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FOSSIL ENERGY

Impacts of Proposed RCRA Regulations and Other Related Federal Environmental Regulations on Fossil Fuel-Fired Facilities

Final Report, Volume I

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Work Performed Under Contract No.: DE-AC21-79ET13543

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Engineering-Science
Atlanta, Georgia

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NOTES ON REPORT ARRANGEMENT

Sections are numbered with Arabic numerals, with hyphenated Arabic numerals used for page numbering within sections (1-1, 1-2, 1-3...).

Figures are numbered with Arabic numerals which designate the Section and with Arabic numerals following a decimal point which designate the sequence within the section. (Figure 1.1, Figure 1.2, Figure 1.3...). Figures are assembled at the end of each section.

Tables are numbered using the same system as used for Figures. Tables are assembled behind the figures at the end of each section.

References are numbered with an "R" preceding an Arabic numeral designating the section and a decimal point followed by arabic numerals identifying the references [(R1.1), (R1.2), (R1.3)...]. References are noted throughout the text and are listed following the tables at the end of each section.

Appendices are designated by alphabetical order and assembled together at the end of the report and numbered with the appendix character followed by a hyphenated Arabic numeral (A-1, A-2, A-3...), UNLESS NOTED OTHERWISE.

REPORT ABBREVIATIONS

ANOVA	Analysis of variance
Btu	British thermal units
CAA	Clean Air Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
DOE	Department of Energy
EEI	Edison Electric Institute
EIA	Energy Information Administration
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ES	Engineering-Science
ESP	Electrostatic precipitators
FERC	Federal Energy Regulatory Commission
FGD	Flue gas desulfurization
FPC	Federal Power Commission
FWPCA	Federal Water Pollution Control Act
LFDESIGN	Design and costing program developed by ES
LTP	Leachate treatment plants
MSRC	Marine Sciences Research Center
MW	Megawatts
NAAQS	National Ambient Air Quality Standards
NH/CP	Non-hazardous/current practice
NPDES	National Pollutant Discharge Elimination System
NSPS	New Source Performance Standards
O&M	Operations and maintenance
OMB	Office of Management and Budget
OSM	Office of Surface Mining Reclamation and Enforcement
PCB	Polychlorinated Biphenyl
ppm	parts per million
PSD	Prevent Significant Deterioration
RACT	Reasonably Available Control Technology
RCRA	Resource Convervation and Recovery Act
SAS	Statistical Analysis System #79.6 (SAS Institute)
SDWA	Safe Drinking Water Act
SIP	State Implementation Plant
SMCRA	Surface Mining Control and Reclamation Act
TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
QTO	Quantity Take-offs
UDI	Utility Data Institute
UIC	Underground Injection Control
USWAG	Utility Solid Waste Activities Group
1980$	Cost expressed in 1980 dollars

EXECUTIVE SUMMARY

INTRODUCTION

One of the principal responsibilities of the U.S. Department of Energy is the encouragement of the use of coal as a principal fuel (in lieu of gas or oil) by the utility and industrial sectors of the U.S. economy. Combustion residues from coal-fired facilities (i.e., fly ash, bottom ash, boiler slag, and flue gas desulfurization (FGD) sludge) are currently exempted from the Resource Conservation and Recovery Act (RCRA), which requires EPA to promulgate regulations for the disposal of hazardous and non-hazardous wastes. This exemption for combustion residues is pending subject to further study by EPA as to their hazard, and the costs and benefits associated with their control.

In order to fulfill its responsibilities, DOE contracted with Engineering-Science to perform a multi-phase engineering and economics study to evaluate the impact of the proposed RCRA regulations and other related Federal environmental regulations on coal-fired utilities. This Interim Phase I report presents the findings of the impacts of proposed RCRA and related federal regulations on the utility sector fossil fuel-fired facilities. Subsequent phases involve parallel engineering studies on the industrial sector as well as economic evaluations.

The framework of this study was based on the development and analysis (engineering and economic) of four regulatory scenarios for the disposal of fly ash, bottom ash and FGD sludge from the utility industry:

1. As a baseline situation, the utility industry would continue current waste disposal practices.
2. The disposal of residues would be regulated as non-hazardous wastes under RCRA.
3. The disposal of residues would be regulated as hazardous wastes under RCRA reflecting a minimum probable cost of compliance.

4. The disposal of residues would be regulated as a hazardous waste under RCRA reflecting a maximum probable cost of compliance.

Compliance requirements for each of the four regulatory scenarios were developed for each of the 23 case study plants. These plants were selected in order to be representative of the 396 coal-fired plants existing in 1980. The information developed for these 23 case studies was then used to develop four cost models. The cost models were used to compute current practice, non-hazardous, hazardous minimum and hazardous maximum costs for the 396 coal-fired utility plants located throughout the country.

The regulatory basis, case study plant selection, design assumptions, case study waste disposal cost estimates, and 1980 national and regional costs are the major areas of this study which are highlighted below.

REGULATORY BASIS

The non-hazardous RCRA regulations considered in this project were in accordance with 40 CFR Parts 241 (dated March 26, 1979) and 257 (dated September 13, 1979). Hazardous RCRA regulations considered were in accordance with 40 CFR Parts 260 through 264 (including revisions through July 26, 1982).

The non-hazardous regulations are in the form of guidelines that do not explicitly require the utility industry to modify its current waste disposal practices. These guidelines, however, tend to normalize the technical design and operating conditions imposed on those disposing of non-hazardous wastes. Section 4 presents the specific design and operating practices, which are considered to be reasonable interpretations of the non-hazardous regulations.

Unlike the non-hazardous regulations, which merely provide guidelines to be used by the various state agencies, the hazardous waste regulations specify more definitive requirements for generators, transporters, owners and operators of hazardous waste treatment, storage and disposal facilities. However, EPA still included provisions for latitude in terms of how the regulations are implemented.

Because no coal combustion waste management systems have ever been permitted under the RCRA hazardous waste regulations, specific requirements for compliance are a matter of speculation. For the purposes of this study, Engineering-Science has established a range of criteria from the least probable cost of compliance to the maximum probable cost of compliance. The assumptions used to develop this compliance range are described in Section 4 of this report.

The requirements of the Clean Air Act, Clean Water Act and other pertinent legislation were also included in the engineering analysis in order to determine their impacts on coal combustion waste disposal. The Clean Air Act requires coal-fired power plants to install scrubbers for flue gas desulfurization, greatly increasing the quantities of solid waste produced for each megawatt of electricity generated. Potential changes to the Clean Air Act, in response to such issues as acid rain, may increase scrubber sludge production even more. The Clean Air Act thus has a direct impact on waste disposal costs regardless of whether or not coal combustion wastes are defined as hazardous. Costs will be even higher if these wastes are disposed of in accordance with the RCRA hazardous waste regulations.

Under the Clean Water Act, any leachate collected from a surface impoundment or a hazardous landfill would require treatment before discharge if coal combusion wastes were classified as hazardous. This would result in increased costs for (1) design, construction, and operation of a leachate treatment plant and (2) increased volumes of sludge requiring disposal. If coal combustion wastes were classified as non-hazardous the facilities will not be required, nullifying the potential impacts of the Clean Water Act on non-hazardous waste disposal.

Other federal regulations which were examined included the Safe Drinking Water Act, the Surface Mining and Reclamation Act, the Toxic Substances Control Act, the Marine Protection Research and Sanctuaries Act, and the Consolidated Permit Program. No significant impacts which would effect the national cost estimates for the disposal of utility coal combustion waste were identified with these latter regulations.

It is important to note that it was beyond the purpose and scope of the study to make any determination as to whether combustion residues should be considered non-hazardous or hazardous.

CASE STUDY PLANT SELECTION

In order to provide a reasonable estimate of utility waste disposal costs, it was necessary to choose a nationally representative group of plants from among the total population of 396 coal-fired utility plants greater than 25 megawatts in size. The selection of these case studies was, therefore, a critical element of the overall project. A Utility Advisory Task Force was established to assist in the final selection of case study sites and to provide technical input to the DOE and Engineering-Science during the execution of the study. This task force consisted of knowledgeable individuals from DOE, utility trade associations, major utility companies and other individuals with specialized expertise in the disposal of coal combustion wastes.

To obtain adequate representation of the utility industry as a whole, plants were selected to represent the entire range of operating factors including plant generating capacity, source and type of coal, existing waste disposal practices, use of FGD sludge stabilization, and land availability.

After careful screening, 23 case study sites were selected for further study. The case study sites were contacted and subsequently visited by Engineering-Science personnel in order to collect engineering information on current practice and identify potential hazardous and non-hazardous waste disposal sites. Details on the characteristics of the 23 plants are presented in Section 3 of this report. A comparison of the case study plants with those of the utility industry as a whole is presented below:

Parameter	Case Study Range	Industry Range
Number of Units Per Plant	1-6	1-10
Generating Capacity (MW)	185-3160	25-3280
First Unit on Line (Year)	1937-1982**	1924-1980
First Unit on Line (Year)	1958-1982**	1938-1980
Ash Percentage of Coal	4.8-25	3.11-25
Ash Waste Generated (10^3 Tons)	32-1330	0.3-2109
FGD Sludge Generated (10^3 Tons)*	14.3-597	0.03-1084
Total Waste Generated (10^3 Tons)	32-1869	0.3-2186
On-site Disposal (10^3 Tons)*	0.2-1642	0.03-2099
Off-site Disposal (103 Tons)*	21-91	0.9-1579
Ash-Sold (10^3 Tons)*	5.8-318	0.06-626

* Only plants with values greater than zero were considered.
**Case Study Plant 51 was brought on-line in 1982.

WASTE DISPOSAL COST ESTIMATES

After completion of the 23 case study site visits, cost estimates were prepared for the disposal of coal combustion residues. Capital costs and operation and maintenance (O&M) costs were estimated for each of the 23 case study sites. A total of four cost estimates were prepared for each of the 23 plants, based on the following regulatory situations:

1. Continuation of current waste disposal practices (a baseline case),
2. Non-hazardous waste disposal, as specified in 40 CFR Parts 241 and 257,
3. Hazardous waste disposal, as specified in 40 CFR Parts 260 through 264, consisting of designs which required the least probable cost of compliance, and
4. Hazardous waste disposal as specified in 40 CFR Parts 260 through 264, consisting of designs which required the maximum probable cost of compliance.

Design Assumptions

Site-specific preliminary engineering studies were prepared for each of the 23 case study sites and returned to the utilities for review and comment. The following general design assumptions were established and applied to current practice, non-hazardous, hazardous minimum, and the hazardous maximum regulatory scenarios developed for the 23 case studies:

- All the designs - current practice, non-hazardous, and hazardous minimum and maximum, should be based on a 35-year design life for the waste disposal facilities.
- The costs of converting existing wet ash and FGD sludge handling to dry handling would be incorporated into all the 23 designs if it could be shown to be cost effective over the design life of the disposal facilities.

- All designs would include capital and operating costs for handling the ash downstream of the plant's storage silos, but not the costs of the silos themselves.
- The EPRI Manual entitled, "Technical Assessment Guide" would be used for all economic analyses since the levelizing techniques are known throughout the industry.

To quantify current practice costs, the preparation of engineering designs were required that were based on the existing conditions and waste disposal practices encountered at each case study site. However, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices were defined as the present methods for handling and disposal of flyash, bottom ash and FGD sludge, as determined during the site visit. The "existing practice" information gathered during the visit was then modified to develop a "current practice" design which would be standardized to meet the following design conditions:

- all waste disposal facilities would have a 35-year design life
- wet ash or FGD sludge handling facilities would be converted to dry handling if shown to be cost effective
- closure costs for impoundments and landfills would include a 12-inch layer of topsoil and a vegetative cover.

The following requirements were selected as reasonable guidelines for non-hazardous design criteria to establish non-hazardous scenario cost estimates:

- Ground-water observation wells located around the periphery of "current" waste disposal sites would be required by 1985.
- A clay or membrane liner and cap would be required on any new ash or FGD disposal facility.
- Liners would not be required in existing permitted ash disposal facilities over their design life; however, a clay cap would be required during closure to minimize future leachate generation.

- Leachate detection would not be required for lined ash or FGD sludge disposal facilities.
- Ground-water observation wells would be required on all newly constructed ash and FGD sludge disposal facilities.

EPA guidance documents were used to establish the design requirements for disposing of coal combustion residues as hazardous wastes. To address the latitude for interpretation of the hazardous waste regulations, two designs were identified to cover a probable range of compliance--hazardous minimum and hazardous maximum. The following is a listing of the major assumptions for each design estimate:

Design Factor	Hazardous Minimum	Hazardous Maximum
Closure of existing disposal facility	Same closure requirements as specified under the non-hazardous scenario.	Same closure requirements as specified in the EPA guidance documents.
Liner System	Single liner system as specified in the EPA guidance documents.	Double liner system system as specified in the EPA guidance documents.

Other general design assumptions which applied to the hazardous minimum and hazardous maximum cases are as follows:

- Hazardous landfill designs would have a cell life of not greater than five years.
- Leachate treatment would be provided on-site to collect and treat leachate generated at the land disposal units.
- Miscellaneous wastes such as coal pile runoff and boiler cleaning waste would be used for ash conditioning, bottom ash make-up water or other uses whenever practical.

For the purpose of this study, it was also assumed that no flyash, bottom ash or FGD sludge would be sold in the future if these wastes were declared hazardous by EPA. The rationale for this assumption was that the revenue received from the sale of these wastes would not offset the potential liability (whether actual or implied).

Case Study Costs

For the 23 case studies, the current practice levelized unit costs varied from $3.15/ton (dry weight basis) for Plant 10 to $14.35/ton for Plant 2. These wide differences in current practice costs were a function of many factors, the most important of which were (1) existing design life of the facilities and (2) distances required for off-site disposal. The median current practice levelized unit disposal cost was $6.46/ton for Plant 6 which was equivalent to a levelized revenue of $5.4 million per year for waste disposal. Total revenue requirements varied between $14,000/year (Plant 4) and $14.3 million/year (Plant 22).

The non-hazardous levelized unit costs varied from $4.18/ton (dry weight basis) for Plant 9 to $25.36/ton for Plant 4. The median non-hazardous levelized unit disposal cost was $8.01/ton for Plant 5, which is equivalent to a levelized revenue requirement of $7.1 million per year for waste disposal. Total levelized revenue requirements varied between $61,000/year (Plant 4) and $15.6 million/year (Plant 22).

As described previously, costs for hazardous waste disposal were developed as a range based on the probable minimum and maximum costs of disposal. For the hazardous minimum design, Plant 51 had the lowest unit disposal cost, $10.26/ton (dry weight basis), while Plant 8 had the highest unit cost, $54.23/ton. For the hazardous maximum condition, Plants 8 and 51 also had the highest and lowest unit disposal costs. Unit costs were $11.71/ton (Plant 51) and $71.32/ton (Plant 8).

For current practice disposal, almost all the costs are associated with operation and maintenance expenses. As the design criteria become more stringent (i.e., going from current practice to hazardous maximum), the costs become more capital intensive. Increasing capital requirements and their financial impact on the utility industry will be addressed in the final Phase I Utility Report. A careful review of the cost data for the 23 plants indicate the following conclusions:

1. Landfill disposal facilities are less capital intensive than surface impoundments.

2. The majority of the costs for dry disposal using current practice and non-hazardous criteria are for ash handling and the land disposal operation.
3. Ash handling represents the largest cost component for wet disposal using current practice and non-hazardous criteria.
4. The majority of the costs for hazardous disposal are for earthwork, the liner system, and ash handling.

One of the major findings of this Phase I Interim Report was that unit disposal costs could be significantly affected by economies of scale, i.e., larger plants had lower per ton disposal costs than smaller ones. The trend for low unit disposal costs with increasing plant size is best defined in the case of hazardous disposal because the hazardous designs followed a fairly rigid format specified in the EPA Guidance Documents. The current practice and non-hazardous designs were more site-specific.

NATIONAL AND REGIONAL 1980 COSTS

The methodology used to develop national disposal costs for the national population of 396 coal-fired power plants with capacities greater than 25 megawatts, was to generate four mathematical models (one for each regulatory scenario, e.g., current practice, etc.) using a regression analysis. The model variables were based on waste quantity and disposal cost data from the 23 case study plants. Several model equations were evaluated for goodness of fit. The power curve format ($y=ax^b$) was selected. This selection was based on this model having the highest coefficient of determination (r^2) value. The selected models had r^2 values between 0.90 to 0.96, indicating an excellent fit of the data.

Thereafter, the models were evaluated using statistical techniques (analysis of variance, residual analysis and outlier analysis) to substantiate the fact that the variables selected for the models accounted for the majority of the observed variability and that none of the individual case studies exerted an undue influence on the models. The specifics of the above methodology are presented in Section 5.

The national costs associated with the four regulatory scenarios are as follows (expressed in constant 1980 dollars):

Regulatory Design	Annual Levelized Revenue ($/year x 10^6)	($/ton)	Total Present Worth ($ x 10^6)
Current Practice	418	6.38	9,370
Non-Hazardous	596	9.03	11,000
Hazardous Minimum	1,540	20.53	30,100
Hazardous Maximum	1,870	24.93	34,600

For this study, disposal costs have been presented as annual levelized revenue and total present worth. The annual levelized cost represents the cost for each plant to continue to produce waste for the next 35 years at an average rate equivalent to their 1980 waste generation rate. A real discount rate of 2.3% per year over the 35-year waste disposal facility design period was used for the present worth and levelization cost analysis.

