential of a site as opposed to its existing condition.

At the same time, the test results indicated the need for more precise definition of the terms (pleasure, comfort, etc.)<sup>15</sup> as well as of the meaning of inherent or intrinsic potential. Most participants felt that they would be able to make more realistic evaluation of a site's potential if allowed to consider it in terms of a given activity. This idea was not tested but would be useful - especially in the context of the following section which considers an index of Potential Visual Equilibrium - and could be presented to

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<sup>14</sup> Even when total figures differed from those of the research staff the participants rated the Cove Site much more nearly in equilibrium than the Point Site.

<sup>15</sup> See Appendix for development of analogous terms and examples.

questionnaire participants verbally, graphically, or in model form which would show a development proposal.

#### ACTIVITY DEMAND AND POTENTIAL EQUILIBRIUM ANALYSIS

If a given environment has greater or lesser significance in terms of the prescribed Visual Attributes it follows that various possible activities (or types of development) have differing requirements (or demands) for these Attributes in their environment. Chart E-3 lists several types of development together with a rating of the importance of each of the prescribed attributes for each type of development. These are called ACTIVITY DEMAND MATRICES. The Activity Demand Index for a type of development is defined as the sum of the ratings for the attributes.

CHART E-3 ACTIVITY DEMAND MATRIX<sup>16</sup>

	Pleas.	Comf.	Div.	Cont.	Prom.	Mean.	INDEX
Residential single family	7	8	3	5	4	5	32
Residential multi family	7	7	4	6	5	5	34
Industrial (heavy)	2	7	2	5	2	5	23
Industrial (light)	3	6	3	5	4	5	26
Commercial retail	8	8	7	6	8	7	44
Commercial (marina)	7	6	6	6	7	6	38
Combined urban Complex*	8	8	8	8	9	9	50
Urban park	9	9	8	8	6	6	46

(Footnotes on following page)

A comparison of the intrinsic visual supply (Potential Supply Index) of a particular environment or site with the visual demand (Activity Demand Index) of a particular activity provides an index of the suitability (Index of Potential Visual Equilibrium) of the activity to the site in terms of visual criteria.

The visual potential of the Point Site for various possible activities was evaluated by this method.<sup>17</sup>

CHART E-4 POTENTIAL SUPPLY AND ACTIVITY DEMAND

	INDEX	Pleas.	Comf.	Diver.	Cont.	Prom.	Mean	
POINTSITE (Potential)	45	8	6	8	7	9	7	(6/6)
Urban Complex (demand)	50	8	8	8	8	9	9	(4/6)
Retail Commer.(demand)	44	8	8	7	6	8	7	(5/6)
Commer. Rec. (Marina) (demand)	38	7	6	6	6	7	6	(4/6)
Multi-fam. res. (demand)	34	7	7	4	6	5	5	(3/6)
City Park (demand)	46	9	9	8	8	6	5	(4/6)

Chart E-4 shows a comparison of the Potential Supply rating of the Point Site for various attributes with the level of those

(footnotes for page A-12)

\*

Including commercial - recreational - cultural and transient residential activity.

16

The attributes are defined in the appendix.

17

Since the Point Site was previously found to be in equilibrium it was not evaluated for other uses although from the chart above it is apparent that other activities had a high potential equilibrium.

attributes required by each type of development.

Note that the Retail Commercial, with 5 out of 6 ratings within one point of the Point Site Potential ratings, has the highest correlation with the Potential of the site of all activities. The comparison indicates that Retail Commercial activity has the highest Potential Visual Equilibrium (if only because of the high correlation); while the other activities listed are also relatively near equilibrium. Any of these, qualified by considerations such as the potential of a development itself to provide additional Visual Environmental Attributes or critical factors (presence of water for purposes of a Marina) not visually accountable, could prove ultimately desirable from a visual standpoint. An activity might also be eliminated if proven economically unfeasible or so ecologically destructive as to be felt undesirable (see following section).

#### COMPARISON WITH NON-VISUAL CRITERIA

The potential for visual improvement of a given environment through its development can be empirically compared with the economic potential of the development and its implications on the natural ecologic systems of the environment.

For example:

The Point Site in our case study was shown not to be in visual equilibrium when compared with its potential as represented by a retail commercial development or combined urban complex. If it could be shown through economic analysis, however, that such a

development was unfeasible (because of high acquisition and development cost for locational reasons); or through analysis of physical factors that resultant destruction of ecological food chain resources would damage the entire fish population of the estuary (hence depleting its recreation or commercial value) other possible uses or alternatives would be considered. The relative degree of importance of all relevant factors including the visual environment is the question that this study attempts to answer. Only on this basis can intelligent and satisfactory policy decisions for development be reached.

It should be possible not only to ascertain the desires and opinions of the general (voting) public and policy makers but to provide, through the foregoing Quantitative Analysis of Visual Environmental Attributes, a basis for more enlightened and wise decisions....

The next logical step would be to evolve a methodology to include an economic input in terms of "willingness to pay" for a given environment (whether by maintaining, modifying or changing it altogether). A follow-up questionnaire should be developed on which people who had rated the site would be asked to place an economic value on their decisions. This is not included in the present study due to time limitations but would be an important part of future research.<sup>18</sup>

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<sup>18</sup> The visual environment is often held to be such an intangible, subjective quality and so variously perceived and appreciated as to defy quantitative measurement. Many qualified and informed observers believe it is impossible to measure let alone to value in economic terms. We do, however, commonly make decisions with respect to the costs we are willing to pay for visual quantity and

(continued on following page)

The questionnaire would relate environmental quality (in the context of an existing or potential visual equilibrium) with the economic value placed on it by the participants. If the questionnaire results showed a substantial agreement among the participants the two factors will have been demonstrably linked.

Theoretically people would be willing to pay more to substantially increase the visual equilibrium of a particular environment or the maintaining of an existing equilibrium. If so, it might be possible to establish a ratio between ratings for visual equilibrium and a willingness to pay or their economic value.

Willingness to Pay in Increased Taxation to Achieve Visual Equilibrium

INDEX	0	1	2	3	4	5	6	7	8	9	(max)
Price (mills)	0.0	0.0	0.0	0.5	1.0	1.5	1.75	2.0	2.25	2.5	( " )

Willingness to Pay in Increased Taxation to Maintain Visual Equilibrium

INDEX	0	1	2	3	4	5	6	7	8	9	(max)
Price	2.5	2.25	2.0	1.75	1.5	1.0	0.5	0.0	0.0	0.0	( " )

The ratios above, theoretical and arbitrary, would not be constants applicable to any environmental condition. The ratio would vary considerably depending on the individual or group, their purposes, prejudices and educational background and with the type of development proposed. People would, most likely, be

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(18 continued)

quality. Private developers and public agencies charged with the responsibility of a building or development project must inevitably decide whether the project is to be: 1) economically expedient, 2) merely consistent with a given standard of design quality or the best possible project that money and design talent can produce. One could legitimately argue that the first alternative is not worthy of consideration but the fact of its every day occurrence cannot be denied.

willing to pay more for a park than for a commercial development.

DEFINITIONS OF TERMS EMPLOYED IN THIS STUDY

- [a] Visual Environmental Attributes are the general kinds of quality that are perceivable in a given environment.
- [b] Existing Supply Rating is the quantity of a given attribute in terms of specified criteria (pleasure, comfort, etc.) to be found in a given environment (high, medium, low).
- [c] Potential Supply Rating is the quantity of a given attribute provided (or suggested) by inherent characteristics of a given environment.
- [d] Index of Visual Equilibrium is the numerical difference between the Potential Supply and Existing Supply of Visual Environmental Attributes in a given environment. If the Existing and Potential Supply are equal the difference is zero and the Visual Environment is in Equilibrium. The greater the difference, the more the Visual Environment is in Disequilibrium.
- [e] Activities Demand Rating is the quantity (high, medium, low) of a given Visual Environmental Attribute required by a given activity. (See Chart E-3).
- [f] Index of Potential Visual Equilibrium is the numerical difference between the Potential Supply and Activity Demand Index for a given activity in a given environment. If the Potential Supply and Activity Demand are equal the difference is zero and the activity and environment are potentially in equilibrium.

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APPENDIX: Visual Environmental Attributes,  
 Analogous terms (grouped vertically - positive and  
 negative) and examples:

1. The attribute of PLEASURE implies:

well-being	as opposed to	frustration
enjoyment	"	depression
spiritual value	"	hopelessness

- a. A meandering river in an urban setting, its grassy banks and tall trees accomodating and sheltering the recreational, cultural and spiritual needs of the population.
- b. A humane but inspiring complex of public buildings evoking the image of their beneficial role in the life of the viewer.