Implementation of the non-hazardous regulations on the coal-fired utility industry will result in a national cost increase for waste disposal of approximately 17% compared to the current disposal practices. Compliance with RCRA hazardous disposal regulations would represent a 220 to 270 percent increase over current practice disposal costs on a national basis. Based on 1980 data, the regions incurring the greatest impact on disposal costs are FERC Regions 3 (East North Central) and 5 (South Atlantic). Regions 1 (New England) and 9 (Pacific) are minimally affected because of the small amount of coal burned in those regions.

Impacts of Other Federal Regulations

Two cost elements of concern were the FGD sludge disposal costs and the leachate treatment plants required by other federal regulations (Clean Air Act and Clean Water Act, respectively). For the 6 million tons of sludge generated in 1980, the levelized annual revenue requirements are approximately $61 and $69 million per year for the current practice and non-hazardous scenarios, respectively. Hazardous minimum and hazardous maximum levelized revenue for FGD disposal is $225 and $309 million per year for the 1980 sludge quantities. Disposal cost for

the hazardous maximum scenario is over 5 times higher than current practice disposal costs.

For the current practice and non-hazardous scenarios, leachate treatment plants are not required, therefore, no costs are incurred. For the year 1980, the total levelized annual revenue requirements for leachate treatment is $125 million for each of the hazardous regulatory scenarios. Based on this analysis, leachate treatment costs account for 6.6 to 8.1 percent of the total hazardous waste disposal costs for the year 1980, for the hazardous minimum and hazardous maximum scenarios, respectively.

FINAL PHASE 1 UTILITY REPORT

This Interim Phase I Utility Report documents the regulatory rationale, design assumptions, and cost information used to develop the cost impacts of RCRA on utility fossil fuel fired facilities. The Final Phase 1 Utility Report will explore the financial impacts these previously reported costs will have on the utility industry. Issues to be addressed in the final report are as follows:

- what are the impacts of RCRA costs on national and regional coal usage?
- how will RCRA impact current and future electrical costs?
- identify overall consumer impacts as a result of RCRA costs increasing electrical costs and reducing disposable income.

The Final Phase 1 Utility Report is scheduled to be published in late 1987.

SECTION 1

INTRODUCTION

PROJECT OBJECTIVES

The overall objectives of this project were to provide an analysis and assessment of the implementation of RCRA regulations and other significant Federal/environmental regulations as they pertain to the utility and industrial sector fossil fuel-fired facilities. Considerations of this assessment include (1) the range of potential impacts on utility and industrial sector fossil fuel-fired facilities and (2) implications to DOE programmatic objectives of encouraging greater utilization of coal.

The project is being conducted as a four-phase effort. This report summarizes the results of the Phase I study, and contains an analysis of engineering and related impacts and an evaluation of associated waste disposal costs resulting from RCRA implementation for utility fossil fuel-fired electric generating facilities. Phase II is a similar assessment for emerging fossil technologies and Phase III is a parallel assessment for industrial coal-fired facilities. Phase IV represents an evaluation of the overall impacts on the utility and industrial sectors (Phases I and III) including financial and consumer impacts, and the effects on national coal use.

The specific objectives of Phase I were as follows:

1. Development of detailed engineering and cost data on utilities through performance of site studies at a total of 23 power plants encompassing a wide and representative range of operating conditions.
2. Estimation of national costs of coal-fired utility waste management/disposal under RCRA regulations based on a comprehensive engineering cost development effort.

3. Assessment of the costs associated with other related Federal/environmental regulations.
4. Consideration of the potential for waste treatment, resource recovery and/or utilization as possible methods of ameliorating disposal costs.

These objectives were addressed by defining and evaluating in detail the following possible regulatory scenarios:

1. Current Practice - a baseline case incorporating the waste disposal practices currently in effect at each of the 23 utility sites visited.
2. Non-hazardous Disposal - the costs to conform to RCRA guidelines for disposing of utility solid wastes as non-hazardous wastes.
3. Hazardous Disposal - the costs to conform to RCRA requirements for disposing of utility solid wastes as hazardous wastes. These costs are presented as a range from the probable least cost of compliance (hazardous-minimum scenario) to the probable maximum cost of compliance (hazardous-maximum scenario), depending upon interpretation of the regulations for a given site.

BACKGROUND

In 1976, the 94th Congress passed the Resource Conservation and Recovery Act (RCRA, PL 94-580) which required the U.S. Environmental Protection Agency (EPA) to promulgate regulations for the control of hazardous and non-hazardous wastes. Hazardous wastes were of more critical concern to Congress and therefore regulations concerning these wastes were published first in 1978.

Hazardous Waste Regulations

Proposed regulations for implementing Sections 3001, 3002, and 3004 of RCRA Subtitle C (hazardous wastes) were first published in the Federal Register on 18 December 1978 (R1.1). In general, the proposed regulations covered classification, transport, storage, and disposal of hazardous wastes. According to those regulations, wastes generated from utility coal combustion would be classified as "special wastes" under Section 3001. These "special wastes" were to be exempt from some of the

treatment and disposal standards (Section 250.45) under Section 3004 until final disposal standards for these wastes could be developed.

Non-hazardous Waste Regulations

Regulations and guidelines for implementing Section 4004 of RCRA Subtitle D (non-hazardous wastes) were published in the Federal Register on March 26, 1979 (R1.2) and September 13, 1979 (R1.3). These regulations provided criteria for use by the states in determining whether a disposal facility should be classified as a non-hazardous landfill or a dump. Guidelines for the design and operation of non-hazardous disposal facilities were also provided in the regulations.

Initial Study by Engineering-Science

In January 1979, the U.S. Department of Energy (DOE) contracted with Engineering-Science, Inc. (ES) to evaluate the impacts of the proposed RCRA regulations (and other related Federal environmental regulations) on utility and industrial sector fossil fuel-fired facilities. This study was undertaken to enable the DOE to assess the potential impacts of these regulations on the Department's goal of reducing oil and gas consumption by the increased use of coal. An interim report was published in November 1979 summarizing the preliminary results of this study (R1.4). The interim report concluded that (1) waste disposal costs would increase substantially if the non-hazardous waste disposal regulations were enforced as proposed and (2) even greater costs would result if coal combustion wastes were classified as hazardous under RCRA.

Temporary Coal Combustion Waste Exemption

On May 19, 1980, EPA temporarily exempted coal combustion wastes (fly ash, bottom ash, flue gas desulfurization wastes) from classification as a hazardous waste (R1.5). In addition, the Solid Waste Disposal Act Amendments of 1980 enacted by PL 96-482 on October 21, 1980 specifically required EPA to:

> "conduct a detailed and comprehensive study and submit a report on the adverse effects on human health and the environment, if any, of the disposal and utilization fly ash waste, bottom ash waste, slag waste, flue gas emission control waste, and other byproduct materials generated primarily from the combustion of coal or other fossil fuels. Such study shall include an analysis of--
>
> (1) the source and volumes of such material generated per year;

(2) present disposal and utilization practices;
(3) potential danger, if any, to human health and the environment from the disposal and reuse of such materials;
(4) documented cases in which danger to human health or the environment from surface runoff or leachate has been proved;
(5) alternatives to current disposal methods;
(6) the costs of such alternatives;
(7) the impact of those alternatives on the use of coal and other natural resources; and
(8) the current and potential utilization of such materials.

In furtherance of this study, the Administrator shall, as he deems appropriate, review studies and other actions of other Federal and State agencies concerning such material and invite participation by other concerned parties, including industry and other Federal and State agencies, with a view toward avoiding duplication of effort."

The EPA study, "Characterization and Environmental Evaluation of Full Scale Utility Waste Disposal Sites" conducted by Arthur D. Little, Inc., required among other things the collection of ground-water data in the vicinity of existing coal combustion waste disposal areas and an assessment as to the degree of danger to public health or the environment from the disposal of utility coal combustion wastes. A draft of the report was released by EPA for comment in March, 1984 (R1.6).

The temporary coal combustion waste exemption did not completely relieve the utilities from being regulated under RCRA Subtitle C, since the utility industry still had a large number of low volume wastes that were disposed of in impoundments, e.g., spent boiler cleaning solutions, cooling tower blowdown, pyrites and demineralizer regenerant. These wastes would have to be tested to determine whether they exhibited any hazardous characteristics on a case-by-case basis. The Utility Solid Waste Activities Group (USWAG, an informal consortium of 65 electric utility operating companies formed to coordinate responses to EPA on RCRA) formally requested that EPA address the extent of the exemption in 1980.

In January, 1981, Gary N. Dietrich (then EPA Deputy Assistant Administrator, Office of Solid Waste) wrote a letter to USWAG indicating that boiler cleaning solutions, boiler blowdown, demineralizer regenerants, pyrites, and cooling tower blowdown would be deferred from regulation

under the hazardous waste provisions of RCRA subject to EPA's final determination of the status of all high volume exempted wastes.

Continuation of Engineering-Science Study

In response to the above actions, the DOE decided to continue its previous investigation in order to ascertain the range and types of potential impacts as well as the incremental costs associated with RCRA and other Federal/environmental regulations as compared to current practice in the utility industry. The remainder of this section describes the objectives, scope and approach used by Engineering-Science to conduct this project.

PROJECT SCOPE

The scope of the overall project is illustrated by a task precedence diagram in Figure 1.1. This report presents the results of the tasks shown for Phase I. A brief description of these tasks is presented in the following paragraphs.

State and Regional Background Data

The purpose of this task was to develop a credible data base on the utility owned coal-fired power plants with a generating capacity of at least 25 megawatts (MW). This data base was obtained from published sources, personal contacts, private data bases and a survey form distributed and compiled by the Utility Data Institute. Data compiled included generating capacity, coal type, facility physical characteristics, regulatory considerations, and other relevant engineering data. Information from this task has been published as part of a separate report entitled "Background Data on Utility Sector Fossil Fuel-Fired Facilities" (R1.7).

Case Studies

A total of 24 power plants were selected as being representative of all 396 utility-owned coal-fired power plants in the U.S. with a capacity greater than 25 MW. Twenty-three case study sites were visited by Engineering-Science personnel in order to collect engineering information on current utility waste disposal practices. Possible future waste disposal sites were also identified. Scheduling problems precluded visiting the last utility site. Summaries were prepared following each site visit and sent to the utility for verification. Documentation of

the selection of the case study plants is presented in Section 3 of this report. The actual case studies are presented in Appendix H of this report (see Volumes 2 and 3).

Case Study Disposal Costs

Capital costs and operation and maintenance (O&M) costs were estimated for each of the 23 power plants included in the case study evaluation. A total of four cost estimates were prepared for each plant, based on the following scenarios:

1. Current waste disposal practices
2. Non-hazardous waste disposal, as specified in RCRA Sections 4004 and 1008
3. Hazardous waste disposal, as specified in RCRA Section 3004, consisting of designs corresponding to;
   a. probable least cost of compliance
   b. probable maximum cost of compliance.

Case study disposal costs are presented in Setion 4 of this report.

The potential costs of related Federal/environmental regulations (e.g., Clean Air Act, Clean Water Act, etc.), were also reviewed for each case study to determine how these regulations might affect waste management/disposal at that site. The impact of each pertinent regulation on waste disposal was assessed and, where possible, quantified in terms of total costs for each case study plant site. Examples of such impacts included (1) the required disposal of sludge generated by air pollution control equipment, (2) the requirements for treating leachate for compliance with an NPDES permit, and (3) the required disposal of sludges generated by leachate treatment facilities.

Potential Modifications to Current Practice

One of RCRA's major objectives is to encourage the use of resource conservation and recovery as an alternative to conventional waste disposal. This task included an assessment of potential modifications to current waste handling practices that could result, either directly or

indirectly, from implementation of RCRA regulations. The modifications considered included:

- coal cleaning prior to combustion
- combustion modification
- waste treatment
- waste utilization
- recovery of resources from coal combustion wastes.

Information from this task has been published in a separate topical report entitled "Process Modifications and Waste Management Practices Affecting Disposal, Utilization, and Recovery of Coal Combustion Wastes." (R1.8).

National Costs

The waste disposal costs estimated for the 23 case study sites were compiled into a series of cost models using a regression analysis. These models were then applied to all 396 existing coal-fired plants to determine waste disposal costs for each Federal Energy Regulatory Commission (FERC) region and for the nation as a whole. Section 5 of this report presents these national waste disposal costs.

PROJECT APPROACH

The key elements of the technical approach used in this project were as follows:

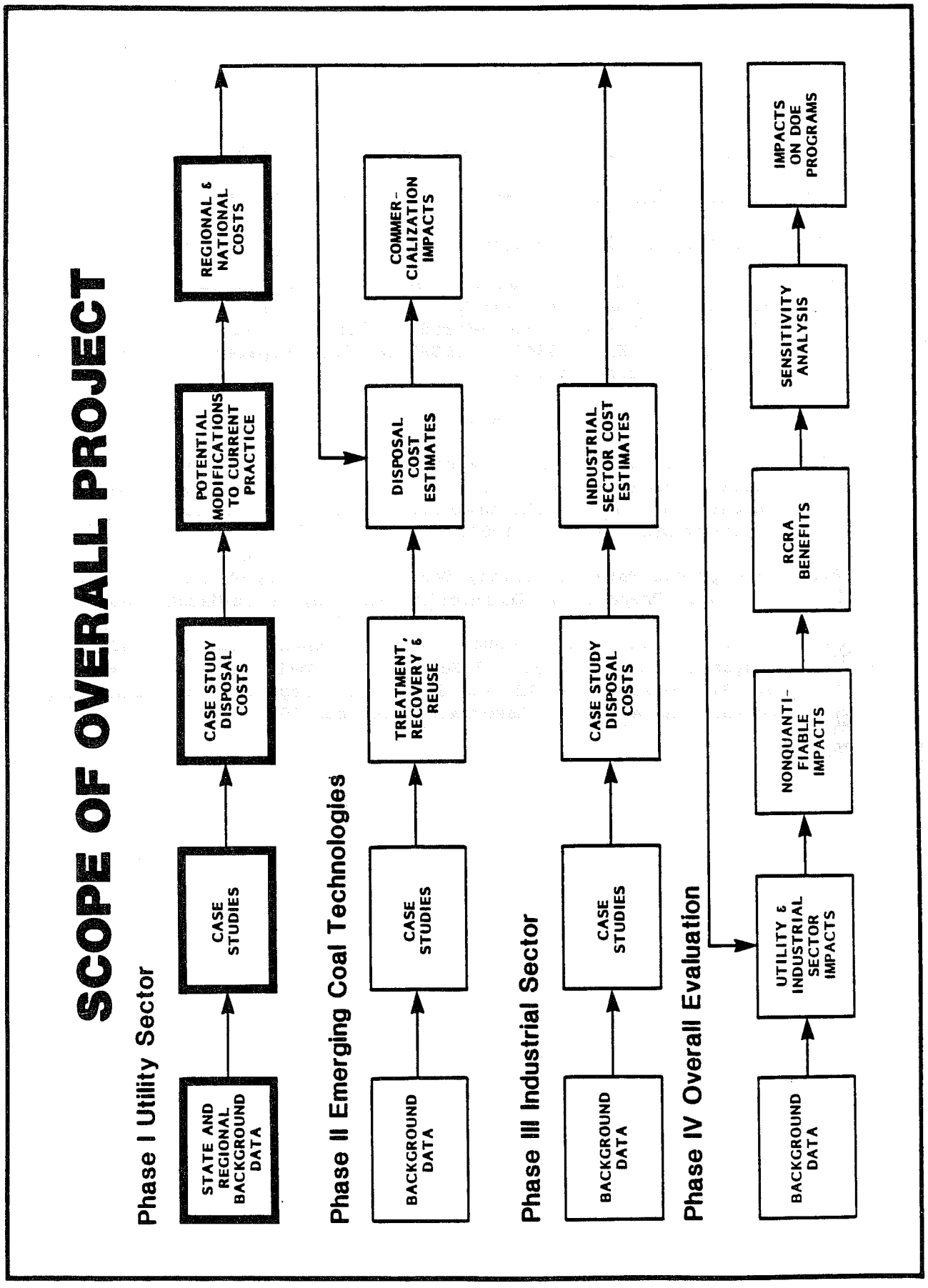
- selection of a case study sample (23 plants) which would be representative of the national 396 plant population over 25 megawatts in size.
- preparation of individualized designs and corresponding cost estimates for each case study plant site.
- development of case study RCRA cost models (using regression analysis) which would then be applied to the total population of plants in order to compile national regulatory impacts.
- use of statistical analysis to validate the representativeness of the above RCRA cost models.

For this project, Engineering-Science assumed the role of a design engineer retained by each of the 23 utilities to estimate the engineering requirements and associated costs that might be required under each regulatory scenario considered (i.e., current practice, non-hazardous, hazardous minimum and hazardous maximum). A preliminary design was prepared for each scenario based upon engineering information obtained during the individual 23 site visits. Quantity take-offs were made for such items as earthwork, paving, synthetic liners, etc. and were multiplied by local unit costs to determine the total cost of each item. Empirically derived values were used for capital cost items whose quantities could not be readily calculated. These included wet to dry conversion costs for fly ash, bottom ash and FGD sludge.

Operation and maintenance costs included manpower, utilities, waste hauling, etc. In short, the project approach was the same as that traditionally used by utilities and other industries for preparing a preliminary design level cost estimate. The accuracy of this estimating approach is generally considered to be within approximately 25 percent of the true cost for a given site.

Another important assumption that was built into the cost estimates was the consideration of only Federal regulations, rather than state or local requirements. The reasons for this assumption are (1) DOE, being a Federal agency, is concerned primarily with the impacts of Federal regulations and (2) the diversity of state and local requirements would necessitate a much larger number of site visits than the 23 that were approved for this project. Most states' hazardous waste regulations reflect, at a minimum, the Federal regulations. Major regulatory differences between Federal and state regulations are in the areas of administration (permitting and reporting) and specific listed hazardous wastes. Generally, state regulations contain only minor differences in specific technical land disposal design criteria. For the above reasons, the consideration of only Federal regulations, rather than state or local requirements, will not appreciably affect individual cost estimates developed for this project.