2. The attribute of COMFORT implies:

security	as opposed to	discomfort
relaxation	"	apprehension
invitation	"	pain

- a. The familiar aspect of a quiet, shaded residential street, a small sheltered sitting area in a crowded bustling retail district, out of the main flow of activity.

3. The attribute of DIVERSITY implies:

excitement	as opposed to	simplicity
choice	"	indifference (monotony)
challenge	"	boredom

- a. An urban commercial "activity node" where people of various ages, status (socio-economic), etc. mingle as they pursue their individual goals: hurrying to work, loafing, conversing, shopping, being entertained, etc.
- b. A forest wilderness, with perhaps a rushing mountain stream, etc.

## 4. The attribute of CONTINUITY implies:

interrelatedness	as opposed to	discontinuity
belonging	"	incongruity
understandability	"	disorientation

- a. A large park with a variety of separate places and activities all structured in relation to a dominant natural feature (such as a stream or river, or man-made device) which is always visible (or easily found) giving a sense of orientation and relation.
- b. A separate urban neighborhood visibly and functionally tied to other parts of the city by transportation arteries, boulevards, open space (greenery) or strong natural features.

## 5. The attribute of PROMINENCE implies:

clarity	as opposed to	indistinguishability
obtrusiveness	"	incomprehensibility
identity	"	unobtrusiveness

- a. A high hill, (natural or developed) or building, highly visible and lending its character to the overall visual environment.
- b. A strong natural feature to which other activities, uses or systems orient themselves, (because of its prominence).

## 6. The attribute of MEANING implies:

purpose	as opposed to	meaningless
symbolic social context	"	superfluousness
informational	"	redundancy

- a. A city square or plaza - clearly intended (and understood) as a place of congregation, meeting, observing or resting - the rules and guide lines for conduct within it explicitly stated or implied by social convention.

CHART E-1EVALUATION FOR ENVIRONMENTAL ATTRIBUTES (Point and Cove Sites)a. PLEASURE

Point Site: Low	(2)
<u>Depressing</u> visage of dirt, oppressive size, inhuman function	(1)
<u>Irrelevancy</u> to man's social aspirations	(2)
<u>Frustration</u> of not participating (in activity)	(3)
Cove Site: High toward medium	(7)
<u>Well-being</u> of healthy exercise, fresh air, etc.	(9)
<u>Happiness</u> associated with activity	(6)
<u>Spiritual</u> satisfaction of communicating with nature	(6)

b. COMFORT

Point Site: Low	(2)
<u>Uninviting</u> to people not employed	(3)
<u>Relaxation</u> prevented by possible danger	(1)
<u>Insecurity</u> of alien atmosphere	(2)
Cove Site: High toward medium	(7)
<u>Invitation</u> to pleasurable activity	(6)
<u>Relaxing, casual</u> place for non-participants	(8)
<u>Security</u> of pleasant - familiar	(7)

c. DIVERSITY

Point Site: Medium toward low	(4)
<u>Simplicity</u> of function and use	(2)
<u>Excitement</u> of texture, color, form - brick buildings	(6)
<u>Challenge</u> of threat to overall environment	(4)
Cove Site: Medium toward low	(4)
Limited <u>choice</u>	(4)
Low key <u>of excitement</u>	(4)
Lack of <u>challenge</u>	(4)

d. CONTINUITY

Point Site: Low	( 2)
<u>Incongruity</u> with surroundings (not belonging)	( 1)
<u>Disorienting</u> in terms of understanding overall city	( 3)
Cove Site: Medium	( 5)
<u>Relation</u> to park - water	( 9)
<u>Belonging</u> to site (natural form, etc.)	( 8)
<u>Understandable</u> function in context of park	( 7)

e. PROMINENCE

Point Site: High toward medium	( 7)
<u>Clarity</u> of form	( 8)
<u>Strong intrusion</u> on surrounding environments	( 7)
<u>Image</u> strong (oppressive - but not expressive of purpose)	( 6)
Cove Site: Medium	( 5)
<u>Clarity</u> of form and function - not highly <u>visible</u>	( 5)
<u>Unobtrusive</u> element in overall park landscape (indistinguishable)	( 4)
<u>Image</u> fairly strong but limited to context of park	( 6)

f. MEANING

Point Site: Medium	( 5)
Little <u>significance</u> to average observer - except for reference	( 5)
<u>Social Context</u> lacking - meaningless	( 2)
<u>Informational</u> value high but indirect (accidental)	( 8)
Cove Site: Medium	( 5)
Of less <u>significance</u> than park as whole	( 4)
<u>Purpose</u> <u>clear</u> and valued but modest	( 8)
Minor <u>symbolic</u> function	( 4)
Negligible <u>information</u> attribute - except internalized	( 4)

APPENDIX C

PRESENTATION OF WILLIAM H. MIERYNK'S STUDY OF THE  
COLORADO RIVER BASIN

APPENDIX C  
COLORADO RIVER BASIN STUDY  
by  
William H. Mierynk

The concern of this study is how a change in water quality might effect water users and eventually industrial output. The base used is the conventional open Leontief Input-Output model with changing input coefficients. Separate transactions tables were derived for each sub-basin and linked together balancing import rows and export columns to form a "pure" interregional model. One of the basic assumptions of this model was the inputs purchased by a given sector depend on the level of that sector's output. A set of sectoral water input coefficients,  $W_i$  were also introduced into the system. The sectors studied included both industrial and agricultural sectors.

DERIVATION OF WATER-INPUT COEFFICIENTS<sup>1</sup>

The water-input coefficients were defined as the number of gallons required, on a net depletion basis, per dollar of total gross output in each sector. They show the amount of water needed,

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<sup>1</sup>William H. Mierynk, Systems Analysis for the Great Lakes Water Resources, "Proceedings of the Fourth Symposium on Water Resources Research of the Ohio State University Water Resources Center" (Ohio State University, 1969), p. 53.

directly and indirectly for a given level of sectoral output. The set of 1960 water coefficients was projected by the extrapolation of past trends.

The relationship between the future water demanded,  $W_t^d$ , and the future supply  $W_t^s$ , determined whether or not water quality would influence industrial outputs. For example, if  $W_t^d \leq W_t^s$ , no adjustments were necessary. If however,  $W_t^d > W_t^s$ , this is an indication that the projections of final demand for goods and services could not be realized. In this case the projections of final demand for water were revised downward until equality of water demand and supply was achieved.

In making these adjustments it was assumed where water is relatively scarce the market will allocate the available supply to the "highest value-added" or "most profitable" uses. This means that the decision was made in advance that the amount of water used would be less in those sectors where each gallon of water consumed yielded the lowest rates of return to their users. At this point, water quality becomes a constraint on the water users. To make the quality-constrained projections it was necessary to estimate the total dissolved solids in parts per million, which would result from the increased use of water to meet the projected levels of total gross output in each sub-basin. To compute the new water input coefficients economic and engineering analyses were merged.

A basic assumption was made that the total gross output of each sector in the year  $i$ ,  $X_{it}$ , will depend upon the availability of an adequate supply of water of a specified quality level,  $W_{it}$ , as well as upon the demand for the output of that sector,  $Y_{it}$ . This results in the static equation,  $X_{it}=f(W_{it}, Y_{it})$ .

#### TRANSLATION OF WATER QUALITY INTO WATER QUANTITY<sup>2</sup>

A major problem faced was translating changes in water quality into quantity terms, that is by computing new water input coefficients based on changes in instream water quality. This relationship between economic output and water inputs of a specified quality varies among sectors. The degradation of water quality necessitates either an

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<sup>2</sup>Ibid., pp. 53-54.

increase in the amount of water used or the installation of water purification equipment.

If the water users' costs were not affected, then it was only necessary to multiply the larger water input coefficients by the projected total gross output.

In most cases degradation of the water necessitates a different combination of inputs. For instance, in the agricultural sector larger quantities of water may be used which would cause more leaching and an increase in the amount of fertilizer necessary, and also an increase in other inputs, such as labor per unit of output. All of these results make it necessary to adjust the technical coefficients to compensate for water of lower quality.

Regardless of whether or not the degradation of water changes the production function, it is necessary to compute new water demand-supply relationships. It is imperative that the adjustment of technical coefficients and changes in final demand are made independently.

To make the final demand adjustments in the  $i$ -th sector involves a set of cross elasticities. These could not be computed because of a lack of price data. Therefore, broad principles were adhered to to make judgmental adjustments in final demand.

### ADJUSTMENTS IN WATER DEMANDED<sup>3</sup>

There were three sectors discussed regarding changes in demand--the agricultural sector, commercial and industrial users, and municipals users.

In each of these sectors it was assumed that their output would be adjusted to the water quality constraints according to the elasticity of their demand curves. For example, with higher water input requirements some farm managers would shift production from lower to higher value-added crops. But the amount of the increase in production in any sector would be constrained by the elasticity of demand for that product(s) of that sector.

For commercial and industrial users it was assumed that in lieu of altering their water inputs the industries would install treatment equipment.

In adjusting final demand, it is assumed some degree of monopolistic competition exists in the

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<sup>3</sup> Ibid., pp. 55-58.

production markets. Thus, part of the increased cost of water treatment is passed on to the consumers in the form of higher prices.

In a rare case an industry might be driven out of business, but normally as the TUC (Total it Curves) shift upwards a cutback in production will suffice. If consumers pay higher prices they have less money to spend elsewhere, so there would be a spillover effect.

The final demand adjustments in commercial and industrial sectors were not found to be of any major consequence.

Municipal users also face a highly inelastic demand schedule for water. But since higher quality standards must be maintained by municipal users treatment costs can be expected to rise more rapidly. As in the commercial and industrial sector it was felt the increased cost would be passed on to the consumers as higher prices. This means the consumers would again have less money to spend elsewhere, but it was not felt this change would be large.

These three cases illustrate three general approaches used in adjusting final demand to changing water quality so that  $W_t^d < W_t^s$ . A degradation of water affects users in both input and output. First of all inputs will have to be increased to compensate and thus input costs will rise. This may or may not cause a decrease in output depending upon the market demand for their products.

APPENDIX D

ENVIRONMENTAL EFFECTS RESULTING FROM THE TOTAL  
PURCHASES AND CONSUMER EFFECTS OF THE  
STRIP-MINING OF COAL INDUSTRY IN KANSAS

In this thesis the two primary environmental considerations are air quality and water quality. The total wasteloads generated are presented in Table D-1 for air emissions and Table D-3 for water effluents.

#### AIR EMISSIONS

To translate the air emissions into environmental effects such as, damage to vegetation, harmful effects to the human respiratory system, etc. an inquiry was made of Mr. Robert J. Chanslor,<sup>1</sup> the Assistant Chief of the Program Support Branch (Air) of the Environmental Protection Agency at Kansas City, Missouri, for suggested steps to be taken. After posing the problem to him, it was decided that pounds of air emissions per year cannot meaningfully be changed to parts per million. This conversion is vital since the effects of pollutants in air to the environment are listed according to the concentration, which is parts per million. Parts per million (ppm) is usually a volumetric measure, that is, it measures both the volume and mass the pollutant occupies per million parts of air. There is atmospheric research being done (since 1964) to develop a diffusion model for pollutants, the study will

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<sup>1</sup>Robert J. Chanslor, Assistant Chief of the Program Support Branch (Air), Environmental Protection Agency, Kansas City, Missouri, telephone interview between writer and respondent on June 4, 1972.

then be computerized and tested in St. Louis to validate the model.<sup>2</sup> This model will take into account meteorological variables such as wind movements, stack parameters, rain, etc., which at present prohibit the conversion of air emissions to parts per million.

#### WATER EFFLUENTS

To translate the water pollutants into environmental effects, Mr. Duane Morgan,<sup>3</sup> an engineer with the Water Pollution Control Department in Wichita, Kansas was contacted. After consultation with Mr. Morgan, it was decided that pounds of water pollutants per year may be compared to domestic sewage characteristics, or population equivalents. The two characteristics of domestic sewage used were 0.17 pounds of Biological Oxygen Demand (BOD) per capita per day and 0.20 pounds of Suspended Solids (SS) per capita per day.<sup>4</sup> The amounts of water effluents applicable in these two categories are 297,810 pounds of BOD and 258,266 pounds of SS (see Tables D-2 and

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<sup>2</sup>As the study has not yet been completed, statistics have not been published nor are they available.

<sup>3</sup>Duane Morgan, Engineer, Water Pollution Control Department, Wichita, Kansas, personal interview between writer and respondent on June 5, 1972.

<sup>4</sup>Leonard Metcalf and Harrison P. Eddy, Wastewater Characteristics (New York: McGraw-Hill, 1972), p. 231.

D-4). The following conversions were necessary. First, to convert the pounds per year to pounds per day. Second, to divide the pounds per day by the appropriate domestic sewage characteristic. Therefore:

BOD:

$$\frac{298,930 \text{ pounds/year}}{365 \text{ days}} = 819 \text{ pounds/day; and}$$

$$\frac{819 \text{ pounds/day}}{0.17 \text{ lbs./capita}} = 4,800 \text{ persons}$$

SS:

$$\frac{258,266 \text{ pounds/year}}{365 \text{ days}} = 708 \text{ pounds/day; and}$$

$$\frac{708 \text{ pounds/day}}{0.20 \text{ lbs./capita}} = 3,600 \text{ persons}$$

The wasteload generated in meeting the "Total Purchases and Consumer Effects" (excluding households) of the Strip-mining of coal industry in Kansas would be, for BOD the equivalent of 4,800 persons, and for SS the equivalent of 3,600 persons.

TABLE D-1  
AIR EMISSIONS  
POUNDS PRODUCED ANNUALLY

Industry	Parti- culates	Hydro- carbons	Organics	Nitrogen Oxides	Sulfur Oxides	Sulfur Dioxide	Sulfur Trioxide	Carbon Monoxide	Ammonia	Aldehydes	Aero- sols	Dust	Acids	Solids
Grain Mills (23)	50	187	224	312	87									
Industrial (28), Agricultural (21) & (29), Other Chemicals (30)	968	948	1,566	124	124									
Petroleum & Coal (31)	8,762	62,586	626	2,503		90,750	1,878	137,689	626	626	626			
Cement & Concrete (33)			2,714	1,085	9,499					271		57,568	4,071	27,139
Other Stone & Clay (34)	4,914				889									
Motor Freight (49)		9,893		32,284				14,840						
Other Mining-- Bituminous Coal (16)		61,460		181,784				83,967						
Electric, Gas, Sanitary Service & Public Utilities (52)			287,509,323	1,337,473,405	28,600,512				87,499,244	191,663,236			237,516,339	144,021
Households		48,712		27,107				558,240						
<b>TOTALS</b>	<b>14,694</b>	<b>183,786</b>	<b>287,514,453</b>	<b>1,337,718,604</b>	<b>28,811,111</b>	<b>90,750</b>	<b>1,878</b>	<b>794,736</b>	<b>87,499,870</b>	<b>191,664,133</b>	<b>626</b>	<b>57,568</b>	<b>237,522,910</b>	<b>171,160</b>

TABLE D-2  
 1970 AIR QUALITY EFFECTS OF THE DEMAND GENERATED BY  
 THE STRIP-MINING OF COAL INDUSTRY IN KANSAS

POLLUTANT	POUNDS		RATIO <sup>1</sup>	POUNDS	
	PER YEAR(1965)			PER YEAR (1970) <sup>2</sup>	
Particulates	14,694		1.6	23,510	
Hydrocarbons	183,786		1.6	294,058	
Organics	287,514,453		1.6	460,023,125	
Nitrogen Oxides	1,337,718,604		1.6	2,140,349,766	
Sulfur Oxides	28,811,111		1.6	46,097,778	
Sulfur Dioxide	90,750		1.6	145,200	
Sulfur Trioxide	1,878		1.6	3,005	
Carbon Monoxide	794,736		1.6	1,271,578	
Ammonia	87,499,870		1.6	139,999,792	
Aldehydes	191,664,133		1.6	306,662,613	
Aerosols	626		1.6	1,002	
Dust	57,568		1.6	92,109	
Acids	237,522,910		1.6	380,036,656	
Solids	171,160		1.6	273,856	

<sup>1</sup>Ratio of 1970 coal industry output of \$9,712,000<sup>3</sup> to the 1965 output of \$6,072,000<sup>3</sup>, or  $\frac{9,712,000}{6,072,000} = 1.6$ .

<sup>2</sup>Column 1 x Column 2.

<sup>3</sup>United States Bureau of the Mines, Yearbook Area Report, 1970 (Washington, D.C.: U.S. Government Printing Office, 1970).