FIGURE 1.1


SCOPE OF OVERALL PROJECT
Phase I Utility Sector
STATE AND REGIONAL BACKGROUND DATA
CASE STUDIES
CASE STUDY DISPOSAL COSTS
POTENTIAL MODIFICATIONS TO CURRENT PRACTICE
REGIONAL & NATIONAL COSTS
Phase II Emerging Coal Technologies
BACKGROUND DATA
CASE STUDIES
TREATMENT, RECOVERY & REUSE
DISPOSAL COST ESTIMATES
COMMER-CIALIZATION IMPACTS
Phase III Industrial Sector
BACKGROUND DATA
CASE STUDIES
CASE STUDY DISPOSAL COSTS
INDUSTRIAL SECTOR COST ESTIMATES
Phase IV Overall Evaluation
BACKGROUND DATA
UTILITY & INDUSTRIAL SECTOR IMPACTS
NONQUANTI-FIABLE IMPACTS
RCRA BENEFITS
SENSITIVITY ANALYSIS
IMPACTS ON DOE PROGRAMS

CITED REFERENCES

R1.1 Federal Register. Volume 43; December 18, 1978, Pages 58946-59028.

R1.2 Federal Register. Volume 44; March 26, 1979, Page 25802.

R1.3 Federal Register. Volume 44; September 13, 1979, Page 54708.

R1.4 "Evaluation of the Impacts of Proposed RCRA Regulations and Other Related Federal/Environmental Regulations on Utility and Industrial Sector Fossil Fuel-Fired Facilities, Utility Sector Phase I", U. S. DOE/ET/13543-TI (DE82008097), Prepared by Engineering-Science, November 1979.

R1.5 Federal Register. Volume 45; May 19, 1980, Page 33120.

R1.6 "Characterization and Environmental Evaluation of Full Scale Utility Waste Disposal Sites," U.S. EPA Contract No. 68-02-3167 Research Triangle Park, prepared by Arthur D. Little, Inc. Preliminary Draft - March 1984.

R1.7 "Background Data on Utility Sector Fossil Fuel-Fired Facilities", U.S. DOE, Prepared by Engineering-Science, Draft-March 1983.

R1.8 "Process Modifications and Waste Management Practices Affecting Disposal, Utilization and Recovery of Coal Combustion Wastes", U. S. DOE/ET/13543-T2 (DE83001840), Prepared by Engineering-Science and Webster & Associates, October 1982.

SECTION 2

REVIEW OF PERTINENT REGULATIONS

INTRODUCTION

This study considers the relationship of the Resource Conservation and Recovery Act (RCRA) with other specific Federal environmental regulations affecting residue disposal from coal-fired utility power plants. This section describes the Resource Conservation and Recovery Act, and its non-hazardous and hazardous waste regulations. Other Federal environmental regulations are discussed as they may pertain to the disposal of utility solid wastes. The regulations which were specifically addressed included the following:

- The Resource Conservation and Recovery Act (RCRA)
- Clean Water Act; including the National Pollution Discharge Elimination System (NPDES).
- Clean Air Act.
- Safe Drinking Water Act; including the Underground Injection Control (UIC) Program.
- Surface Mining Control & Reclamation Act (SMCRA).
- Toxic Substances Control Act (TSCA)
- Marine Protection Research and Sanctuaries Act.
- Consolidated Permit Program.

THE RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

RCRA (Public Law 94-580) was passed on October 21, 1976 with the objectives of protecting human health and the environment, and conserving resources through:

- providing assistance for the development of solid waste management plans which will promote improved solid waste management techniques, and the safe disposal of nonrecoverable residues
- providing training grants in occupations involving the design, operation, and maintenance of solid waste disposal systems
- prohibiting future open dumping on the land and requiring the conversion of existing open dumps to facilities which do not pose a danger to the environment or to health
- regulating the treatment, storage, transportation, and disposal of hazardous wastes
- providing for the promulgation of guidelines for solid waste collection, transport, separation, recovery, and disposal practices and systems
- promoting solid waste management, resource recovery, and resource conservation systems which preserve and enhance the quality of air, water, and land resources
- establishing a cooperative effort between government and private enterprise to recover valuable materials and energy from solid waste

Thus, RCRA encompasses very broad and far reaching aspects of solid waste management. Because of this, RCRA is highly significant in prescribing non-hazardous and hazardous solid waste management practices at the utility sites. Additional detailed information on the historical development of RCRA and its regulations is presented in Section 1 of Appendix A.

RCRA NON-HAZARDOUS WASTE REGULATIONS

Subtitle D of RCRA requires that EPA establish regulatory guidelines for acceptable solid waste management practices including (1) defining acceptable disposal facilities (sanitary landfills), (2) requiring all future disposal only in acceptable facilities, and (3) allowing use of unacceptable disposal facilities (open dumps) only on an interim basis until they can be upgraded or replaced.

Subtitle D does not give EPA direct permitting authority over non-hazardous solid waste management and disposal. The law sets up a

system through which state environmental agencies revise their existing solid waste plans which are then submitted to EPA for review and approval. Once approved, the plans are implemented by the state agencies. The RCRA non-hazardous waste regulations have thus been written as guidelines to aid state agencies in developing solid waste plans as well as to aid EPA in review and approval of these plans.

RCRA does not require the individual state agencies to participate in the solid waste plan program. However, signficant financial incentives are provided to reimburse participating states for the costs of upgrading their solid waste regulations to meet the minimum EPA criteria. In 1983, all but two states (New Mexico and Alaska) participated in the program.

The following are the most recently published major non-hazardous land disposal regulations and guidelines which are included in Title 40 of the Code of Federal Regulations:

Regulatory Section	Scope	Publication Date	Status
241	Landfill Disposal Guidelines	3/26/79	Proposed
257	Facility Classification & Practices	9/13/79	Promulgated

Landfill Disposal Guidelines

The landfill disposal guidelines under Part 241 are organized into general considerations and recommended practices. The guidelines are structured to allow the individual states flexibility in evaluating disposal site design and operating procedures on a case-by-case basis. Although there are no absolute requirements contained within Part 241 which would explicitly require the utility industry to modify its current waste handling practices, the areas discussed in the following paragraphs could impact the design and operation of disposal facilities within the utility industry.

Site Selection

Section 241.200 requires that landfills be designed consistent with public health requirements, particularly with respect to the following factors:

- o environmentally sensitive areas including wetlands, 100-year floodplains, etc.
- o suitability of on-site soil for cover and vehicle maneuverability
- o environmental and socioeconomic factors
- o zones of active faults and karst terrain
- o site access roads

Design

Section 241.201 requires that the disposal facility be designed in accordance with the following considerations:

- o current and projected ground-water use
- o surface water quality
- o leachate control measures
- o 100-year floodplain

Leachate Control

Section 241.202 addresses leachate control and states that when necessary it can be accomplished by considering one or more of the following practices:

- o bottom of landfill disposal facility at least 1.5 meters above seasonal high ground-water table
- o no uncontrolled surface runoff entering the landfill
- o provision to remove precipitation falling directly on the land disposal facility
- o consideration of site hydrogeologic conditions
- o natural liners at least 12 inches thick and synthetic liners at least 20 mils.

Monitoring

Section 241.206 requires that a ground-water monitoring system be installed to detect the discharge of leachate into an underground drinking water source.

Facility Classification and Practices

The purpose of the Part 257 regulations is to promulgate baseline criteria against which states can evaluate existing land disposal operations to determine whether they should be upgraded. Specific criteria related to this project are summarized in the following paragraphs.

Floodplains

Section 257.3-1 requires that facilities located within the 100-year floodplain not restrict the flow of the base flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste, so as to pose a hazard to human life, wildlife, or land or water resources.

Endangered Species

Section 257.3-2 requires that the facility not contribute to the taking or impairment of critical habitat for endangered or threatened species of plants, fish or wildlife.

Surface Water

Section 257.3-3 requires that landfills not discharge pollutants which violate requirements of the Clean Water Act.

Ground Water

Section 257.3-4 prohibits contamination of underground drinking water sources beyond the limits of the solid waste boundary or an alternative boundary established based on a hydrogeologic investigation and an engineering study of the area's water resources. Contamination limits are specified to be less than the following values:

Arsenic	0.05 mg/l
Barium	1.0 mg/l
Cadmium	0.01 mg/l
Lead	0.05 mg/l
Mercury	0.002 mg/l
Nitrate (as N)	10.0 mg/l
Selenium	0.01 mg/l
Silver	0.05 mg/l

Summary

In summary, the primary purpose of the non-hazardous waste disposal guidelines proposed under Parts 241 and 257 is to eliminate open dumping and to provide a set of guidelines against which state agencies can compare their existing solid waste management regulations and upgrade them, where necessary. The guidelines as proposed do not explicity require the utility industry to modify its current waste disposal practices but, rather pose a series of environmental concerns which should be addressed when evaluating prospective disposal sites.

From a practical standpoint, the Part 257 regulations will raise the level of awareness of the utilities to specific environmental concerns and tend to normalize the technical design and operating conditions imposed on those disposing of non-hazardous wastes. Section 4 presents the specific design and operating practices which are considered to be reasonable interpretations of the non-hazardous regulations.

RCRA HAZARDOUS WASTE REGULATIONS

Regulations which have been promulgated under Subtitle C of RCRA set forth criteria for both the identification and management of hazardous wastes. The regulations, excluding interim status standards, are organized as follows under Title 40 of the Code of Federal Regulations:

Part 260 - Hazardous Waste Management System - General.
Part 261 - Identification and Listing of Hazardous Wastes.
Part 262 - Standards Applicable to Generators of Hazardous Waste.
Part 263 - Standards Applicable to Transporters of Hazardous Wastes.
Part 264 - Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities.

Most power companies own and operate their own dedicated disposal facilities as opposed to utilizing commercial hazardous waste disposal sites because of the large quantities of coal combustion wastes generated by coal-fired power plants. This would, in most instances, put the individual power companies in the position of being waste transporters

and disposers, as well as generators. Thus, most power companies would be subject to regulation under Parts 262, 263 and 264.

Table 2.1 lists the various subparts of Parts 262, 263, and 264 and identifies which regulations would affect costs if coal-combustion wastes were to be classified as hazardous. The cost impacts have been identified as being either major or minor with respect to total solid waste management costs that a utility would incur. The following paragraphs discuss the most significant RCRA impacts on utility waste management costs, based on hazardous waste regulations published through July 26, 1982.

Waste Generator Standards

Part 262 specifies requirements for generators of hazardous wastes. These standards impose administrative costs for preparing waste manifests, record keeping and reporting. However, such costs represent a relatively small percentage of the total solid waste management costs incurred by coal-fired power plants.

Waste Transporter Standards

Part 263 establishes standards that would affect those power plants which dispose of their hazardous wastes off-site. Standards address manifesting, labeling, using proper containers and reporting accidental discharges. These standards, like the generator standards, would represent a small fraction of the total waste disposal costs.

Waste Treatment, Storage and Disposal Facility Standards

Part 264 (Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities) has by far the greatest potential impacts on utility waste disposal. Of the many Part 264 requirements, those described in the following paragraphs are felt to have the most significant impacts.

Facility Location Standards

Standards pertaining to the location and siting of hazardous waste disposal facilities are specified in Section 264.18. Though previously proposed editions of the regulations addressed a variety of criteria (e.g., wetlands and endangered species habitats) the current regulations are limited to seismic considerations and floodplains.

The seismic criteria state that new hazardous waste management facilities should not be located within 200 feet of geological faults

which have experienced displacement within Holocene time (approximately the past one million years). Appendix VI to Part 264 specifies certain counties within 12 western States (including Alaska and Hawaii) where seismic compliance demonstration is required. Within these areas, people wishing to construct a hazardous waste management facility must show, through the use of fault mapping, that the proposed site complies with the seismic criteria. Less than nine percent of existing coal-fired power plants are located within the specified states and only about two percent are located in active fault areas (R2.1). Therefore, RCRA seismic criteria has a minimal impact on the coal-fired utility industry as a whole.

The regulation specifies that facilities located within the 100-year floodplain must be designed to prevent washout during a 100-year flood. Because it would be impractical in most cases to design disposal facilities to meet this criteria, such facilities would effectively be prohibited from being built within floodplains. Between 30 and 50 percent of existing coal-fired power plants are located within 100-year floodplain areas (R2.1). The RCRA location criteria would force many of these plants to construct off-site disposal facilities, substantially increasing waste transportation and disposal costs.

Ground Water Protection Standards

Subpart F establishes the following maximum contaminant concentrations in the ground water downgradient of a waste management area:

Constituent	Maximum Concentration
Arsenic	0.05 mg/l
Barium	1.0 mg/l
Cadmium	0.01 mg/l
Chromium	0.05 mg/l
Lead	0.05 mg/l
Mercury	0.002 mg/l
Selenium	0.01 mg/l

The facility must monitor ground-water quality for the above parameters on a semi-annual basis to assure that no statistically

significant increase occurs. If such an increase is observed, monitoring frequency must be increased to quarterly to assure that the allowable concentrations are not exceeded (except for those parameters whose background values exceed the allowable concentrations). If the ground water is being contaminated beyond the allowable limits, the owner must establish and implement an approved remedial action program.

An owner/operator can avoid the above monitoring requirements if he (1) installs a double liner in the landfill or surface impoundment, (2) locates the facility entirely above the seasonal high water table, and (3) installs and maintains a system to detect migration of liquids into the space between the liners. This provision is intended to relieve the owner/operator of a small hazardous waste disposal facility of the ground-water monitoring costs. However, complying with this provision would not be cost-effective for most coal-fired power plants.

Although the ground-water monitoring requirements will impose substantial sampling and analytical costs over many years, these costs are relatively small compared to total solid waste management costs incurred by a major coal-fired power plant. However, if an unacceptable level of contamination is observed, remedial actions might include construction of slurry walls to contain the contamination, removal of contaminated soil, treatment of contaminated ground water, and/or other costly methods of resolving the problem. It is difficult to quantify these costs because there have been no documented cases where such contamination has occurred as a result of coal combustion waste disposal (R2.2).

Surface Impoundment Design Standards

Since approximately one-half the coal-fired utility industry currently disposes of their utility wastes in surface impoundments (R2.1), these regulations would have major ramifications if utility wastes were declared hazardous. Subpart K specifies that no migration of waste may occur during the active life of a newly constructed surface impoundment. The owner/operator has a choice of (1) using a synthetic liner to satisfy the regulatory requirements specified in Subpart K or (2) using a soil-based liner such as clay, provided that all waste residues contained in the impoundment (including the liner materials and any contaminated subsoils adjacent to the liner) are removed or decontaminated

upon closure. For most coal-fired power plants, it would be considerably less costly to implement the first option, i.e., a synthetic liner.

Subpart K also specifies that provisions be made to prevent overtopping resulting from either normal or abnormal operations. Finally, all dikes are required to be structurally secure.

Landfill Design Standards

Subpart N specifies that new hazardous waste landfills include an impermeable liner that prevents wastes from passing into the liner during its active life. Although synthetic liners are not specifically referred to in the regulations, they are discussed in the preamble to the regulations and are cited as the only known liner material that is capable of meeting the above requirement. Also recommended is a leachate collection system that prevents leachate from accumulating to a depth of more than 12 inches (30 cm) above the liner.

For storm-water handling, a run-on control system must be installed to protect the active portion of the landfill from the peak discharge of a 25-year storm. Landfill run-off from a 24-hour, 25-year storm must also be controlled. Any collection/holding facilities associated with run-on and run-off control systems must be emptied expeditiously after a storm so that their capacity is available for the next storm.

Finally, any particulate matter subject to wind dispersal (e.g., fly ash) must be covered or otherwise managed to control such dispersal.

Closure and Post-closure Standards

All hazardous waste treatment, storage and disposal facilities (both new and existing) must be closed within 180 days after receiving final waste volumes. Post-closure care, including maintenance and monitoring of the waste containment system, must continue for 30 years after closure has been completed.

To close a surface impoundment which has a synthetic liner, a landfill or landfill cell, the owner/operator must provide a final cover which:

- provides long-term minimization of migration of liquids through the closed landfill,
- functions with minimum maintenance,
- promotes drainage and minimizes erosion or abrasion of cover,

- accommodates settling and subsidence so that the cover's integrity is maintained, and
- has a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

Miscellaneous Administrative Standards

The RCRA hazardous waste regulations, if applied to the coal-fired utility industry, would result in a variety of minor cost impacts primarily in the administrative area. These requirements, though not as significant as those resulting from the location and design standards previously discussed, represent costs that the coal-fired utility industry does not presently incur.

The administrative cost impacts indicated in Table 2.1 fall primarily into the following general areas:

- Waste Manifesting - Administrative labor for preparation of waste manifest forms and recordkeeping to document manifest completion.
- Record Keeping and Reporting - Administrative labor to maintain necessary records and submit regular reports on hazardous waste activities to regulatory agencies.
- Waste Analysis - Analytical costs to characterize wastes if operating circumstances change that could effect waste characteristics.
- Facility Inspection - Administrative labor to regularly inspect hazardous waste management facilities and document inspections.
- Contingency Planning - Administrative labor to develop contingency plans and implement them during emergency circumstances.
- Personnel Training - Administrative labor to provide required training for hazardous waste workers.
- Ground-water Monitoring - Labor costs for sampling monitoring wells and laboratory costs for analyzing ground-water samples.
- Closure/Post-Closure - Administrative labor for development of closure and post-closure plans and cost estimates, as well as for inspection and monitoring during post-closure care period.