TABLE D-3  
WATER QUALITY  
POUNDS PRODUCED ANNUALLY

Industry Code	Sediment Yield	Nitrogen	Phosphorous	Potassium	Total Solids	BOD	Suspended Solids	Grease	Dissolved Solids	Phenol	Sulfide	Cyanide	Fluoride	Solid Garbage
Corn (1)	3,164,000 <sup>A</sup>	2,730	882	13,440										
Sorghum (2)		8,905	2,877	43,840										
Wheat (3)		2,904	330	6,798										
Other Grains (4)		264	30	618										
Soybeans (5)		4,290	1,386	21,120										
Hay (6)		6,298	1,474	18,894										
Other Agricultural Products (11)		44	5	103										
Cattle (9)		17,520	5,840		580,350	58,035								
Dairy Cows (17)		2,920	730		73,000	8,760								
Sheep (11)														
Hogs (10)		12,410	4,015		187,245	51,830								
Poultry (8)		3,650	3,650		69,715	17,520								
Meat Products (21)		193				1,741	1,539	124						
Dairy Products (22)						235								
Other Food & Kindred Products (24)						558	638		598					
Paper & Allied Products (26)						9,545	8,484		38,885					
Petroleum & Coal Products (31)						3,129				31	9			
Primary Metals (35)							91,625			47		21	23	
Other Mining-- Bituminous Coal (16)	12,650,000													
Households						35,478	59,130		105,120					1,132,051
TOTALS	15,814,000	62,128	21,219	104,813	910,310	186,831	161,416	124	144,603	78	9	21	23	1,132,051

A. This represents the sediment yield from all agricultural.

B. Summarized in cattle wasteload generated acres on the first 7 industries listed.

TABLE D-3 (Cont'd)  
 WATER QUALITY  
 POUNDS PRODUCED ANNUALLY

Industry	Ammonia	Ferric Sulfate	Lube Oils	Sulfuric Acid	Emissions	Soluble Metals	Heat
Primary Metals	57	1,994	2,595	9,676	303	58	
Electric, Gas, Sanitary Service & Public Utilities							↑ 5° F
TOTALS	57	1,994	2,595	9,676	303	58	↑ 5° F

TABLE D-4  
 1970 WATER QUALITY EFFECTS OF THE DEMAND GENERATED  
 BY THE STRIP-MINING OF COAL INDUSTRY IN KANSAS

POLLUTANT	POUNDS		RATIO <sup>1</sup>	POUNDS	
	PER YEAR(1965)			PER YEAR(1970) <sup>2</sup>	
Sediment Yield	15,814,000	1.6		25,302,400	
Nitrogen	62,128	1.6		99,405	
Phosphorus	21,129	1.6		33,806	
Potassium	104,813	1.6		167,701	
Total Solids	910,310	1.6		1,456,496	
B.O.D.	186,831	1.6		298,930	
Suspended Solids	161,416	1.6		258,266	
Grease	124	1.6		198	
Dissolved Solids	144,603	1.6		231,365	
Phenol	78	1.6		125	
Sulfide	9	1.6		14	
Cyanide	21	1.6		34	
Fluoride	23	1.6		37	
Solid Garbage	1,132,051	1.6		1,811,282	
Ammonia	57	1.6		91	
Ferric Sulfate	1,994	1.6		3,190	
Lube Oils	2,595	1.6		4,152	
Sulfuric Acid	9,676	1.6		15,482	
Emissions	303	1.6		485	
Soluble Metals	58	1.6		93	

<sup>1</sup>Ratio of 1970 coal industry output of \$9,712,000<sup>3</sup> to the 1965 output of \$6,072,000<sup>3</sup>, or  $\frac{9,712,000}{6,072,000} = 1.6$ .

<sup>2</sup>Column 1 x Column 2.

<sup>3</sup>United States Bureau of the Mines, Yearbook Area Report, 1970 (Washington, D.C.: U.S. Government Printing Office, 1970).

APPENDIX E  
IMPACT OF THE MINED-LAND CONSERVATION  
AND RECLAMATION ACT

In this section the impact of the Mined-Land Conservation and Reclamation Act<sup>1</sup> is discussed. Under the following conditions of 200 pounds of cattle to the acre<sup>2</sup>, 500 acres of strip-mined land<sup>3</sup>, and the price of one pound of beef of \$.22; there would be a "Total Purchases and Consumer Effect" (excluding households) of \$22,000.00. After following this amount through the "Kansas Direct, Indirect, and Induced Requirements Matrix"<sup>4</sup> Table E-1, the total amounts of wasteload generated is presented in Table E-2, Water Quality Effects After Reclamation and Table E-3, Air Quality Effects After Reclamation.

#### WATER EFFLUENTS

To translate the water pollutants into environmental effects, the two characteristics of domestic sewage used were 0.17 pounds of Biological Oxygen Demand (BOD) per capita per day and 0.20 pounds of Suspended Solids (SS) per capita per day were used (see Appendix D). The following conversions were necessary. First, to convert the pounds per year to pounds per day. Second, to divide the

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<sup>1</sup>Mined-Land Conservation and Reclamation Act, sec. 49-406, K.S.A. Supplement (1968).

<sup>2</sup>Maurice Barnes, cattleman, Weir, Kansas.

<sup>3</sup>See Appendix A, Table 1.

<sup>4</sup>Dr. Emerson's Interindustry Study, previously cited.

pounds per day by the appropriate domestic sewage characteristic. Therefore:

BOD:

$$\frac{46,736 \text{ pounds/year}}{365 \text{ days}} = 128 \text{ pounds/day; and}$$

$$\frac{128 \text{ pounds/day}}{0.17 \text{ lbs./capita}} = 1,296 \text{ persons}$$

SS:

$$\frac{472,936 \text{ pounds/year}}{365 \text{ days}} = 1,296 \text{ pounds/day; and}$$

$$\frac{1,296 \text{ pounds/day}}{0.20 \text{ lbs./capita}} = 6,479 \text{ persons.}$$

The wasteload generated in meeting the "Total Purchases and Consumer Effects" (excluding households) for the \$22,000.00 derived cattle output would be, for BOD the equivalent of 1,296 persons, and for SS the equivalent of 6,479 persons.

SEDIMENT YIELD:

To assess the impact of this reclamation act, it would be necessary the environmental effect of the sediment which might be lost if the land were left barren. This would result in 12,650,000 lbs. of sediment annually

(see Chapter 3, p. 47). Sedimentation studies relating to the environmental effect of sediment in streams was not available at this time.<sup>5</sup>

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<sup>5</sup>Verlin Peterson, Kansas State University Extension Agronomist, telephone call, June 10, 1972.

TABLE E-1  
ENVIRONMENTAL EFFECTS OF THE CATTLE GRAZING INDUSTRY & ITS ECONOMICALLY RELATED INDUSTRIES

Industry and Code <sup>1</sup>	Direct, Indirect, Induced Co-efficient <sup>2</sup>	Calculated Output of Cattle in \$'s <sup>A</sup>	Total Purchases and Consumer Effects, in \$'s <sup>B</sup>	Average Wholesale Price per Unit in \$'s	Total Purchases and Consumer Effects in units of product	Average Crop Yield <sup>4</sup>	Acres Required for Total Purchases and Consumer Effects <sup>C</sup>	Cause	Loss of Plant Nutrients <sup>5</sup> from Harvested Crop Areas--lbs/acre/year			Loss--Direct, Indirect & Induced Effect on Cattle Industry--lbs/yr. <sup>D</sup>			
									Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium	
Corn (1)	.042706	\$22,000	939.53	1.289 bu.	729 bu.	74 bu.	10.0	Leaching Erosion	17 48	-- 21	39 281	170 480	-- 210	390 2,510	
Sorghum (2)	.166888	\$22,000	3,671.54	1.76/100 bu. <sup>6</sup> 1 bu. sorghum 56 lbs. <sup>7</sup> .985 bu.	3,727 bu.	52 bu.	72.0	Leaching Erosion	17 48	-- 21	39 281	1,224 3,456	-- 1,512	2,805 20,232	
Wheat (3)	.020908	\$22,000	459.98	1.620 bu.	284 bu.	27 bu.	11.0	Leaching Erosion	33 11	-- 5	38 65	363 121	-- 55	418 715	
Other Grains (4)	.000218	\$22,000	4.80	1.008 bu.	4 bu.	37 bu. <sup>I</sup>	.2	Leaching Erosion	33 11	-- 5	38 65	7 2	-- 1	8 13	
Soybeans (5)	.002727	\$22,000	59.99	2.855 bu.	21 bu.	27 bu. <sup>9</sup>	1.0	Leaching Erosion	17 48	-- 21	39 281	17 48	-- 21	39 281	
Hay (6)	.216745	\$22,000	4,768.39	26.25 ton	182 tons	1.85 tons	10.0	Leaching Erosion	23 24	-- 11	-- 141	230 240	-- 110	-- 1,410	
Other Agricultural Products (11)	.005649	\$22,000	124.28	.65.87 <sup>E</sup> grains 8.70 <sup>F</sup> wool 49.71 <sup>E</sup> sheep	.10 lb. <sup>F</sup> 1.23 lb. <sup>F</sup> .22 lb. <sup>F</sup>	659 lb. <sup>G</sup> 7 lb. <sup>H</sup> 226 lb. <sup>H</sup>	186 lbs. <sup>I</sup>	4.0	Leaching Erosion	33 11	-- 5	38 65	132 44	-- 20	152 260
TOTALS:								108.2				6,534	1,929	29,536	

- A. Coefficient (Column 2) x Calculated Industrial Output of Cattle in \$'s (Column 3) = Total Purchases and Consumer Effects in \$'s.
- B. Total Purchases & Consumer Effects in \$'s (Column 4) / Average Wholesale Price per Unit (Column 5) = Total Purchases & Consumer Effects in Product Units.
- C. Total Purchases & Consumer Effects in Units of Product (Column 6) / Average Crop Yields (Column 7) = Acres Required.
- D. Acres Required (Column 8) x Loss of Plant Nutrients (Column 9) = Total Pounds of Nutrients Lost.
- E. For detailed calculation, refer to Table A-2
- F. For detailed calculation, refer to Table A-3
- G. Pollution characteristics not available.
- H. Treated as Cattle.<sup>9</sup>
- I. For detailed calculation, refer to Table A-4

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TABLE E-1 (Cont'd)

Industry and Code	Direct, Indirect, Induced Co-efficient	Calculated Output of Cattle in \$'s	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price	Total Purchases and Consumer Effects in units of product	Environmental Effects																																				
(Poultry & Poultry Products, cont'd.)						<p>To convert the number of chickens to pounds of chicken, <math>1.25 \times 3.5 \text{ lbs}^{15} = 404 \cdot \frac{4.4}{5} = 1 \text{ unit}</math>. Since waste measurements are per 5 lbs, <math>\frac{10 \text{ lbs. (TPCE)}^B}{5} = 2 \text{ units}</math>. Also, 13,694 lbs. from Kansas Sector 21 <math>\frac{13,694 \text{ lbs.}}{5} = 2,739</math>. The total number of chickens required would be 1 for egg laying + 2 for poultry processing + 17 from Sector 21 = 20.</p>																																				
Cattle (9)	1.263107	\$22,000	27,788.35	.22 lb. <sup>A</sup>	126,309 lbs.	<p>The wastes from cattle, hogs, and chickens are as follows:</p> <table border="1"> <caption>Pollutional Characteristics of Untreated Animal Wastes<sup>16</sup></caption> <thead> <tr> <th>Animal</th> <th>Animal Weight</th> <th>Solids lbs/day</th> <th>BOD lbs/day</th> <th>Nitrogen lbs/day</th> <th>Phosphorus lbs/day</th> </tr> </thead> <tbody> <tr> <td>Cattle</td> <td>1,000</td> <td>10.0</td> <td>1.0</td> <td>0.3</td> <td>0.1</td> </tr> <tr> <td>Dairy Cow</td> <td>1,000</td> <td>10.0</td> <td>1.2</td> <td>0.4</td> <td>0.1</td> </tr> <tr> <td>Swine</td> <td>100</td> <td>0.9</td> <td>0.25</td> <td>0.06</td> <td>0.02</td> </tr> <tr> <td>Poultry</td> <td>5</td> <td>0.06</td> <td>0.015</td> <td>0.003</td> <td>0.003</td> </tr> </tbody> </table>	Animal	Animal Weight	Solids lbs/day	BOD lbs/day	Nitrogen lbs/day	Phosphorus lbs/day	Cattle	1,000	10.0	1.0	0.3	0.1	Dairy Cow	1,000	10.0	1.2	0.4	0.1	Swine	100	0.9	0.25	0.06	0.02	Poultry	5	0.06	0.015	0.003	0.003						
Animal	Animal Weight	Solids lbs/day	BOD lbs/day	Nitrogen lbs/day	Phosphorus lbs/day																																					
Cattle	1,000	10.0	1.0	0.3	0.1																																					
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Swine	100	0.9	0.25	0.06	0.02																																					
Poultry	5	0.06	0.015	0.003	0.003																																					
Hogs (10)	.002208	\$22,000	48.58	.13 lb.	374 lbs.	<p>Kansas production resulting from the cattle industry:</p> <p>Dairy Products 170 lbs.; Poultry 20 units; Hogs 374 lbs.; Cattle 126,309 lbs.</p> <table border="1"> <thead> <tr> <th>Animal</th> <th>Units</th> <th>Solids lbs/day</th> <th>BOD lbs/day</th> <th>Nitrogen lbs/day</th> <th>Phosphorus lbs/day</th> </tr> </thead> <tbody> <tr> <td>Cattle</td> <td>126.3</td> <td>1,263</td> <td>126</td> <td>38</td> <td>13</td> </tr> <tr> <td>Dairy Cow</td> <td>.2</td> <td>2</td> <td>—</td> <td>—</td> <td>—</td> </tr> <tr> <td>Swine</td> <td>3.7</td> <td>3</td> <td>1</td> <td>—</td> <td>—</td> </tr> <tr> <td>Poultry</td> <td>20.0</td> <td>1</td> <td>—</td> <td>—</td> <td>—</td> </tr> <tr> <td></td> <td></td> <td>1,269</td> <td>127</td> <td>38</td> <td>13</td> </tr> </tbody> </table> <p>Total Wastes Annually (x 365): 463,185    46,355    13,870    4,745</p>	Animal	Units	Solids lbs/day	BOD lbs/day	Nitrogen lbs/day	Phosphorus lbs/day	Cattle	126.3	1,263	126	38	13	Dairy Cow	.2	2	—	—	—	Swine	3.7	3	1	—	—	Poultry	20.0	1	—	—	—			1,269	127	38	13
Animal	Units	Solids lbs/day	BOD lbs/day	Nitrogen lbs/day	Phosphorus lbs/day																																					
Cattle	126.3	1,263	126	38	13																																					
Dairy Cow	.2	2	—	—	—																																					
Swine	3.7	3	1	—	—																																					
Poultry	20.0	1	—	—	—																																					
		1,269	127	38	13																																					

A. For detailed calculation, refer to Table A-3.  
 B. Total Purchases and Consumer Effects.

TABLE E-1 (Cont'd)

Industry and Code	Direct, Indirect, Induced Co-efficient	Calculated Output of Cattle in \$'s	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price	Total Purchases and Consumer Effects in units of product	Environmental Effects				
						A. WATER QUALITY				
Meat Products (21)	.013697	\$22,000	301.33 or 280.24 cattle <sup>A</sup> 6.03 hogs <sup>A</sup> 15.06 chickens <sup>A</sup>	.365 lb. <sup>B</sup> .37 lb. <sup>B</sup> .17 lb. <sup>B</sup>	768 lbs. <sup>C</sup> 16 lbs. <sup>C</sup> 86 lbs. <sup>D</sup>	MEAT PRODUCTS				
						Wasteload per ton processed <sup>17</sup>	Animal	BOD (lb)	Suspended Solids (lb)	Nitrogen (lb)
						Cattle	28.5	25.3	3.17	2.01
						Hogs	31.4	20.9	3.15	3.29
						Cattle	11.4	10.1	1.3	8.0
						Hogs	3.1	2.1	.3	.3
						Totals:	14.5	12.2	1.6	8.3
Dairy Products (22)	.007496	\$22,000	164.91 or 13.19 milk <sup>A</sup> 6.25 ice cream <sup>A</sup> 143.47 condensed milk <sup>A</sup>	.26 qt. <sup>B</sup> 1.77 gal. <sup>B</sup> 8.20 case of 48 <sup>18</sup>	51 qts. or 13 gal. 5 gal. 17 cases	DAIRY PRODUCTS				
						Wasteload per unit processed <sup>19</sup>		BOD (lbs.)	Soap & Chemical BOD (lbs.)	
						Fluid Milk (lbs.)	.0010		.0001	
						Ice Cream (gal.)	.0032		.0003	
						Condensed Milk (lbs.)	.0046		.0005	
<p>To convert 13 gal. of fluid milk to pounds, multiply by 8.614 lbs.<sup>20</sup>, or 112 lbs.</p> <p>To convert 17 cases of condensed milk to pounds, there are 48 cans/case<sup>21</sup>, and they contain 14.5 oz. of condensed milk per can<sup>21</sup>. . . 17 cases x 48 cans = 816 cans, and 816 cans x 14.5 oz. = 11,832 oz. or 740 lbs. (<math>\frac{11,832}{16}</math>).</p>										
<p>A. For detailed calculation, refer to Table A-2.            B. For detailed calculation, refer to Table A-3.            C. Environmental Effect summarized on following page.            D. Summed with wasteload generated in Sector 8, Poultry and Poultry Products.</p>										

TABLE E-1 (Cont'd)