- Insurance - Insurance premiums to cover sudden and non-sudden release of hazardous waste and/or contaminated leachate to the environment.

Summary

Unlike the non-hazardous regulations which merely provide guidelines to be used by the various state agencies, the hazardous waste regulations specify more definitive requirements for generators, transporters, owners and operators of hazardous waste treatment, storage and disposal facilities. However, EPA still included provisions for considerable latitude in terms of how the regulations are implemented.

To facilitate the review and approval of RCRA permit applications, EPA has issued guidance documents to accompany the regulations (R2.2 and R2.3). The intent of the guidance documents is to present designs which, if submitted to EPA for approval, should receive a draft permit. The owner/operator remains free to chose options unmentioned in the EPA guidance document if they can be shown to be technically equivalent to the EPA suggested designs.

Because no coal combustion waste management systems have ever been permitted under the RCRA hazardous waste regulations, specific requirements are a matter of speculation. For the purposes of this study, Engineering-Science has established a range of criteria from the least probable cost of compliance to the maximum probable cost of compliance. The assumptions used to develop this range are described in Section 4 of this report.

OTHER FEDERAL ENVIRONMENTAL REGULATIONS

In addition to the evaluation of engineering and related direct economic impacts of RCRA, this project also addressed the impacts of other Federal/environmental regulations on the disposal of coal residues from utility power plants. The following are environmental regulations which were evaluated:

- Clean Air Act
- Clean Water Act, including the National Pollution Discharge Elimination System (NPDES)

- Safe Drinking Water Act, including the Underground Injection Control (UIC) Program
- Surface Mining Control and Reclamation Act (SMCRA)
- Toxic Substances Control Act (TSCA)
- Marine Protection Research and Sanctuaries Act
- Consolidated Permit Program

The qualitative impacts of each of these regulations on waste disposal for coal-fired power plants is summarized in Table 2.2 and described below. Quantifiable impacts for applicable regulations have been estimated for the 23 case study plants and the cost information used to develop national impacts presented in Section 5. Additional background information published through July 30, 1982 on the regulations is presented in Appendix A.

Clean Air Act

The Clean Air Act requires coal-fired power plants to install scrubbers for flue gas desulfurization, greatly increasing the quantities of solid waste produced for each megawatt of electricity generated. Potential changes to the Clean Air Act, in response to such issues as acid rain, may increase scrubber sludge production even more.

A 1200 MW power plant burning a 10% ash coal will typically generate 325,000 tons of ash annually. The burning of a 2.5% sulfur coal and the removal of 85% of the sulfur in a FGD system could generate 250,000 tons of scrubber sludge, which is approximately equal to the total fly ash removed in the electrostatic precipitator.

The Clean Air Act thus has a direct impact on waste disposal costs regardless of whether or not coal combustion wastes are defined as hazardous. Of course, costs will be even higher if these wastes are disposed of in accordance with the RCRA hazardous waste regulations.

Clean Water Act

If coal combustion wastes were classifed as hazardous, any leachate collected from a surface impoundment or a hazardous landfill would require treatment before discharge. A likely treatment approach would be lime precipitation of heavy metals in a treatment unit with subsequent settling of the metal sludge. These sludges could then be co-disposed with the coal combustion wastes. The typical 1200 MW power

plant cited above (disposing of 575,000 tons of combined ash and scrubber sludge in a hazardous landfill) might generate an additional 50 tons of sludge annually from a leachate treatment facility.

This approach would result in slightly increased costs for (1) design, construction and operation of a leachate treatment plant and (2) increased volumes of sludge requiring disposal. As described previously in this section, it is unclear whether or not non-hazardous waste disposal facilities will require leachate collection facilities. At present, it appears that such facilities will not be required, nullifying the potential impacts of the Clean Water Act on non-hazardous waste disposal.

The regulations promulgated under the Clean Water Act also specify effluent limitations for pH and suspended solids in coal pile runoff. The current practice for power plants practicing wet ash disposal is to direct coal pile runoff to the ash pond for settling of any suspended solids and combine subsequent discharge with the ash pond effluent to a local water body. Plants practicing dry disposal must utilize a separate system for handling coal pile runoff either using it for ash conditioning or treating and discharging it directly. In the case of either wet or dry ash disposal, the solids in the coal pile runoff must be disposed of, increasing total waste disposal costs. However, because the classification of these solids (hazardous or non-hazardous) is independent from the classification of coal combustion wastes, the costs associated with disposal of solids from coal pile runoff are not considered within the scope of this study.

Safe Drinking Water Act

One of the key aspects of the Safe Drinking Water Act was the establishment of Primary Drinking Water Standards. Both the non-hazardous and hazardous RCRA regulations specifically referenced these standards as ground-water concentration limits which should not be exceeded in the vicinity of a waste treatment, storage or disposal facility. It is therefore reasonable to assume that any changes in the Primary Drinking Water Standards would result in modifications to hazardous and non-hazardous RCRA regulations. However, it is not possible to quantify such changes at the present time.

Another element of the Safe Drinking Water Act is the Underground Injection Control (UIC) program which was initiated by EPA to control the injection of toxic wastes in aquifers. This disposal technique has characteristically been utilized by the chemical industry for the disposal of highly toxic liquid wastes which were uneconomical to dispose of in any other manner. When the wastes injected are hazardous, there is an overlapping jurisdiction in the UIC program and the RCRA hazardous waste program. However, because underground injection has not been utilized within the utility industry for disposal of any waste materials, the UIC program has no direct applicability to the utility industry.

The Safe Drinking Water Act gives EPA the authority to regulate Federally funded projects in order to protect sole source aquifers. While some utilities receive Federal funds (most notably, the Tennessee Valley Authority), these constitute a small percentage of the total coal-fired power generation in the U.S. This provision of the Safe Drinking Water Act therefore has a minimal impact on waste disposal in the coal-fired power industry as a whole.

Surface Mining Control and Reclamation Act (SMCRA)

It is currently economically attractive for utilities located near a strip mining operation to utilize the active strip mine for ultimate disposal of coal combustion wastes. The disposal of these wastes, if conducted within the permitted mining area, would come under the authority of the Office of Surface Mining to enforce SMCRA regulations addressing the handling of top soil, spoil, regrading, revegetation, and surface and ground water considerations. Although the disposal of utility solid wastes in an active strip mining area is regulated under SMCRA, no specific technical disposal requirements for handling the wastes have been identified. It is therefore likely that the RCRA technical requirements would be incorporated into a SMCRA waste disposal permit with little or no additional costs beyond what would otherwise be required under RCRA alone.

If utility waste were declared hazardous by EPA under RCRA, the jurisdiction for administration of waste disposal activities would have to be decided between EPA and the Department of the Interior. While legal issues regarding the administration of the program are not within

the scope of this project, it is clear that this jurisdictional issue could slow down the permitting of new disposal sites and/or increase administrative costs of interfacing with these agencies.

Toxic Substances Control Act (TSCA)

As of 1982, the only substances regulated by TSCA that impact the utility industry are polychlorinated biphenyls (PCB), a component of the dielectric fluid in transformers and capacitors. Under TSCA, EPA has issued a ban on the manufacturing, processing, and distribution of products containing PCBs and has developed specific disposal options identified for the disposal of wastes contaminated with PCB.

Utilities faced with the disposal of transformers or capacitors which contain dielectric fluid with a PCB concentration over 50 ppm are specifically regulated under TSCA as to the disposal of both the transformer and the dielectric fluid. While compliance with these regulations certainly imposes a cost on power plant owners, this cost is associated with power generation/distribution, not steam generation. Because this cost will be based on the amount of power generated (and will be independent from the type of fuel used), TSCA will not affect current or future coal usage and is therefore not of concern to DOE under this project.

Marine Protection, Research and Sanctuaries Act

Ocean disposal has long been utilized by municipalities located along the coast to dispose of solid wastes and wastewater treatment plant sludges and by industries who are disposing of difficult-to-handle wastes. However, Engineering-Science knows of no utility plants in the U.S. which currently dispose of coal combustion wastes via ocean disposal. The Marine Protection Research and Sanctuaries Act therefore has no existing impact on the disposal of wastes from existing coal-fired power plants.

According to a recent study undertaken by the Marine Sciences Research Center, (MSRC) under the joint sponsorship of EPRI, DOE, EPA, New York State Energy Research and Development Authority and the Power Authority of the State of New York, artificial reefs can be created from blocks of coal combustion wastes at a levelized cost of $46 per ton of solid waste disposed (assuming the block plant and barge loading facility were adjacent to the power plant (R2.4). This is considerably

higher than the cost of conventional non-hazardous disposal under RCRA, so there would be no reason for a utility to dispose of these wastes in the ocean unless some type of subsidy were provided.

If coal combustion wastes were declared to be hazardous, the cost of ocean disposal via artificial reefs would be less than the cost of land disposal for some power plants located in coastal metropolitan areas. However, a number of environmental questions would have to be answered with regard to leachability and possible negative environmental impacts associated with the disposal of utility wastes in the ocean. It therefore appears that the Marine Protection, Research and Sanctuaries Act will not significantly impact solid waste disposal from coal-fired power plants.

Consolidated Permit Program

In 1981, the individual EPA regional offices were preparing staffing plans to implement the consolidated permit program. Because of staffing shortages, it would have been necessary for EPA to assign engineers to review permit applications outside of their individual technical areas of expertise (e.g., NPDES, PSD or RCRA). In addition, as the program developed, it was viewed by the Reagan Administration as being cumbersome and inefficient.

For the above reasons, the Consolidated Permit Program has never been implemented officially by the EPA regional offices. Although permit application forms are still being utilized within the agency, current information indicates that the program will be officially "de-consolidated" by mid-1983. Therefore, there is no identified impact to the utility industry associated with the Consolidated Permit Program.

Summary

In Table 2.2, the impacts of environmental regulations on coal fired utilities are summarized. Individual regulated areas and the specific impacts on the handling and disposal of utility wastes are presented.

TABLE 2.1

POTENTIAL REGULATORY IMPACTS ON COAL-FIRED UTILITY WASTE MANAGEMENT COSTS

RCRA Regulation Section	Construction Capital	O&M (Labor and Equipment)	Administrative
Part 262 - Standards Applicable to Generators of Hazardous Wastes			
Subpart A - General			
Subpart B - The Manifest			Minor
Subpart C - Pre-transport Requirements			
Subpart D - Record Keeping and Reporting			Minor
Subpart E - Special Conditions			
Part 263 - Standards Applicable to Transporters of Hazardous Waste			
Subpart A - General			
Subpart B - Compliance with the Manifest System and Recordkeeping			Minor
Subpart C - Hazardous Waste Discharges		Minor	Minor
Part 264 - Standards Applicable to Owners and Operators of Hazardous Waste Treatment Storage and Disposal Facilities			
Subpart A - General			
Subpart B - General Facility Standards			
264.11 Identification number			Minor
264.12 Required notices			Minor
264.13 General waste analysis			Minor
264.14 Security	Minor	Minor	
264.15 General inspection requirements		Minor	Minor
264.16 Personnel training			Minor
264.18 Location standards	Major		
Subpart C - Preparedness and Prevention			
264.31 Design and operation of facility	Major	Major	
264.32 Required equipment	Minor		
264.33 Testing and maintenance of equipment		Minor	
264.34 Access to communications or alarm system	Minor		
264.35 Required aisle space	Minor		
264.37 Arrangements with local authorities			Minor
Subpart D - Contingency Plan and Emergency Procedures			Minor
Subpart E - Manifest System, Record Keeping and Reporting			Minor
Subpart F - Ground-water protection			
264.97 General ground-water monitoring requirements	Minor		Minor
264.98 Detection monitoring program			Minor
264.99 Compliance monitoring program			Minor
264.100 Corrective action program	Possibly	Possibly	Minor

TABLE 2.1
(Continued)

POTENTIAL REGULATORY IMPACTS ON COAL-FIRED UTILITY WASTE MANAGEMENT COSTS

RCRA Regulation Section		Construction Capital	O&M (Labor and Equipment)	Administrative
Subpart G - Closure and Post-Closure				
264.111	Closure performance standard	Major		
264.112	Closure plan; amendment of plan			Minor
264.114	Disposal of decontamination of equipment		Minor	
264.115	Certification of closure			Minor
264.117	Post-closure care and use of property		Minor	Minor
264.118	Post-closure plan; amendment of plan			Minor
264.119	Notice to local land authority			Minor
264.120	Notice in deed to property			Minor
Subpart H - Financial Requirements				Minor
Subpart I - Use and Management of Containers				
Subpart J - Tanks				
Subpart K - Surface Impoundments				
264.221	Design and operating requirements	Major		
264.222	Double-lined surface impoundments	Major		
264.226	Monitoring and inspection			Minor
264.227	Emergency repairs; contingency plans	Possibly	Possibly	Minor
264.228	Closure and post-closure care	Major	Minor	Minor
Subpart L - Waste Piles				
Subpart M - Land Treatment				
Subpart N - Landfills				
264.301	Design and operating requirements.	Major	Major	
264.302	Double-lined landfills.	Major		Minor
264.303	Monitoring and inspection			Minor
264.309	Surveying and record keeping			Minor
264.310	Closure and post-closure care	Major	Minor	Minor
Subpart O - Incinerators				

Key: MINOR - Relatively minor cost impact as compared to total solid waste management cost.

MAJOR - Major cost impact

POSSIBLY - Costs would not be incurred except in instances where contamination control systems fail and remedial action is necessary. Cost impacts could possibly falls under major or minor, depending on specific circumstances.

Note: Where no notation is given, that section is considered to have a negligible impact on coal-combustion waste disposal costs.

TABLE 2.2
SUMMARY OF IMPACTS OF ENVIRONMENTAL REGULATIONS
ON COAL-FIRED UTILITIES

Federal Environmental Regulations	Regulated Areas	Regulatory Impacts on Coal-Fired Utilities
Clean Air Act	o Sulfur Emissions	o Sludges generated by FGD systems substantially increase solid waste quantities per unit of power generated.
Clean Water Act	o Discharge of treated leachate	o Significantly increases waste disposal costs due to requirement for treating leachates. Leachate treatment produces additional sludge which increases waste disposal volumes, with a resulting minor increase in disposal costs.
	o Coal pile runoff	o Does not impact solid waste disposal.
Safe Drinking Water Act	o Drinking water	o No direct impact.
	o Underground Injection Control Program	o Underground injection is not practiced in the industry and economic considerations will probably preclude future usage.
	o Sole source aquifers	o Only applicable to projects receiving federal funds therefore would not presently impact the utility industry.
Surface Mining Control & Reclamation Act	o Strip mines	o Little impact associated with the disposal of utility waste in an active strip mine.
Toxic Substances Control Act	o PCB contaminated wastes	o Generated from power distribution equipment regardless of type of fuel used; therefore, not pertinent to coal waste disposal as compared to other fuels.
Marine Protection Sanctuaries Act	o Ocean dumping of waste	o Ocean dumping is currently not utilized and economic considerations will probably preclude future usage.
Consolidated Permit Program	o Initiated to expedite review and issuance of 4 permits - RCRA, NPDES, UIC, Dredge or Fill.	o Program has not been implemented by the Regional Offices and was abandoned in mid 1983.

CITED REFERENCES

R2.1 "Background Data on Utility Sector Fossil Fuel-Fired Facilities", U.S. DOE, Prepared by Engineering-Science, Draft--April 1983.

R2.2 "RCRA Guidance Document, Landfill Design, Liner Systems and Final Cover", Draft, U.S. Environmental Protection Agency, July 1982.

R2.3 "RCRA Guidance Document, Surface Impoundment Cover and Freeboard Control," Draft, U.S. Environmental Protection Agency, July 1982.

R2.4 Coal Waste Artificial Reef Program - Phase 3 - Comprehensive Report. Electric Power Research Institute. EPRI CS-2009; November, 1981.

OTHER REFERENCES

Coal Waste Artificial Reef Program - Phase 3 - Summary Report. Electric Power Research Institute. EPRI CS-2009; October, 1981.

Coal Waste Artificial Reef Program - Phase 3 - Engineering - Economic Evaluation of Fixed Coal Waste Block Production and Disposal. Electric Power Research Institute. EPRI CS-2009; August, 1981.

Coal Waste Artificial Reef Program - Phase 4A. Electric Power Research Institute. EPRI CS-2009; September, 1982.

Engineering Evaluation of Projected Solid Waste Disposal Practices - Volume 1, Electic Power Research Institute. EPRI CS-2627; September, 1982.

SECTION 3

CASE STUDY SITE VISITS

INTRODUCTION

As described in Section 1, the development of waste disposal cost information was based on site-specific engineering designs prepared for 23 coal-fired power plants which were selected to be nationally representative of the entire population of 396 utility-owned coal-fired power plants over 25 MW in capacity. The selection of these case studies was therefore a critical element of the overall project. This section describes (1) the procedures used to select the case study sites, (2) the techniques used to gather information during the subsequent site visits, (3) the baseline information gathered and (4) the relationship of the case study sites to the total coal-fired utility population.

PRELIMINARY CASE STUDIES FOR THE FIRST SIX SITES

The initial phase of this project was undertaken in 1979 and consisted of an assessment of the impacts of the RCRA hazardous waste regulations (proposed in December 1978) and the non-hazardous waste regulations (promulgated in March 1979) on six utility sites. Based on these regulations and the characteristics of coal combustion wastes, it was determined that the following parameters have a major effect on waste disposal costs in the industry:

- plant generating capacity
- projections of future generating capacity
- source and type of coal
- ash and sulfur content of coal
- particulate and SO_2 controls
- solid waste disposal technology
- use of FGD sludge stabilization
- land availability.