Industry and Code	Direct, Indirect, Induced Co-efficient	Calculated Output of Cattle in \$'s	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price	Total Purchases and Consumer Effects in units of product	Environmental Effects																									
						BOD (lbs.)	Soap & Chemical BOD (lbs)																								
(Dairy Products, cont'd.)						<table border="1"> <tr> <td>Total Wasteload generated by 112 lbs. of fluid milk; 5 gal. of ice cream and 740 lbs. of condensed milk.</td> <td>Fluid Milk</td> <td>.10</td> <td>.010</td> </tr> <tr> <td></td> <td>Ice Cream</td> <td>.01</td> <td>.002</td> </tr> <tr> <td></td> <td>Condensed Milk</td> <td>3.40</td> <td>.370</td> </tr> <tr> <td></td> <td>Totals:</td> <td>3.51</td> <td>.382</td> </tr> </table>			Total Wasteload generated by 112 lbs. of fluid milk; 5 gal. of ice cream and 740 lbs. of condensed milk.	Fluid Milk	.10	.010		Ice Cream	.01	.002		Condensed Milk	3.40	.370		Totals:	3.51	.382							
Total Wasteload generated by 112 lbs. of fluid milk; 5 gal. of ice cream and 740 lbs. of condensed milk.	Fluid Milk	.10	.010																												
	Ice Cream	.01	.002																												
	Condensed Milk	3.40	.370																												
	Totals:	3.51	.382																												
Grain Mill Products (23)	.064727	\$22,000	1,423.99	.06/lb.	23,733 lb. or 12 tons	<p>A. AIR QUALITY</p> <table border="1"> <thead> <tr> <th rowspan="2">Wasteload per ton processed<sup>22</sup></th> <th colspan="5">GRAIN MILL PRODUCTS</th> </tr> <tr> <th>Particulates (lbs)</th> <th>Hydrocarbons (lbs)</th> <th>Organics (lbs)</th> <th>Nitrogen Oxides (lbs)</th> <th>Sulfur Oxides (lbs)</th> </tr> </thead> <tbody> <tr> <td></td> <td>.6</td> <td>3.0</td> <td>3.6</td> <td>5.0</td> <td>1.4</td> </tr> <tr> <td>Total Wasteload generated by 12 tons.</td> <td>9.6</td> <td>36.0</td> <td>43.2</td> <td>60.0</td> <td>16.8</td> </tr> </tbody> </table>			Wasteload per ton processed <sup>22</sup>	GRAIN MILL PRODUCTS					Particulates (lbs)	Hydrocarbons (lbs)	Organics (lbs)	Nitrogen Oxides (lbs)	Sulfur Oxides (lbs)		.6	3.0	3.6	5.0	1.4	Total Wasteload generated by 12 tons.	9.6	36.0	43.2	60.0	16.8
Wasteload per ton processed <sup>22</sup>	GRAIN MILL PRODUCTS																														
	Particulates (lbs)	Hydrocarbons (lbs)	Organics (lbs)	Nitrogen Oxides (lbs)	Sulfur Oxides (lbs)																										
	.6	3.0	3.6	5.0	1.4																										
Total Wasteload generated by 12 tons.	9.6	36.0	43.2	60.0	16.8																										
Other Food and Kindred Products (24)	.016796	\$22,000	369.51	1.6 <sup>5</sup> /doz. cans <sup>A</sup>	224 doz. cans or 2,688 cans or 112 cases <sup>B</sup> ( $\frac{2,688}{24}$ )	<p>A. WATER QUALITY</p> <table border="1"> <thead> <tr> <th rowspan="2">Plant BOD (lbs)</th> <th rowspan="2">Suspended Solids (lbs)</th> <th rowspan="2">Total Dissolved Solids (lbs)</th> <th colspan="2">OTHER FOOD &amp; KINDRED PRODUCTS</th> </tr> <tr> <th>Wastewater Vol. MGP</th> <th></th> </tr> </thead> <tbody> <tr> <td>Wasteload per case produced<sup>24</sup></td> <td>.7</td> <td>.8</td> <td>.75</td> <td>.000075</td> </tr> <tr> <td>Total Wasteload generated by 112 cases</td> <td>78.4</td> <td>89.6</td> <td>84.0</td> <td>.0084</td> </tr> </tbody> </table>			Plant BOD (lbs)	Suspended Solids (lbs)	Total Dissolved Solids (lbs)	OTHER FOOD & KINDRED PRODUCTS		Wastewater Vol. MGP		Wasteload per case produced <sup>24</sup>	.7	.8	.75	.000075	Total Wasteload generated by 112 cases	78.4	89.6	84.0	.0084						
Plant BOD (lbs)	Suspended Solids (lbs)	Total Dissolved Solids (lbs)	OTHER FOOD & KINDRED PRODUCTS																												
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Total Wasteload generated by 112 cases	78.4	89.6	84.0	.0084																											

A. For detailed calculation, refer to Table A-3.

B. Assuming 24 #303 cans = 1 case of vegetables and 24 #202 cans = 1 case of fruit.<sup>23</sup>

TABLE E-1 (Cont'd)

Industry and Code	Direct, Indirect, Induced Co-efficient	Calculated Output of Cattle in \$'s	Total Purchases and Consumer Effects, in \$'s	Average Wholesale Price	Total Purchases and Consumer Effects in units of product	Environmental Effects				
Industrial Chemicals (28)	.028782	\$22,000	633.20	1,606.86/ton <sup>A</sup>	.4 ton	A. AIR QUALITY				
Agricultural Chemicals (29)	.002033	\$22,000	44.73	52.38/ton <sup>A</sup>	.9 ton					
Other Chemicals (30)	.005464	\$22,000	120.21	260.00/ton <sup>A</sup>	.5 ton					
						INDUSTRIAL, AGRICULTURAL, & OTHER CHEMICALS				
						1.8 tons				
						Wasteload per ton produced <sup>25</sup>				
						Total wasteload generated by 1.8 tons				
						Particulate Matter (lbs)	Saturated Hydrocarbons (lbs)	Organics (lbs)	Nitrogen Oxides (lbs)	Sulfur Oxides (lbs)
						4.7	4.6	7.6	.6	.6
						8.5	8.3	13.7	1.1	1.1
Petroleum & Coal Products (31)	.031722	\$22,000	697.88	.12 gal. <sup>A</sup>	5,816 gal. or 138 bbl. <sup>B</sup>	A. WATER QUALITY				
						PETROLEUM & COAL PRODUCTS				
						Wasteload per barrel produced <sup>27</sup>				
						Total Wasteload generated by 138 bbl.				
						BOD (lbs)	Phenol (lbs)	Sulfide (lbs)	Wastewater	
						.1	.001	.0003	100 gal.	
						13.8	.138	.0414	13,000 gal.	

A. For detailed calculation, refer to Table A-3.

B. 42 gal. of oil = 1 bbl.<sup>26</sup>

TABLE E-1 (Cont'd)

Industry and Code	Direct, Indirect, Induced Co-efficient	Calculated Output of Cattle in \$'s	Total Purchases and Consumer Effect, in \$'s	Average Wholesale Price	Total Purchases and Consumer Effects in units of product	Environmental Effects
-------------------	--	-------------------------------------	--	-------------------------	--	-----------------------

(Petroleum & Coal Products, cont'd.)

B. AIR QUALITY

PETROLEUM & COAL PRODUCTS

Wasteload per Barrel produced <sup>25</sup>	Total Wasteload Generated by 135 bbl.
Hydrocarbons (lbs.) 2.0	276.00
Nitrogen Oxides (lbs.) .05	11.04
Sulfur Dioxide (lbs.) 2.9	400.20
Sulfur Trioxide (lbs.) > .06	8.23
Carbon Monoxide (lbs.) 4.4	607.20
Particulate Matter (lbs.) .28	38.64
Ammonia (lbs.) < .02	2.76
Aldehydes (lbs.) < .02	2.76
Organic Acids (lbs.) < .02	2.76
Aerosols (lbs.) < .02	2.76

Cement & Concrete (33) .000871 \$22,000 19.16 3.34 bbl. 6 bbl.

A. AIR QUALITY

CEMENT & CONCRETE

	Dust	Aldehydes	Nitrogen	Acids	Organic	Sulfur Oxides	Solids
Wasteload per bbl. processed <sup>29</sup>	28.0	.1320	.5280	1.98	1.32	4.62	.13
Total Wasteload generated by 6 bbl.	168.0	.7920	3.1680	11.88	7.92	27.72	.78

TABLE E-1 (Cont'd)

Industry and Code	Direct, Indirect, Induced Co-efficient	Calculated Output of Cattle in \$'s	Total Purchases and Consumer Effect, in \$'s	Average Wholesale Price	Total Purchases and Consumer Effects in units of product	Environmental Effects		
Other Stone & Clay (34)	.002116	\$22,000	46.55	5.43/50 sq. ft.	9 - 50 sq. ft. or 450 sq. ft. or 1.350 lbs. or .7 ton <sup>B</sup>	A. AIR QUALITY		
						OTHER STONE & CLAY--GLASS		
						Particulate Matter	Sulfur Oxides	
						Wasteload per ton processed <sup>32</sup>	21	3.5
						Total wasteload generated by .7 ton.	14.7	2.7
Primary Metals (35)	.000588	\$22,000	12.94	46.02 <sup>A</sup>	.3 tons or .4 ingot tons <sup>C</sup>	A. WATER QUALITY		
						PRIMARY METALS		
						Wasteload per Ingot Ton Processed <sup>33</sup>	Total Wasteload Generated by .4 tons	
						Suspended Solids (lbs.)	125.00	50.00
						Ferric Sulfate (lbs.)	2.72	1.10
						Lube Oils (lbs.)	3.54	1.40
						Sulfuric Acid (lbs.)	13.2	5.30
						Soluble Metals (lbs.)	.079	.03
						Phenols (lbs.)	.064	.03
						Cyanides (lbs.)	.025	.01
						Fluorides (lbs.)	.031	.01
						Ammonia (lbs.)	.075	.03
						Emissions (lbs.)	.414	.17

A. For detailed calculation, refer to Table A-3.

B. To convert 9-50 sq. ft. to tons, first change to number of square feet, or 450, then multiply by 3 lbs.<sup>30</sup>, which equals 1,350 lbs. or .7 tons.