Data were then collected to characterize the coal-fired power plants within the six Federal Energy Regulatory Commission Regions (Figure 3.1) having the greatest coal burn. These data set the basis for further screening of power plants within each FERC region in order to select six plants (one from each region) that would represent the range of conditions existing among all power plants under consideration.

Screening and Selection of Preliminary Case Study Candidates

A preliminary selection of one power plant within each of the six FERC regions was made and each selected power plant was compared with the selections in other regions to ensure consideration of a wide cross-section of factors affecting solid waste disposal. Following a review by the Department of Energy (DOE), Edison Electric Institute (EEI), and the Electric Power Research Institute (EPRI), these preliminary selections were finalized. Power plants selected for the first six case studies are described below:

Plant No.	FERC Region	Generating Capacity MW
2	2	707
6	3	1,981
13	5	3,160
16	6	585
22	7	2,379
23	8	716

Case Study Site Visits

Corporate utility officials for each of the selected case study sites were contacted to (1) seek their participation in the study and (2) arrange an appropriate time to visit the facility. A visit was then made to each selected site to obtain site-specific data required for the preparation of waste disposal designs and cost estimates.

The estimated waste disposal costs for the first six case studies were used as the basis for an initial assessment of regional and national costs for all utility-owned coal-fired power plants. These results were presented in an interim report published in November 1979 (R3.1)

which concluded that (1) waste disposal costs would increase substantially if the non-hazardous waste disposal regulations were enforced as proposed and (2) even greater costs would result if coal combustion wastes were classified as hazardous under RCRA. Thereafter, DOE decided to continue its investigation in order to obtain a more detailed analysis of the range and types of potential impacts as well as the incremental costs associated with the revised RCRA regulations and other Federal/environmental regulations as compared to current waste disposal practice in the utility industry.

SELECTION OF ADDITIONAL UTILITY SITES

During the summer of 1980, a Utility Advisory Task Force was established to assist in selecting additional case study sites and to provide technical input to the DOE and Engineering-Science during the execution of the study. This task force consisted of knowledgeable individuals from DOE, utility trade associations, major utility companies and other individuals with specialized expertise in the disposal of coal combustion wastes. Organizations and utilities represented on the Utility Advisory Task Force included:

- American Electric Power Service Corporation
- American Public Power Association
- Central Illinois Light Company
- Duke Power Company
- Edison Electric Institute
- Electric Power Research Institute
- Georgia Power Company
- National Ash Association
- Northern States Power Company
- Tennessee Valley Authority
- Utility Solid Waste Activities Group
- U.S. Department of Energy (various locations)

The first task force meeting was held to establish a methodology for selecting the remaining case study sites. The following preconditions were agreed upon:

1. The six sites already visited would be included in a total of 23 case study sites.
2. Plants would be selected to represent the range of factors prevelant in the coal-fired power industry.
3. At least one of the sites included in the A. D. Little study for EPA (R3.2) would be included in our study to permit comparison of results.
4. The number of sites visited in each FERC Region would be proportional to the projected coal burn in that region in 1990.
5. In order to assure relatively constant coal characteristics, the plants to be visited would be those that receive their coal from long term contracts rather than spot purchases.
6. The plants in each region would be ranked and grouped according to their relative waste disposal costs. The number of plants to be included from each group would be proportional to the relative size of that group as a fraction of all plants in a given region.

A second task force meeting was then held to select a total of 17 primary sites and an alternate for each. Those generating plants meeting the above criteria were selected in order to obtain a representative distribution of the operating and site characteristics affecting waste disposal costs.

CASE STUDY DATA COLLECTION PROCEDURE

The approach used to collect site visit data was developed to (1) assemble the information required for subsequent project activities, (2) minimize the time required from utility personnel, and (3) assure that all information was accurate. The procedure developed to accomplish these objectives is described in the following subsections.

Development of Verification Document

Standard forms containing the following types of information were prepared in order to identify data requirements:

- general plant identification data
- types of fuel burned

- boiler descriptions
- particulate control devices
- flue gas desulfurization equipment
- additives used to enhance gas stream cleanup
- solid waste disposal practices
- flue gas emission control regulations
- wastewater treatment practices
- physical characteristics of power plant and disposal sites

Prior to visiting each case study site, Engineering-Science staff completed a document for that site based on available information. The partially completed documents were then sent to each utility as a Verification Document (OMB Form FE-735A) with a request to (1) verify or correct the data that had been entered and (2) add any missing information. An example verification document is presented in Appendix B.

Preparation of Data Management Plan

A Data Management Plan was also prepared to assure that the site visit teams collected all the needed information in the proper format. The Data Management Plan appears in Appendix C and contains the following elements:

1. General Case Study Requirements
   - Site Visit Checklist
   - Subject/Source Matrix
   - Case Study Report Outline
2. Pre-Visit Case Study Data
   - FPC Form 67 for 1980
   - Review of Other Federal Forms
   - Verification Document
3. Site Visit Interview Sheet
   - Plant Description
   - Power Generation Equipment
   - Characteristics of Principal Coal Used in 1980
   - Air Emission Control Equipment
   - Waste Quantities and Characteristics
   - Current Waste Storage Practices

- Current Waste Treatment Practices
- Current Waste Disposal Practices
- Design Data for Current Disposal Facilities
- Design Data for Future Disposal Facilities
- Impacts of Other Regulations on Waste Disposal
- Local Jurisdictional/Geo-Political Constraints
- Checklist of Supplemental Case Study Information.

Site Visits

The actual site visits were conducted by Engineering-Science and varied in duration from one to three days depending upon the number of individuals to be interviewed and complexity of the facility. Individuals interviewed included plant operating personnel, plant management, plant engineering staff, corporate and plant environmental staffs, local and state regulatory officials, and Federal agencies such as the U.S. Geologic Survey and Soil Conservation Service.

A Site Visit Summary, based on the data management plan, was prepared following each visit. Draft versions of the Site Visit Summary were submitted to each utility visited for review and approval prior to using the data.

Updates from the First Six Sites

The procedures described above were used to collect the required data from all 23 case study sites. However, return visits were not required for the original six sites visited in 1979 because sufficient information was already on file. This previously collected information was updated and verified by correspondence and via telephone conversations.

CHARACTERISTICS OF THE CASE STUDY PLANTS

Table 3.1 summarizes the 1980 operating characteristics for the 23 case study plants as compiled during the site visits. More detailed descriptions of these 23 case study plants can be found in the individual engineering studies located in Appendix H (Volumes 2 and 3).

The 23 individual case study plants had between one and six units (i.e., boilers) with an average of three units per plant. The average nameplate generating capacity for the study plants was 1,199 MW with a range between 185 and 3160 MW.

The year of boiler start up at the case study plants varied for the first unit from 1937 to 1982 and for the last unit from 1958 to 1982. The average years were 1965 for the first unit on line and 1974 for the last unit on line.

During 1980, the amount of coal burned by the individual case study plants ranged from 317,000 to 11,087,000 tons of coal. The ash content varied from 4.8 to 25 percent, and the sulfur content varied between 0.33 and 5.39 percent. Fifteen of the plants burned some bituminous coal; sub-bituminous coal was burned in six plants; and lignite was burned in three plants during 1980.

The individual case study plants generated between 32,000 and 1,869,300 tons of waste or an average of 500,000 tons per plant during 1980. On an individual plant basis, FGD sludge composed between zero and 55 percent of the total waste or between zero and 596,900 tons per year. Fly ash, bottom ash and boiler slag accounted for between 32,000 tons and 1,330,400 tons of the waste produced at each plant.

Of the 23 case study sites, 10 plants used total wet handling of all wastes, seven plants used total dry handling while six plants had partial wet and dry handling facilities. A majority of the waste produced at each plant site was disposed on-site, amounting to as much as 1,642,500 tons at one plant. Only three plants disposed of their waste off-site: Plants 2 and 8 disposed of all wastes through off-site disposal or sales while Plant 20 used all three methods (on-site, off-site and sales) to dispose of its wastes. Sixteen of the 23 case study plants disposed of a portion of their wastes through sales or donation.

The portion of flue gas scrubbed in the case studies varied from zero to 100 percent depending on the plant. Ten plants had scrubbers on at least one unit, but only one had scrubbers on all units. Of the 10 FGD plants which had scrubber sludge, four used wet handling for disposal, two dewatered the sludge via vacuum filters and four used fixation prior to disposal.

RELATIONSHIP OF THE CASE STUDY SITES TO THE INDUSTRY

A subsequent evaluation of the relationship of the case study sites to the industry was conducted for the following reasons:

1. The initial case study plant selections were performed using primarily information from the 1978 FPC 67 forms which are incomplete and unverified. UDI subsequently provided verified 1980 data (R3.3).
2. Case study site visits provided verified information for the 23 plants visited.
3. Some alternate plant sites had to be utilized since some primary plant selections were unable to participate in the study.

For these reasons a reevaluation of the comparison of the case study plants to the industry was necessary.

Figure 3.2 provides a comparison of the case study plants with those of the utility industry as a whole. The number of plants above the case study plant maximum value and below the case study plant minimum value are plotted for waste generation and associated parameters. The following chart displays the range of values for the case study plants and those for the industry.

Parameter	Case Study Range	Industry Range
Number of Units Per Plant	1-6	1-10
Generating Capacity (MW)	185-3160	25-3280
First Unit on Line (Year)	1937-1982**	1924-1980
Last Unit on Line (Year)	1958-1982**	1938-1980
Ash Percentage of Coal	4.8-25	3.11-25
Ash Waste Generated (10^3 Tons)	32-1330	0.3-2109
FGD Sludge Generated (10^3 Tons)*	14.3-597	0.03-1084
Total Waste Generated (10^3 Tons)	32-1869	0.3-2186
On-site Disposal (10^3 Tons)*	0.2-1642	0.03-2099
Off-site Disposal (10^3 Tons)*	21-91	0.9-1579
Ash-Sold (10^3 Tons)*	5.8-318	0.06-626

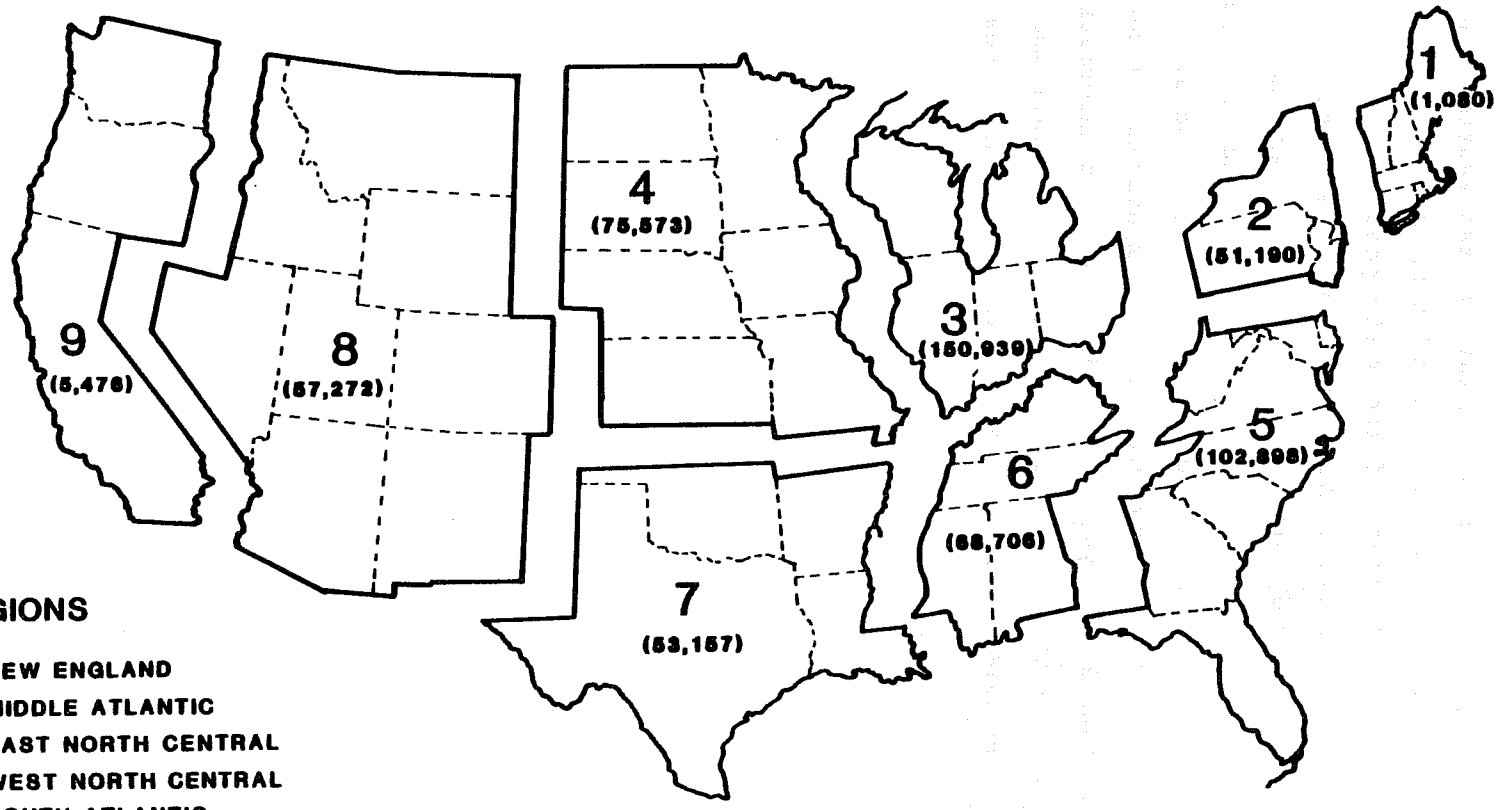
*Only plants with values greater than zero were considered.
**Case Study Plant 51 was brought on-line in 1982.

Previous experience has shown that of the above parameters, total waste generation has the most direct impact on total disposal costs (R3.1). The total waste quantities thus form the basis for analysis and

projection of costs from the 23 case study plants to the remaining plants in the industry. Only 1.7 percent (1,239,000 tons) of the total waste (75,060,000 tons) produced by the coal-fired utility power plants is produced by plants annually generating less wastes than the minimum value of the case study plants (32,000 tons per year). Approximately 2.9 percent (2,186,000 tons) of the waste generated by the industry is generated by only one plant which generates more waste than the maximum value for the case study plants (1,869,000 tons per year). These data indicate a very close relationship between the size distribution of the 23 case study plants compared to the industry as a whole.

In addition to the above qualitative comparisons, a detailed quantitative statistical analysis of the disposal cost information from the 23 case study plants was performed to further validate the representativeness of the case studies to the industry as a whole (see Section 5).

FEDERAL ENERGY REGULATORY COMMISSION REGIONS AND 1980 COAL BURNS



REGIONS

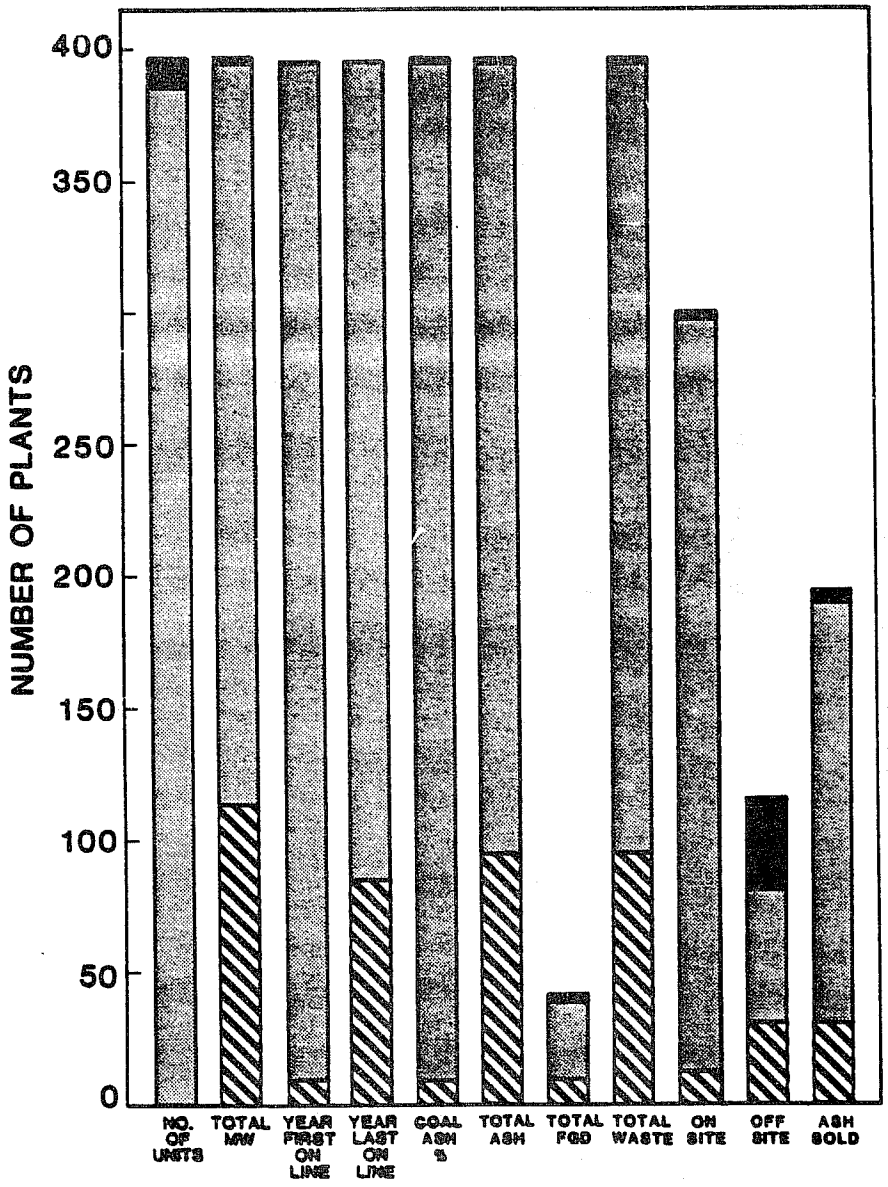
1. NEW ENGLAND
2. MIDDLE ATLANTIC
3. EAST NORTH CENTRAL
4. WEST NORTH CENTRAL
5. SOUTH ATLANTIC
6. EAST SOUTH CENTRAL
7. WEST SOUTH CENTRAL
8. MOUNTAIN
9. PACIFIC - PLUS ALASKA & HAWAII

NOTE: 1980 COAL BURNS IN PARENTHESES ARE EXPRESSED IN THOUSANDS OF TONS PER YEAR

FIGURE 3.1

FIGURE 3.2

Representativeness of Case Study Sites to Coal-Fired Utility Industry



LEGEND

- Number of plants above case study maximum value
- Number of plants within case study values
- Number of plants below case study values

TABLE 3.1

CASE STUDY PLANT CHARACTERISTICS AND DATA

Parameter	Case Study Plant Numbers																						
	2	3	4	5	6	8	9	10	11	12	13	14	16	18	20	22	23	24	28	39	50	51	52
FERC Region	2	2	3	3	3	4	4	4	4	5	5	5	6	6	7	7	8	8	3	7	6	7	5
Power Generation Data																							
No. of Units (Boilers)	2	2	3	3	6	5	2	4	2	3	4	5	3	4	2	3	2	2	2	2	5	1	4
Generating Capacity (MW)	707	1800	185	1181	1981	209.5	1468	1064	674	1249	3160	1155	585	846.5	1166	2379	716	1636	1024	1020	919.5	447	1996
First Unit On-Line (Year)	1959	1965	1951	1967	1957	1937	1972	1958	1970	1970	1971	1957	1969	1955	1956	1977	1975	1971	1976	1977	1966	1982	1965
Last Unit On-Line (Year)	1976	1965	1958	1977	1978	1961	1977	1980	1977	1976	1975	1961	1979	1957	1978	1979	1976	1971	1978	1980	1980	1982	1970
Scrubbed Capacity (MW)	0	0	0	531	806	0	838	918	440	0	0	0	510	0	0	2379	716	0	0	0	485	447	0
Coal Data																							
Coal Rank (1)	B	B	B	B	B	B	B/S	S	L	B	B	B	B	B	S	L	S	S	S	B	B	L	B
Ash Percent	8.1	17.9	12.8	9.9	13.9	10.3	15.7	9.4	8.8	10.0	11.0	12.1	14.7	13.0	4.8	11.6	8.7	10.0	9.4	5.4	12.6	25.0	12.0
Sulfur Percent	1.8	1.67	3.4	2.54	4.59	2.66	5.39	1.14	0.58	2.2	1.7	1.0	1.61	2.10	0.33	1.1	0.78	0.50	0.49	0.35	3.91	2.4	1.11
1980 Coal (10^3 tons)Φ	800	4298	419	3441	3954	317	3457	2735	3601	2827	7171	2396	600	2009	2513	11,087	2506	3170	3604	2863	2109	2500	4708
Waste Generation Data																							
Ash (10^3 tons)	91.3	767.2	52.2	329	544.1	32	415	259.2	284	282.7	788	265	88.3	260	119.8	1330.4	217.6	382.7	252.7	150	337	625	549
FGD Sludge (10^3 tons)	0	0	0	239.3	522.2	0	511	151.9	134	0	0	0	14.3	0	0	538.9	107	0	0	0	256	596.9	0
Total Waste (10^3 tons)	91.3	767.2	52.2	568.3	1066.3	32	926	411.1	418	282.7	788	265	102.6	260	119.8	1869.3	324.6	382.7	252.7	150	593	1221.9	549
Waste Disposal Data																							
On-Site Disposal (10^3 tons)	0	639.2	3.0	568.3	1066.3	0	608	405.3	410	82.7	640.9	265	102.6	260	0.2	1642.5	324.6	274.7	218.3	74.8	568	1021.9	480.5
Off-Site Disposal (10^3 tons)	91.3	0	0	0	0	21	0	0	0	0	0	0	0	0	79.7	0	0	0	0	0	0	0	0
Ash Sold (10^3 tons)	0	128	49.2	0	0	11	318	5.8	8	200	147.1	0	0	0	39.9	226.8	0	108	34.4	75.2	25	200	68.5

(1) B (Bituminous); S (Sub-Bituminous); L (Lignite)

CITED REFERENCES

R3.1 "Evaluation of the Impacts of Proposed RCRA Regulations and Other Related Federal/Environmental Regulations on Utility and Industrial Sector Fossil Fuel-Fired Facilities, Utility Sector Phase I", U.S. DOE/ET/13543-TI (DE82008097), Prepared by Engineering-Science, November 1979.

R3.2 "Characterization and Environmental Evaluation of Full Scale Utility Waste Disposal Sites", U.S. EPA Contract No. 68-02-3167 Research Tringle Park, prepared by Arthur D. Little, Inc., Preliminary Draft - March, 1984

R3.3 "Background Data on Utility Sector Fossil Fuel-Fired Facilities", U.S. DOE, Prepared by Engineering-Science, Draft-March 1983.

OTHER REFERENCES

"EPA Utility FGD Survey: January-March 1980", PEDCo Environmental, Inc. EPA-600/7-80-0296; May 1980.

"Steam Electric Plant Factors - 1978", National Coal Association, 1978.

"Steam Electric Plant Factors - 1979", National Coal Association, 1979.

1981 Keystone Coal Industry Manual, G.F. Nielsen Editor, McGraw-Hill, Inc., New York, NY, 1981.

SECTION 4

CASE STUDY DISPOSAL COST DATA

INTRODUCTION

After completion of the 23 case study site visits (described in Section 3), cost estimates were prepared for the disposal of coal combustion residues (i.e., fly ash, bottom ash, boiler slag, and FGD sludge). This section presents a detailed description of the design assumptions for the waste disposal options, the methodology used to develop waste disposal costs, and the disposal costs associated with the 23 case study plants. As described in Section 1, these costs were developed to address the following four RCRA regulatory scenarios:

- current waste disposal practices in the utility industry for the year 1980, a baseline case (termed current practice)
- disposal of coal combustion residues as non-hazardous wastes under RCRA (termed non-hazardous)
- disposal of coal combustion residues as hazardous wastes under RCRA assuming a probable least cost of compliance (termed hazardous minimum)
- disposal of coal combustion residues as hazardous wastes under RCRA assuming a probable maximum cost of compliance (termed hazardous maximum).

As described in Section 2, the RCRA hazardous waste regulations have undergone numerous substantial revisions and there is considerable latitude for interpretation regarding specific cases. For these reasons, hazardous waste disposal costs were identified as a range from the least probable cost of compliance (referred to as hazardous minimum) to the maximum probable cost of compliance (referred to as hazardous maximum).

For the purposes of this section, only key design information for the 23 case studies are presented. Full descriptions of each of the 23 utility sites are presented in the individual case study reports which are located in Appendix H of this report (Volumes 2 and 3).

MAJOR DESIGN ASSUMPTIONS

At the outset of the project, ES realized that a number of design assumptions would have to made to complete the 23 case study engineering designs and cost estimates. To provide a concensus for our assumptions, Engineering-Science received assistance from the Utility Advisory Task Force, which had been established to assist in the selection of the case study sites. A major review meeting of the Utility Advisory Task Force was held during February 1982. The minutes of that meeting are summarized in Appendix D. A summary of the conclusions and recommendations of the task force is presented in the following subsections.

General Design Assumptions

The following design assumptions were agreed upon during the task force meeting and applied to current practice, non-hazardous, hazardous minimum, and hazardous maximum regulatory scenarios developed for the 23 case studies:

- All the designs - current practice, non-hazardous, and hazardous minimum and maximum, should be based on a 35-year design life for the waste disposal facilities.
- The costs of converting existing wet ash and FGD sludge handling to dry handling would be incorporated into all the 23 designs if it could be shown to be cost effective over the design life of the disposal facilities.
- All designs would include capital and operating costs for handling the ash downstream of the plant's storage silos, but not the costs of the silos themselves.
- The EPRI Manual entitled, "Technical Assessment Guide" would be used for all economic analyses since the levelizing techniques are known throughout the industry (R4.1).

Current Practice

The current practice regulatory scenario was defined as a baseline disposal case for the year 1980 against which other more stringent disposal scenarios would then be compared. The collection of actual disposal cost data from each of the 23 case study plants was initially considered. This approach was subsequently dismissed since the existing waste disposal facilities at each site would have varying design lives, construction materials, and accounting procedures and thus making any attempt at normalization impossible.

The selected procedure to quantify current practice costs entailed the preparation of engineering designs based on the existing conditions and waste disposal practices encountered at each case study site. However, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices were defined as the present methods for handling and disposal of flyash, bottom ash and FGD sludge, as determined during the site visit. The "existing practice" information gathered during the visit was then modified to develop a "current practice" design which would be standardized to meet the following design conditions:

- all waste disposal facilities would have a 35-year design life
- wet ash or FGD sludge handling facilities would be converted to dry handling if shown to be cost effective
- closure costs for impoundments and landfills would include a 12-inch layer of topsoil and a vegetative cover.

An example of a standardized "current practice" design for a surface impoundment is presented in Figure 4.1.

Non-Hazardous Design

As explained in Section 2, RCRA permits for non-hazardous wastes are issued by individual state regulatory agencies. The federal role is limited to establishment of minimum state design guidelines throughout the nation. The task of evaluating the non-hazardous regulations from a Federal standpoint therefore required considerable interpretation and assumptions. With the assistance of the Utility Advisory Task Force, the following requirements were selected as reasonable guidelines that

might be selected by state regulators if the non-hazardous guidelines in Parts 241 and 257 are applied to coal-fired utilities:

- Ground-water observation wells located around the periphery of "current" waste disposal sites would be required by 1985.
- A clay or membrane liner and cap would be required on any new ash or FGD disposal facility.
- Liners would not be required in existing permitted ash disposal facilities over their design life; however, a clay cap would be required during closure to minimize future leachate generation.
- Leachate detection would not be required for lined ash or FGD sludge disposal facilities.
- Ground-water observation wells would be required on all newly constructed ash and FGD sludge disposal facilities.

An example of the design basis for the non-hazardous case is illustrated in Figure 4.1.

The above requirements are cited as interpretations of how the existing non-hazardous guidelines might be implemented in the future. At issue is (1) how a regulator, in a particular state, would approach these issues in the future and (2) establishment of assumptions that, in the aggregate, are representative of conditions throughout the nation. For example, some of the above assumptions may not be reasonable for sites which are located in arid climates with very deep ground-water tables because of the small quantities of leachate generated and the high potential for contaminant attenuation in the soils below the disposal facility. The above assumptions should not be viewed as recommendations of how these regulations should be implemented. Instead, the assumptions should be viewed as being representative of non-hazardous waste disposal criteria on a national basis.

Hazardous Designs (Minimum and Maximum)

Along with its most recent (July 26, 1982) final regulations governing hazardous waste land disposal and surface impoundments, EPA also issued guidance documents to accompany the regulations (R4.2 and R4.3). These RCRA guidance documents present designs which, if submitted to EPA for approval, should receive a draft permit. Wherever

possible, Engineering-Science used these guidance documents to establish the design requirements for disposing of coal combustion residues as hazardous wastes. To address the latitude for interpretation of the hazardous waste regulations, two designs were identified to cover a probable range of compliance--hazardous minimum and hazardous maximum. The following is a listing of the major assumptions for each design estimate:

Design Factor	Hazardous Minimum	Hazardous Maximum
Closure of existing disposal facility	Same closure requirements as specified under the non-hazardous scenario	Same closure requirements as specified in the EPA guidance documents.
Liner System	Single liner system as specified in the EPA guidance documents. (Figures 4.2 and 4.4)	Double liner system system as specified in the EPA guidance documents. (Figures 4.3 and 4.5)

In the July 26, 1982 final regulations governing hazardous waste disposal, a limited exemption for existing disposal units was described. The exemption did not clearly address the type of disposal facility commonly used by utilities, i.e., surface impoundments. This was realized by EPA when the regulations were published, as indicated from the following excerpt (R4.4):

> "EPA does not currently have enough information to distinguish among various types and sizes of existing portions [of disposal facilities] to fashion a narrower exemption. EPA requests public comment about the scope of the exemption and welcomes suggestions about how this exemption can be better crafted to address those situations where substantial retrofitting would not be necessary or could be accomplished without causing environmental harm or excessive burdens or, alternately, where upgrading practices as existing facility may provide de minimis protection."

Given the current level of public interest concerning hazardous wastes, it seems unlikely that long-term disposal of these wastes would be permitted in existing facilities that did not conform to the appropriate design criteria. ES therefore evaluated the options of either

(1) closing the existing site and constructing a new disposal facility or (2) retrofitting the existing site to conform to the hazardous disposal requirements. Retrofitting was more economical in only one of the 23 case study plants. Until EPA can develop a more specific exemption on how to handle existing capacity of land disposal units, it is our judgement that EPA regional offices or state agencies will require closure of existing portions of land disposal units and construction of new disposal units.

In addition to the previous design assumptions, the Utility Advisory Task Force also addressed three other hazardous design considerations which applied to both the hazardous minimum and maximum cases, as follows:

- Hazardous landfill designs would have a cell life of not greater than five years.
- Leachate treatment would be provided on-site to collect and treat leachate generated at the land disposal units. In addition to the collection system installed at the land disposal unit, other capital cost items include transport of the leachate to a facility designed to treat leachate. A process flow diagram of a conceptual leachate treatment facility is presented in Figure 4.6). A detailed discussion of the facility cost is presented in Appendix E.
- Miscellaneous wastes such as coal pile runoff and boiler cleaning waste would be used for ash conditioning, bottom ash make-up water or other uses whenever practical.

For the purpose of this study, it was also assumed that no flyash, bottom ash or FGD sludge would be sold in the future if these wastes were declared hazardous by EPA. The rationale for this assumption was that the revenue received from the sale of these wastes would not offset the potential liability (whether actual or implied).

LFDESIGN MODEL

To efficiently execute the large number of repetitive designs and cost estimates which were required for this project, Engineering-Science developed "LFDESIGN," a computer-assisted design and costing technique.

LFDESIGN is a system of related computer programs developed to generate preliminary designs and cost estimates for the four utility waste disposal cases (i.e., current practice, non-hazardous, hazardous minimum and hazardous maximum). The LFDESIGN logic diagrams in Figures 4.7 and 4.8 illustrate the general sequence of program execution as well as the data and information flow. The logic incorporated into the various program functions is presented in detail in Appendix E of this report.

Due to the wide variety of conditions represented by the case study plants, the most practical approach for developing current practice and non-hazardous costs was to (1) perform the designs manually, (2) input the quantity take-off information, and (3) allow the computer to generate the specific cost information (see Figure 4.7). Since the hazardous designs were much more standardized than either the current practice or non-hazardous designs, it was possible for the LFDESIGN model to perform many more design quantity take-off calculations, as well as computing cost extensions (see Figure 4.8). Specific details on the manual quantity take-off information are presented in Appendix E.

CASE STUDY ENGINEERING REPORTS

Individual engineering studies were conducted for the utility sites visited and reports containing site-specific engineering designs were prepared for each of the 23 utility sites. LFDESIGN was utilized to assist the design engineers in the development of the various solid waste disposal costs. Copies of the 23 draft case study reports were returned to the utilities for the review and comment. The final revised engineering reports are presented in Appendix H (see Volumes 2 and 3). Table 4.1 summarizes pertinent design information which was utilized for the current practice, nonhazardous, and hazardous (minimum and maximum) designs.

Current Practice and Non-hazardous Designs

The current practice and non-hazardous waste quantities to be disposed varied between 2,400 and 2,059,000 tons/year (see Table 4.1). Seven of the plants already had dry ash handling facilities which met the minimum design assumptions (see General Design Assumptions in this section). The costs of converting the other 16 plants to dry handling facilities were incorporated into the designs where it could be shown to

be cost effective over the design life of the plant. For both the current practice and non-hazardous designs, 12 of the 23 plants required some capital expenditures to address waste disposal during the first 10 years, while seven of the plants required no capital expenditure over the entire 35-year design life. For the three plants which utilized clay in their existing waste disposal units, this practice was continued for any required expansion of current practice facilities. Nine of the case studies required additional land to meet the disposal requirements of the 35-year design life for the current practice and non-hazardous designs.

Hazardous Designs

Waste quantities to be disposed in the hazardous minimum and maximum scenarios for some of the case studies increased over quantities used for the current practice and non-hazardous scenarios (see Table 4.1). This is because ash waste that was currently sold under current practice and non-hazardous scenarios will have to be land disposed under the two hazardous scenarios.

Of the 16 case studies which had all or partial wet handling of ash in current practice, it proved to be cost effective in all but 2 cases to convert to dry ash handling for the hazardous scenarios. This is because most available land for future waste disposal is further away from the power plant making the operation of wet handling systems and surface impoundments more costly. Only Plants 10 and 13 utilize on-site surface impoundments for the hazardous design scenarios (see Table 4.1). The distances from the power plants to the impoundments are 1.25 and 1.0 miles, which were the two shortest distances of all of the plants investigated.

It was assumed that four plants would be able to dispose of their hazardous wastes within active strip mining areas by constructing landfills meeting RCRA hazardous disposal requirements. The remaining plants were assumed to use off-site landfills (see Table 4.1). The siting of these landfills was based on conversations with plant personnel and local geologists as well as the experience of the Engineering-Science design staff. Area requirements for the hazardous scenario case studies vary between 220 and 2,275 acres. The distances to the hazardous disposal sites from the plant sites vary up to 40 miles.