C. To convert gross tons to ingot tons, multiply by 1.311.<sup>31</sup>

TABLE E-1 (Cont'd)

Industry and Code	Direct, Indirect, Induced Co-efficient	Calculated Output of Cattle in \$'s	Total Purchases and Consumer Effect, in \$'s	Average Wholesale Price	Total Purchases and Consumer Effects in units of product	Environmental Effects						
Electric, Gas & Sanitary Service (52)	.034517	\$22,000	759.37	.0103 per KWH	73,725 KWH	1 lb. of coal required per KWH so 73,725 lbs. of coal or 37 tons.						
A. AIR QUALITY												
ELECTRIC, GAS & SANITARY SERVICE												
						Aldehydes	Nitrogen Oxides	Acids	Organics	Solids	Ammonia	Sulfur Oxides
					Wasteload Coal lb./ton <sup>34</sup>	2.0	5.0	30.0	20.0	200.0	2.0	60.0
					Total Wasteload Generated by 37 tons.	74.0	296.0	1,110.0	740.0	7,400.0	74.0	2,220.0
Households	.714726	\$22,000	\$15,723.97	\$2,639 per capita income <sup>35</sup>	6 persons	A. WATER QUALITY						
1. HOUSEHOLD WASTES												
						State of Solids	Mineral (grams)	Organic (grams)	Total (grams)	BOD		
					Wasteload per capita per day <sup>36</sup>	Suspended	25	65	90	42		
						(a) setttable	(15)	(39)	(54)	(19)		
						(b) non-settable	10	(26)	(36)	(23)		
						Dissolved	50	50	160	12		
						Total	105	145	250	54		
					Total Wasteload Generated by 6 persons x 365 days	Suspended	125	325	450	210		
						(a) setttable	(75)	(195)	(270)	(95)		
						(b) non-settable	(50)	(130)	(180)	(115)		
						Dissolved	400	400	500	60		
						Total	525	725	1,250	270		
					454 grams							
					$\frac{2,190}{454} = 5$							

TABLE E-1(Cont'd)

(Households, cont'd.)

2. GARBAGE—SOLID WASTES LBS/DAY<sup>37</sup>

	Urban	Rural
Households and Commercial:	4.01	3.3

Population breakdown in 1960:<sup>38</sup> Urban 69.9% Rural 30.1%

6 people would be: Urban 4.0 Rural 2.0

	lbs/day	day/yr	total lbs.
Urban	4 x 4.01	x 365	= 5,854.6
Rural	2 x 3.30	x 365	= 2,409.0

Total Wasteload generated by

3. AUTOMOBILE EMISSIONS

Kansas cars and taxicabs:  $\frac{1,013,708^{39}}{2,222,178^{40}} = .45 \text{ cars/person}$

6 persons x .45 cars/person = 3 cars.

Automobile Emissions<sup>41</sup>

Type of Emission	Lbs/Car Day	No. of Cars	Days/Yr	Total Lbs/Yr
Carbon Monoxide	4.16	x 3	x 365	= 4,555.2
Nitrogen Oxides	.202	x 3	x 365	= 221.2
Hydrocarbons	.363	x 3	x 365	= 397.5

## FOOTNOTES

- (1) M. Jarvin Emerson, with Leonard D. Atencio, Phillip D. Brooks, and J. David Reed, The Interindustry Structure of the Kansas Economy, Manhattan, Kansas, January, 1969 (Topeka, Kansas: Office of Economic Analysis and Kansas Department of Economic Planning Division, 1969), Appendix C, Kansas Direct, Indirect, and Induced Requirements Matrix.
- (2) Ibid., The Interindustry Structure of the Kansas Economy, Direct, Indirect, and Induced Coefficients Matrix.
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TABLE E-2  
WATER QUALITY  
EFFECTS AFTER RECLAMATION  
IN POUNDS PER YEAR

Industry	Nitro- gen	Phos- phorus	Potas- sium	Sedi- ment Yield	Sus- pended Solids	BOD	Grease	Phe- nol	Sul- fide	Ferric Sulfate	Lube Oils	Sul- furic Acid	Sal- uble Metals	Cya- nide	Fluo- rides	Ammo- nia	Emis- sions
Corn (1)	650	210	3,200														
Sorghum (2)	4,660	1,512	23,040														
Wheat (3)	484	55	1,133														
Other Grains (4)	9	1	21														
Soybeans (5)	65	21	320														
Hay (6)	470	110	1,410														
Other Agricultural Products (11)	176	20	412														
From all the industries above				758,000													
Dairy Products (7)					730												
Poultry & Poultry Products (8)					365												
Cattle (9)	13,870	4,745			460,995	45,990											
Hogs (10)					1,095	365											
Meat Products (21)	2				12	15	6										
Dairy Products (22)						4											
Other Food & Kin- dred Products (24)					174	78											
Petroleum & Coal Products (31)						14		.10	.04								
Primary Metals (35)					50			.03		1	1	5	.03	.01	.01	.03	.17
Households					1,250	270											
					8,265												
	20,406	6,674	29,536	758,000	472,936	46,736	8	.14	.04	1	1	5	.03	.01	.01	.03	.17
																	1.34

TABLE E-3  
 AIR QUALITY  
 EFFECTS AFTER RECLAMATION  
 IN POUNDS PER YEAR

Industry	Parti- culates	Hydro- carbons	Organics	Nitrogen Oxides	Sulfur Oxides	Sulfur Dioxide	Sulfur Trioxide	Carbon Monoxide	Ammonia	Aldehydes	Aerosols	Dust	Acids
Grain Mill Products (23)	10	36	43	60	17								
Industrial, Agricultural & Other Chemicals (28, 29, 30)	9	6	14	1	1								
Petroleum & Coal Products (31)	39	276	3	11		400	8	607	3	3	3		
Cement & Concrete (33)	1		8	3	28					1		168	12
Other Stone & Clay (34)	15				3								
Electric, Gas & Sanitary Service (52)	7,400		740	296					74	74			1,110
Households		398		221				4,555					
	7,474	718	808	592	49	400	8	5,162	77	78	3	168	1,122

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TABLE A-3

COMPUTATION OF AVERAGE PRICES<sup>A</sup>

Industry and Code <sup>2</sup>	Product <sup>2</sup>	Calculation		Average Price		Other Comments
		Dollar Amount	Unit	Dollar Amount	Unit	
Sorghum (2)		1.76	100 lbs.	.935 <sup>3</sup>	bu.	1 bu. sorghum = 56 lb. <sup>4</sup>
Other Grains (4)	Oats	1.720		.711	bu.	
	Barley	2.300		1.130	bu.	
	Rye	2.650		1.184	bu.	or 2.22 per bushel
		<u>6.670</u>		<u>3.025/3</u>		or \$1.01 per bushel.
Hay (6)	Alfalfa	50.000		24.500	ton	
	Timothy	no timothy		28.000	ton	
				<u>52.500/2</u>		26.250 ton
Other Agricultural Products (11)	Sweet potatoes			10.050	100 lbs.	
	Sweet potatoes, Chicago			9.750	100 lbs.	
	Beans, dried			8.750	100 lbs.	
	Clover seed			29.667	100 lbs.	
	Cabbage			4.250	100 lbs.	
	Carrots			7.236	100 lbs.	
	Onions			4.318	100 lbs.	
	Potatoes			6.375	100 lbs.	
				<u>80.396/8</u>		10.050 100 lbs. of grain

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A. Indirect Assumption: Total Sector Output is divided equally among representative products.

✓ SOURCE: U.S. Department of Labor, Wholesale Prices & Indexes for Commodity Groups, Subgroups, Product Classes & Individual Items (Washington, D.C.: U.S. Government Printing Office, 1965), pp. 6-21; unless otherwise indicated

TABLE A-3 (Cont'd)

Industry and Code	Product	Calculation		Average Price		Other Comments
		Dollar Amount	Unit	Dollar Amount	Unit	
Other Agricultural Products, Cont'd.	Good French Combing & Staple	1.325	lb.			
	Short French Combing & Staple	1.175	lb.			
	Good French Combing & Staple	1.295	lb.			
	Average French Combing & Staple	1.125	lb.			
	Good French Combing & Staple	1.275	lb.			
	Good French Combing & Staple	<u>1.175</u>	lb.			
		7.370/6		1.228	lb.	or \$122.833 per 100 lb.
Dairy Products (7)	Milk, Chicago	.265	qt.			
	Milk, San Francisco	.235	qt.			
	Milk, Washington, D.C.	.290	qt.			
	Milk, Dallas	<u>.260</u>	qt.			
		1.050/4		.2625	qt.	or \$.26 per qt.
Poultry & Poultry Products (8)	<u>A. Chickens &amp; Turkeys</u>					
	Broilers & Fryers, Arkansas-Missouri	.131	lb.			
	Broilers & Fryers, North Georgia	.130	lb.			
	Turkeys, Fryers	.220	lb.			
	Turkeys, Toms	<u>.210</u>	lb.			
		.691/4		.1727	lb.	or \$.17 per lb.
	<u>B. EGGS</u>					
	Large, New England	.343	doz.			
	Extra large, Chicago	.273	doz.			
	Fancy Heavy Weights, NY	.320	doz.			
Grade A Large, San Francisco	<u>.400</u>	doz.				
	1.336/4		.334	doz.	or \$.33 per doz.	

TABLE A-3 (Cont'd.)

Industry and Code	Product	Calculation		Average Price		Other Comments	
		Dollar Amount	Unit	Dollar Amount	Unit		
		<i>Dec., 1975</i>					
Cattle (9)	Steers, Prime	25.375	100 lbs.				
	Steers, Choice	45.500 23.875	100 lbs.				
	Steers, Good	41.250 21.750	100 lbs.				
	Steers, Standard	36.750 18.875	100 lbs.				
		<u>123.50.</u> 89.875/4			22.468	100 lbs.	or \$.22 per lb.
Meat Products (21)	Beef, Prime	41.250	100 lbs.				
	Beef, Choice	40.429	100 lbs.				
	Beef, Utility	26.050	100 lbs.				
	Beef, Standard	33.000	100 lbs.				
	Beef, Good	38.643	100 lbs.				
		<u>179.372/5</u>			35.874	100 lbs.	or \$.36 per lb.
	Bacon	49.500	100 lbs.				
	Fatback	11.300	100 lbs.				
	Ham, Smoked	48.300	100 lbs.				
	Picnics, Smoked	28.600	100 lbs.				
	Pork Loins, Fresh	47.000	100 lbs.				
		<u>184.700/5</u>			36.940	100 lbs.	or \$.37 per lb.
Dairy Products (22)	A. Milk			.2625	qt.	previously calculated	
	B. Ice Cream, bulk	1.864	gal.				
	Ice Cream in 1/2 gal.	<u>1.671</u>	gal.				
	3.535/2			1.767	gal.	or \$1.77 per gal.	
Other Food & Kindred Products	Applesauce	1.387	doz. cans				
	Peaches	2.399	doz. cans				
	Beans	1.710	doz. cans				
	Soup	<u>1.120</u>	doz. cans				
		6.616/4			1.654	doz. cans	or \$1.65 per doz. cans
Paper & Allied Products (26)	Book Paper, A Grade	16.770	100 lbs.				
	Book Paper, #2 Plain Offset	17.967	100 lbs.				
	Wood Bond	17.614	100 lbs.				
	Writing Paper	<u>27.685</u>	100 lbs.				
		80.036/4			20.009	100 lbs.	or \$20.01 per 100 lbs. or \$.20 per lb.

TABLE A-3 (Cont'd.)

Industry and Code	Product	Calculation		Average Price		Other Comments	
		Dollar Amount	Unit	Dollar Amount	Unit		
Industrial Chemicals (28) <sup>A</sup>	<b>A. Organic Chemicals</b>						
		High-Dye, Red	6,200.00	ton			
		Low-Coal, tar pitch	- 42.00	ton			
			<u>6,158.00/2 =</u>				
			3,079.00 + 42.00 =				
			3,121.00 per ton				
		<b>B. Inorganic Chemicals</b>					
		High-calcium Carbide	171.400	ton			
		Low-calcium Oxide	- 14.063				
			<u>157.337/2 =</u>				
			78.668 + 14.063 =				
			<u>92.731 ton =</u>				
			3,213.731/2 =				
			1,606.865 ton or				
		\$1,606.86 per ton					
Agricultural Chemicals (29)	Ammonia, Anhydrous	92.00	ton				
	Ammonium Nitrate	70.00	ton				
	Ammonium Sulfate	32.00	ton				
	Nitrogen Solutions	130.00	ton				
	Sodium Nitrate	48.00	ton				
	Urea	96.00	ton				
	Nitrogenous process tankage	27.60	ton				
	Phosphate Rock	7.38	ton				
	Superphosphate	18.60	ton				
	Superphosphate, Triple	45.00	ton				
	Muriate, domestic	24.00	ton				
	Sulfate	38.00	ton				
			<u>628.58/12</u>		52.382 ton	or \$52.38 per ton.	

A. Due to lack of price information and a list of chemicals produced in Kansas, the best price estimate was the median of the range of those prices of industrial chemicals available.

TABLE A-3(Cont'd)

Industry and Code	Product	Calculation		Average Price		Other Comments
		Dollar Amount	Unit	Dollar Amount	Unit	

Other Chemicals (30)	<u>Dynamites</u>					
	Ammonia Gelatine	23.20	100 lbs.			
	Ammonium Nitrate	3.50	100 lbs.			
		<u>26.70/2</u>		13.35	100 lbs.	or \$.13 per lb.

Petroleum & Coal Products (31)	Gasoline, Tulsa 91-92, Octane Regular	.1130	gal.				
	Light Distillate, Tulsa, Kerosene	.1040	gal.				
	Middle Distillate, Tulsa #2	.0900	gal.				
	Residual Fuels, Tulsa #6, Ordinary	.0428	gal.				
	Lubricating Oil Materials, Neutral, Tulsa	.2400	gal.				
		<u>.5898/5</u>			.118	gal.	or \$.12 per gal.

Primary Metals (35)	Iron Ore, Mesabi, Bessemer	10.700	gross ton			
	Iron Ore, Non-Bessemer	10.550	gross ton			
	Iron Ore, Brazilian	10.400	gross ton			
	Steel #1, Heavy Melting	36.614	gross ton			
	Steel #2, Heavy Melting	30.563	gross ton			
	Steel Scrap #2, Bundle	23.602	gross ton			
	Steel, Melting, R.R. #1	41.810	gross ton			
	Steel Scrap #1, Bundles	39.310	gross ton			
	Steel, Stainless, Bundles	210.665	gross ton			
		<u>414.214/9</u>			46.024	gross ton

18.50  
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Ag. Stat. 1975  
 U.S. Dept. of Ag-  
 A 147 : 975

TABLE A-4

## REPRESENTATIVE AVERAGE CROP YIELDS

Industry	Representative Crops	Average Yields in Bushels/Acre			Representative Yield in Bushels/Acre (Col. 3 Total/the number of crops, 3)
		'65	'70	'74	
Other Grains (4)	Oats	50.2	50.2	49.2	46.6
	Barley	37.8 <sup>1</sup>	42.9	42.8	37.2
	Rye	22.6	22.6	25.8	21.5
		110.6/3			36.9 or 37

  

Industry	Representative Crops	Average Yields in Cwt <sup>A</sup> /Acre			Representative Yield in cwt/Acre (Col. 3 Total/the number of crops, 5)
		'65	'70	'74	
Other Agricultural Products (11)	Potatoes	210	229	246	210.0 <sup>2</sup>
	Cabbage				201.0 <sup>2</sup> — 199
	Beans, dry edible				11.1 <sup>3</sup> — 109
	Carrots				220.0 <sup>4</sup> — 219
	Onions				289.0 <sup>5</sup> — 289
				931.1/5	186.2 or 186

<sup>1</sup>Reader's Digest Association, Reader's Digest, Almanac and Yearbook, 1971 (Pleasantville: Reader's Digest Association, Inc., 1971), p. 175.

<sup>2</sup>U.S. Department of Agriculture, Agricultural Statistics, 1970 (Washington, D.C.: Government Printing Office, 1971), p. 166.

<sup>3</sup>Ibid., Agricultural Statistics, 1970, p. 284.

<sup>4</sup>Ibid., Agricultural Statistics, 1970, p. 168.

<sup>5</sup>Ibid., Agricultural Statistics, 1970, p. 180.

<sup>A</sup>cwt = Hundred weight, or 100 lbs.