Other major design information presented in Table 4.1 includes the depth of hazardous waste in the disposal facility, the number of cells, cell life, etc. The variability of this information is primarily due to a number of factors including solid waste volume, ground water depth and site topography.

CASE STUDY COST DATA

Costs for current practice, non-hazardous, and hazardous disposal have been exerpted from the case study engineering reports (see Appendix H) and are summarized in Tables 4.2 through 4.5. These costs are presented as levelized costs in terms of constant 1980 dollars in accordance with the EPRI "Technical Assessment Guide" (R4.1), and as present worth costs. As explained earlier, the EPRI levelizing procedure is commonly used throughout the utility industry, while EPA utilizes present worth for most of its economic analyses.

Levelization is a standard electric utility industry financial analysis technique used to calculate the annual revenue requirements associated with investment alternatives. The levelized cost associated with a stream of actual costs is that constant value which, if expended every year over the period of analysis, yields the same present value as the series of actual costs. A levelized cost is what financial analysts term an annuity. Real annuities are constant in real (constant dollar) terms and increase at the rate of inflation in nominal (current dollar) terms.

The levelized value of a cost stream may be calculated by dividing the present value of the cost stream by the sum of the discount factors used for the present value calculation. Thus for this project, where a real annuity was used as the levelized cost function, the sum of the real discount factors were used to calculate the levelized value of the cost stream. Assumptions used in the levelization procedure were as follows:

- Total Nominal Return - 8.4%
- Inflation Rate - 6%
- Total Real Return - 2.3%

A detailed discussion of the levelization procedure for capital and O&M cost components are presented in Appendix E, Section 4.0.

The design period of interest for the entire project was 35 years from 1980 to 2014. For the purpose of this evaluation, it was assumed that RCRA would be implemented in 1980 and for simplicity that compliance would also be required immediately. Questions were raised during the report review about the timing of future permits issued by EPA and the length of time plants would be operating under interim status. Both of these issues impact overall cost when considering the time value of money since they tend to postpone compliance expenditures.

These issues were addressed as follows. The ultimate objective of this study was to develop an indication of the eventual national economic impact resulting from the RCRA regulations. The word "eventual" is critical because (1) it was not known what EPA's schedule would be for implementing the RCRA regulations on the utility industry, and (2) ES wanted to avoid the kind of economic analysis which considers only near-term impacts while burdening future generations with the costs of these regulations. The year 1980 was chosen as the base year for normalizing costs because it was the most recent year for which accurate ash production data was available.

Current Practice Costs

For the 23 case studies, the current practice levelized unit costs varied from $3.15/ton (dry weight basis) for Plant 10 to $14.35/ton for Plant 2 (see Table 4.2). These wide differences in current practice costs were a function of many factors, the most important of which were (1) existing design life of the facilities and (2) distances required for off-site disposal. In the case of Plant 10, no appreciable capital expenditures were required; whereas all wastes from Plant 2 were disposed 15 miles off-site, thereby indicating a relatively high unit disposal cost. The median current practice levelized unit disposal cost was $6.46/ton for Plant 6 which was equivalent to a levelized revenue of $5.4 million per year for waste disposal. Total revenue requirements varied between $14,000/year (Plant 4) and $14.3 million/year (Plant 22) - (see Table 4.2).

Non-Hazardous Disposal Costs

The non-hazardous levelized unit costs varied from $4.18/ton (dry weight basis) for Plant 9 to $25.36/ton for Plant 4 (see Table 4.3). Plant 9 had a low non-hazardous unit cost because it would require only ground-water monitoring under the non-hazardous regulations while Plant 4 had the highest non-hazardous unit cost because it had a large fly ash pond which would require closure. The median non-hazardous levelized unit disposal cost was $8.01/ton for Plant 5, which is equivalent to a levelized revenue requirement of $7.1 million per year for waste disposal. Total levelized revenue requirements varied between $61,000/year (Plant 4) and $15.6 million/year (Plant 22) - (see Table 4.3).

Hazardous Disposal Costs

As described previously, costs for hazardous waste disposal were developed as a range based on the probable minimum and maximum costs of disposal. These results are presented in Tables 4.4 and 4.5, respectively. For the hazardous minimum design, Plant 51 had the lowest unit disposal cost, $10.26/ton (dry weight basis), while Plant 8 had the highest unit cost, $54.23/ton. The low unit cost for Plant 51 results from the disposal of wastes in an active strip mine, a relatively inexpensive approach even with landfill cells designed to meet RCRA hazardous disposal regulations. Plant 8, on the other hand, would have to locate its landfill off-site resulting in a very high unit disposal cost. Also, Plant 8 produced substantially smaller waste volumes than Plant 51, further increasing its disposal cost per ton.

For the hazardous maximum condition (see Table 4.5), Plants 8 and 51 also had the highest and lowest unit disposal costs. Unit costs were $11.71/ton (Plant 51) and $71.32/ton (Plant 8).

COMPARATIVE ANALYSIS OF MAJOR COST ELEMENTS

The results described previously indicate a wide range of waste disposal unit costs within each broadly defined regulatory scenario (current practice, non-hazardous, and hazardous minimum and maximum). It is useful to investigate the various components of these costs to determine which ones have the greatest impact on the "total costs."

This study therefore included evaluations of the following cost elements:

- o capital versus O&M costs
- o specific design assumptions used in estimating current practice, non-hazardous and hazardous disposal costs
- o significance of economies of scale

Capital Versus O&M Costs

A comparison of capital versus O&M costs for the 23 case study sites is presented in Table 4.6. For current practice disposal, almost all the costs are associated with operation and maintenance expenses. As the design criteria become more stringent (i.e., going from current practice to hazardous maximum), the costs become more capital intensive. This increase in capital requirements could have a significant financial impact on the utility industry; this potential impact will be addressed in the final Phase I Utility Report.

Specific Design Assumptions

Table 4.7 provides a comparison of specific cost components within each design scenario for two plants -- one using a landfill for hazardous waste disposal (Plant 18), the other using a surface impoundment (Plant 13). A careful review of these data indicate the following conclusions.

1. Landfill disposal facilities are less capital intensive than surface impoundments.
2. The majority of the costs for dry disposal using current practice and non-hazardous criteria are for ash handling and the land disposal operation.
3. Ash handling represents the largest cost component for wet disposal using current practice and non-hazardous criteria.
4. The majority of the costs for hazardous disposal are for earthwork, the liner system, and ash handling.

As discussed earlier, the major differences in design assumptions between hazardous minimum and maximum were (1) the closure requirements

for existing facilities and (2) the use of single versus double liners for landfills and impoundments. Figure 4.9 shows how the difference between minimum and maximum levelized hazardous disposal cost for each case study site was divided into these two components. It can be seen that most of the difference is based on the additional costs associated with the double liner.

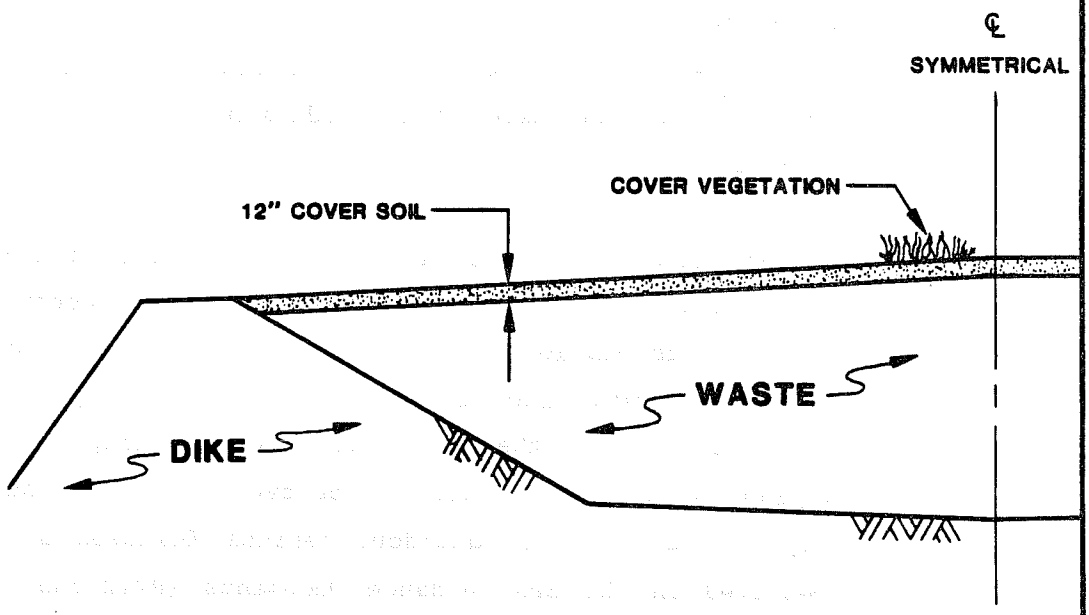
Economies of Scale

One of the major findings of the Phase I Interim Report (R4.5) was that unit disposal costs could be significantly affected by economies of scale, i.e., larger plants had lower per ton disposal costs than smaller ones. This relationship was also observed in reviewing Figures 4.10 through 4.13 which illustrates the trend for low unit disposal costs with increasing plant size. This trend was better defined in the case of hazardous disposal because the hazardous designs followed a fairly rigid format specified in the EPA Guidance Documents (R4.2 and R4.3). The current practice and non-hazardous designs were more site-specific.

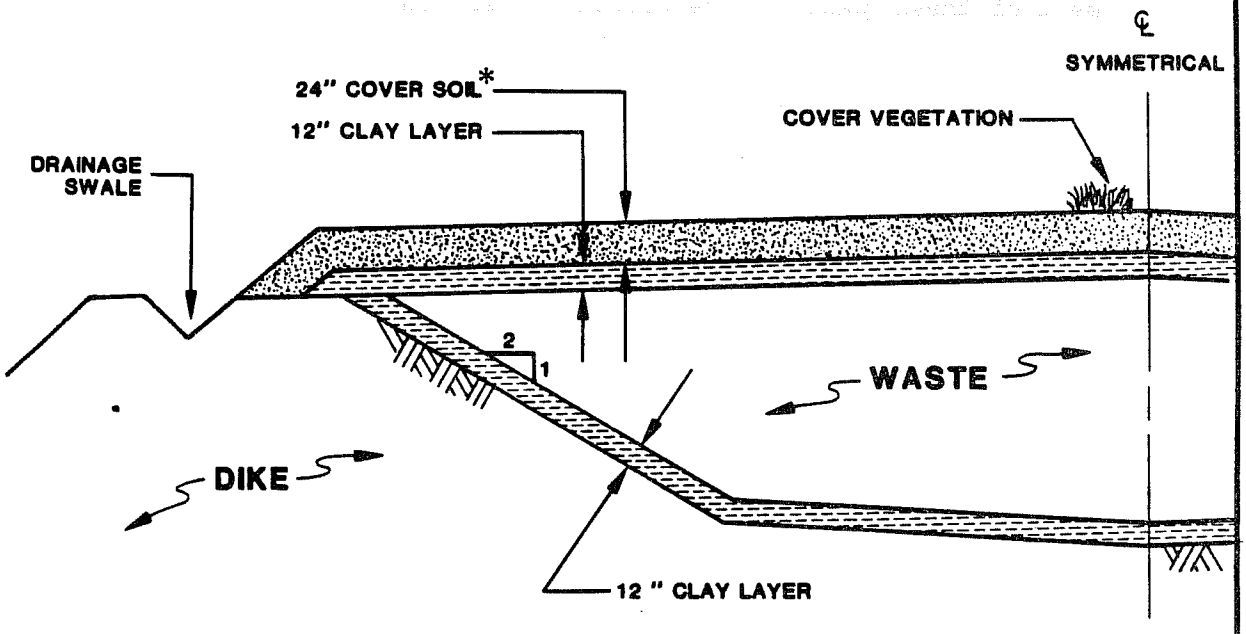
These conclusions regarding economies of scale precluded the use of unit disposal costs, a commonly used procedure to quantify industry wide impacts. To properly consider economies of scale, disposal cost models were developed using waste quantities as the independent variable. The development of these models is described in Section 5.

FIGURE 4.1

CURRENT PRACTICE SURFACE IMPOUNDMENT - TYPICAL HALF SECTION



NON-HAZARDOUS SURFACE IMPOUNDMENT - TYPICAL HALF SECTION

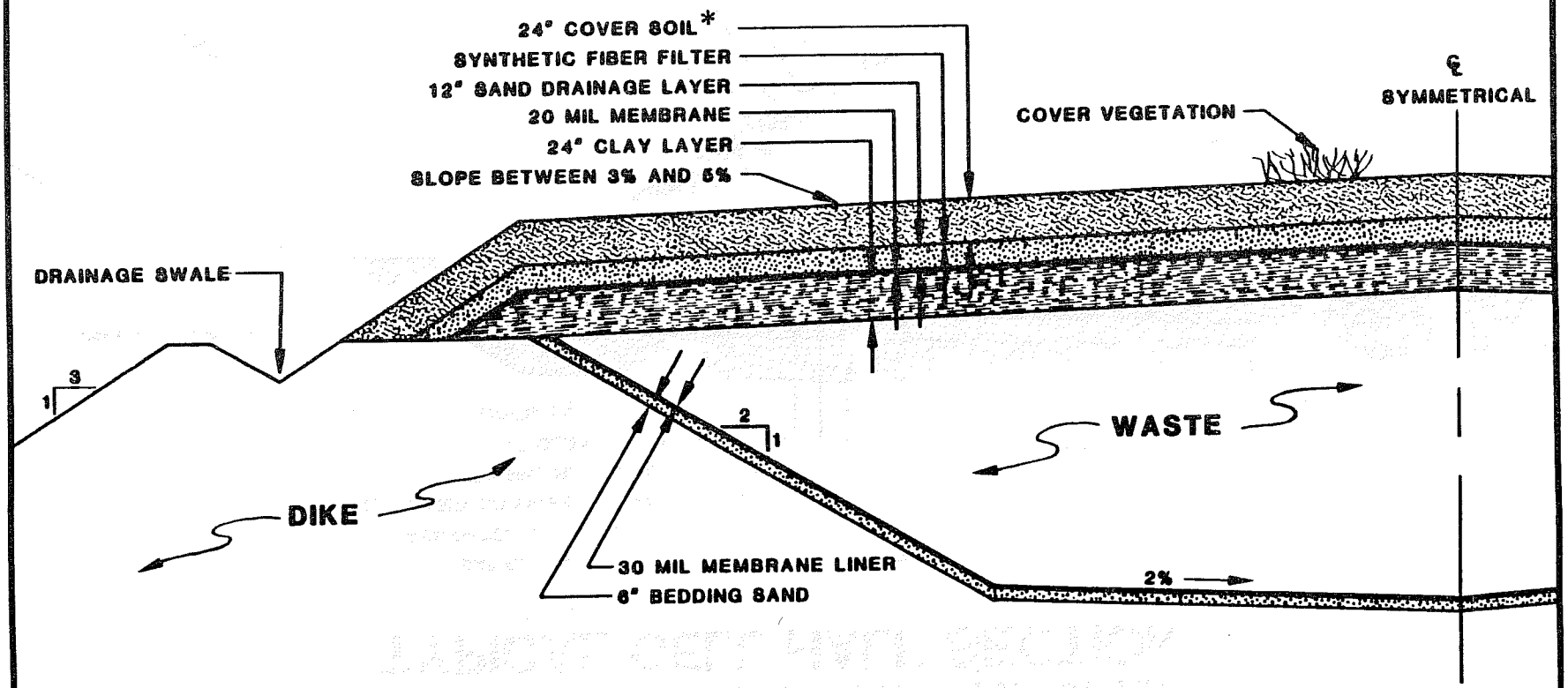


NOTE:

*24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

ES ENGINEERING-SCIENCE

HAZARDOUS MINIMUM SURFACE IMPOUNDMENT - TYPICAL CELL HALF SECTION

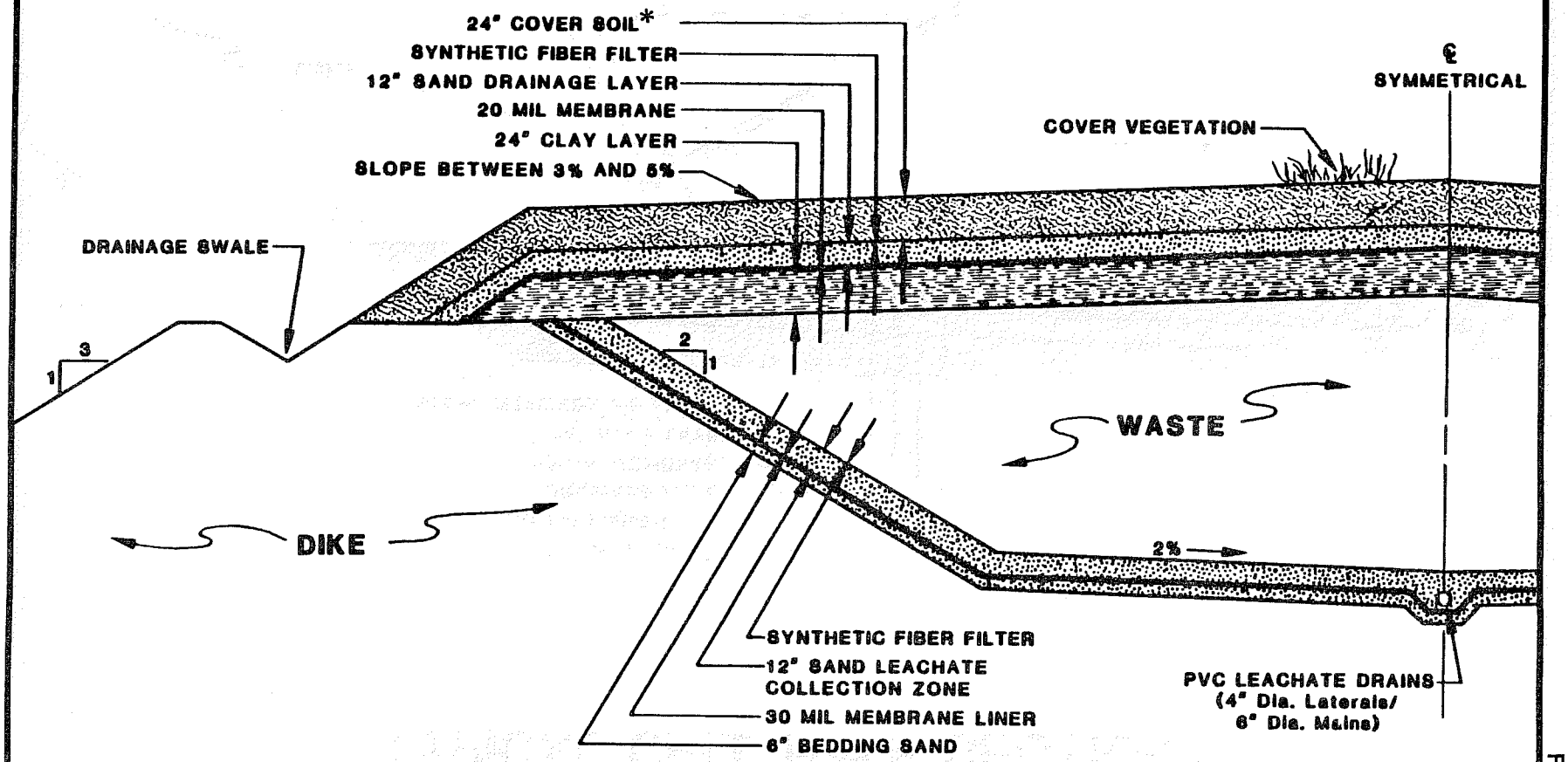


NOTE:

*24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.2

HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION

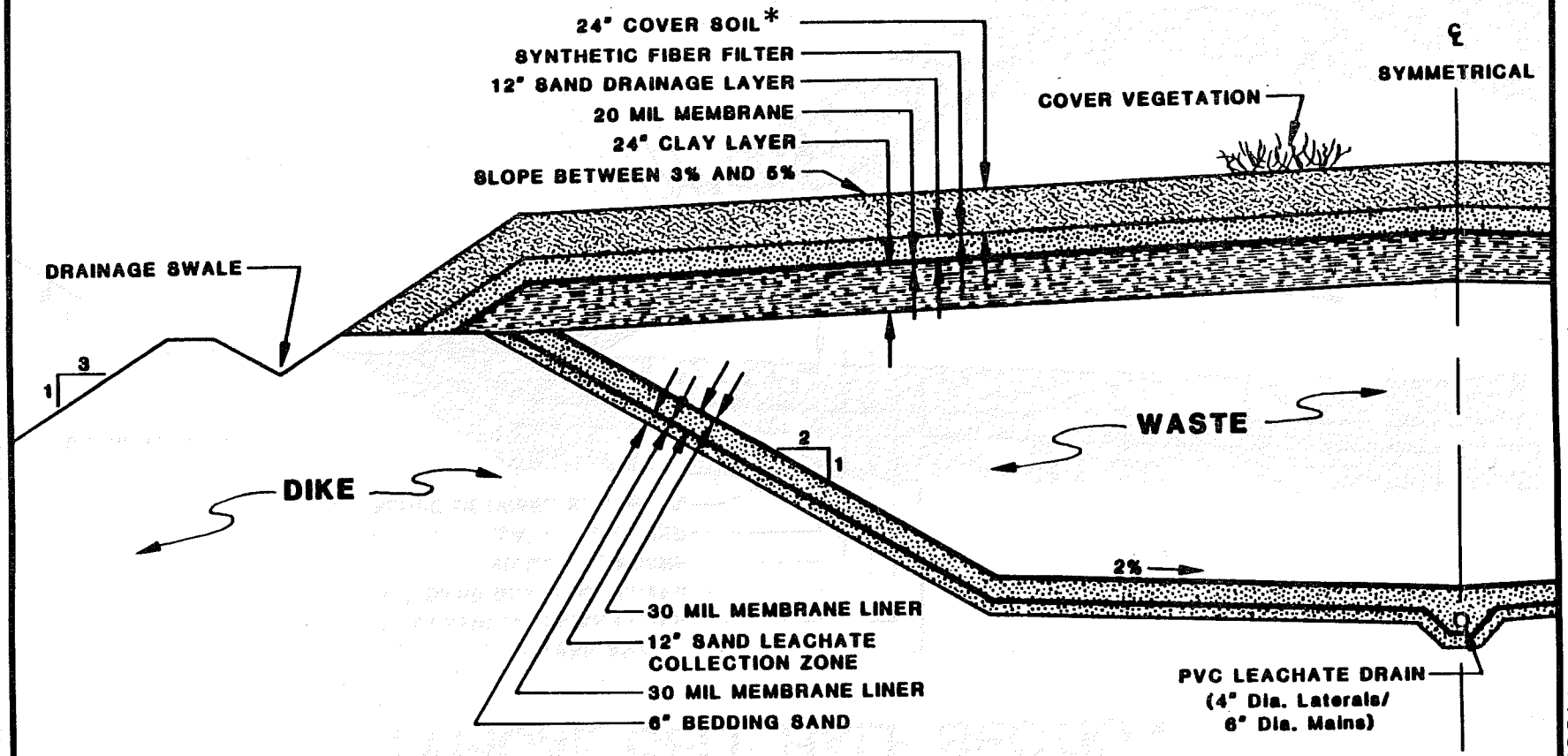


NOTE:

*24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.3

HAZARDOUS MAXIMUM SURFACE IMPOUNDMENT – TYPICAL CELL HALF SECTION

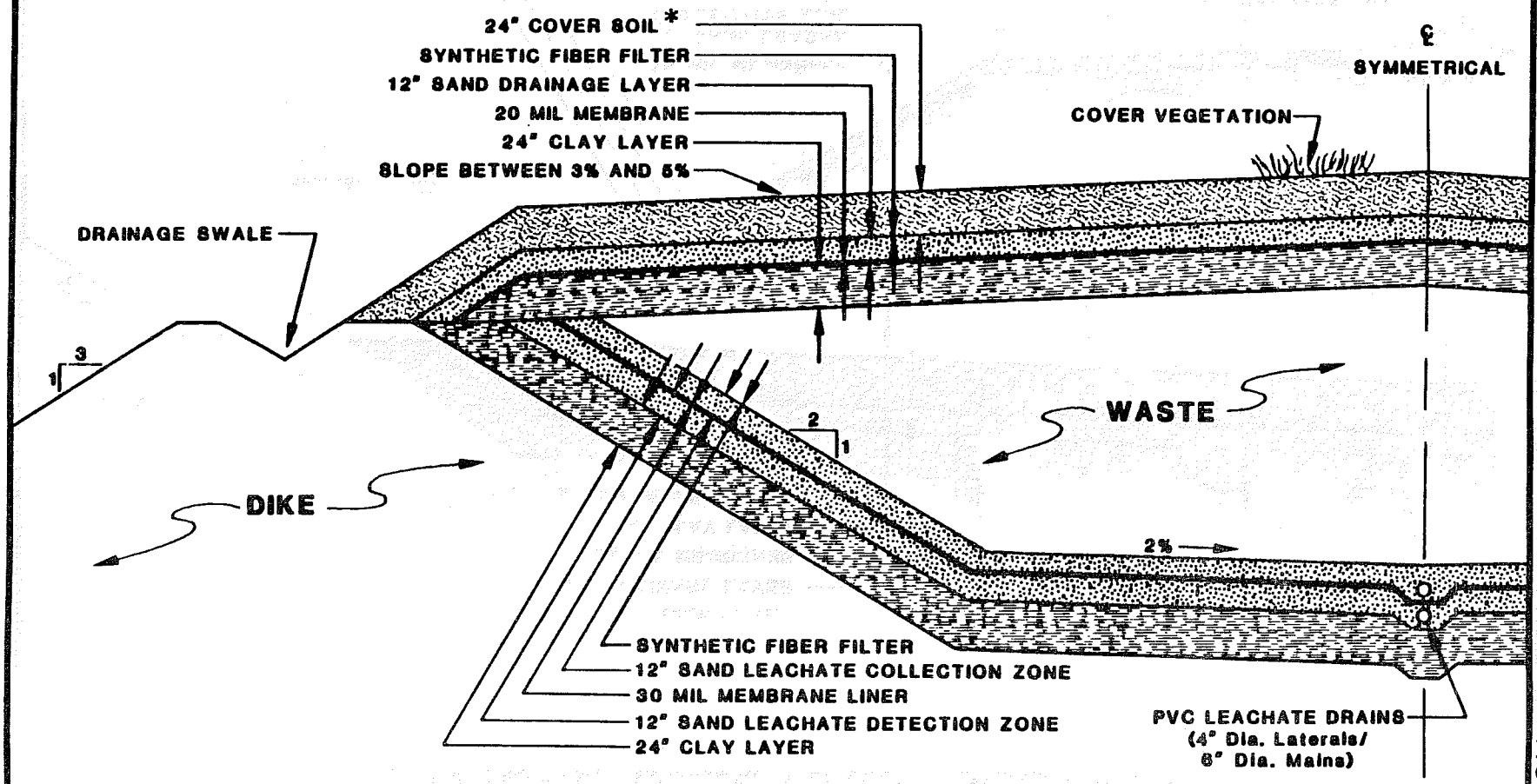


NOTE:

*24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.4

HAZARDOUS MAXIMUM LANDFILL - TYPICAL CELL HALF SECTION



NOTE:

*24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.5

FIGURE 4.6

Leachate Treatment Plant Process Flow Diagram

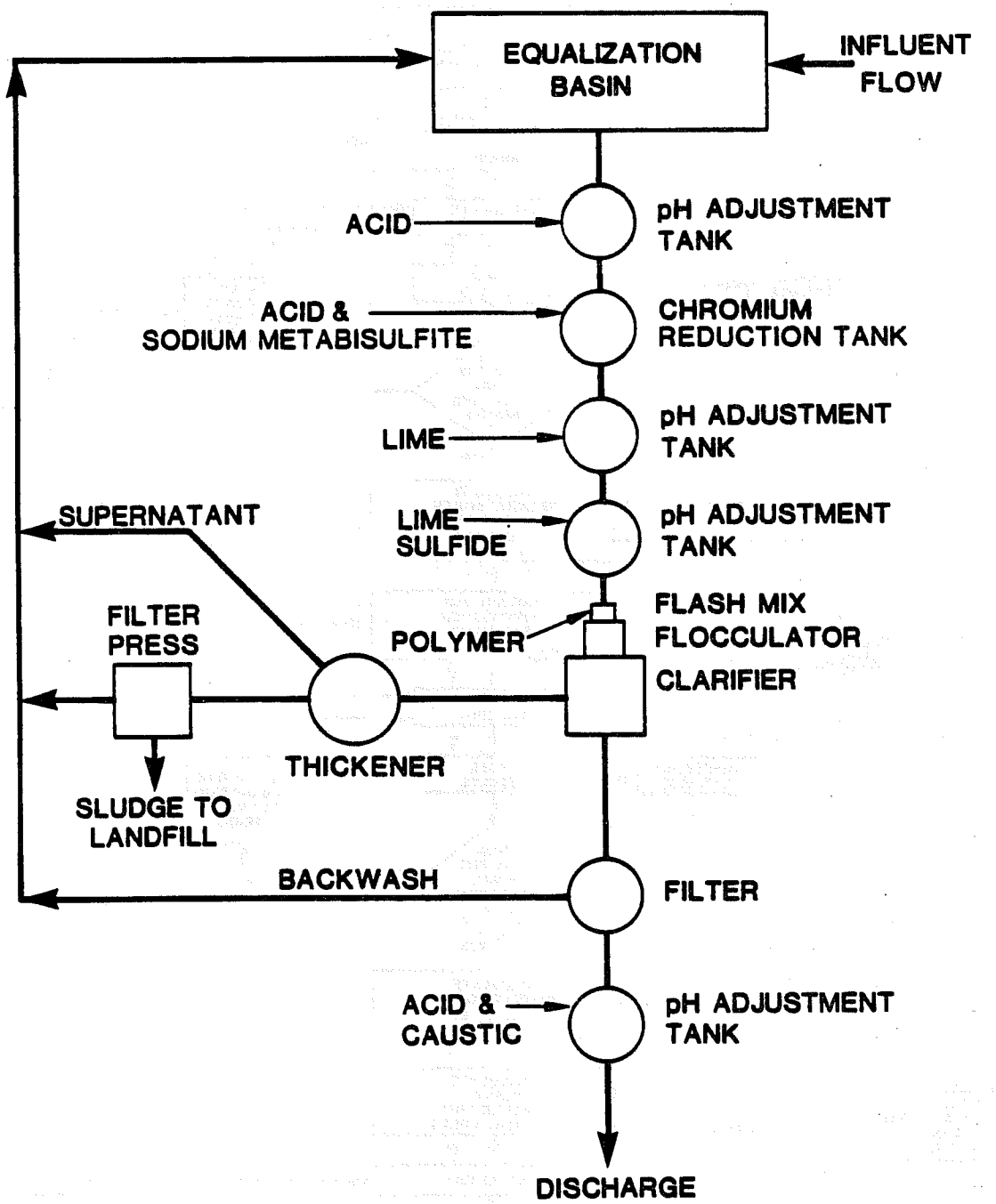
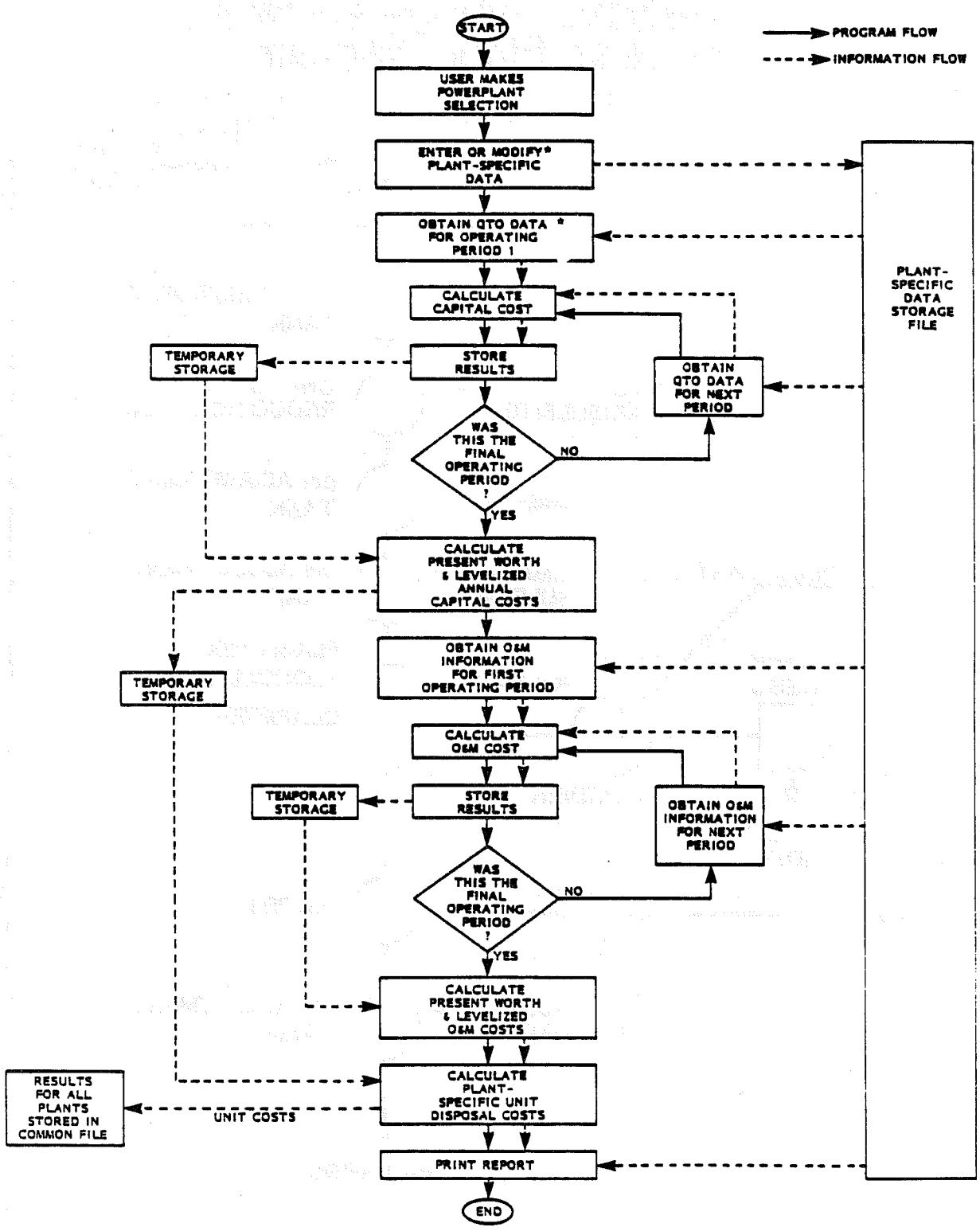


FIGURE 4.7

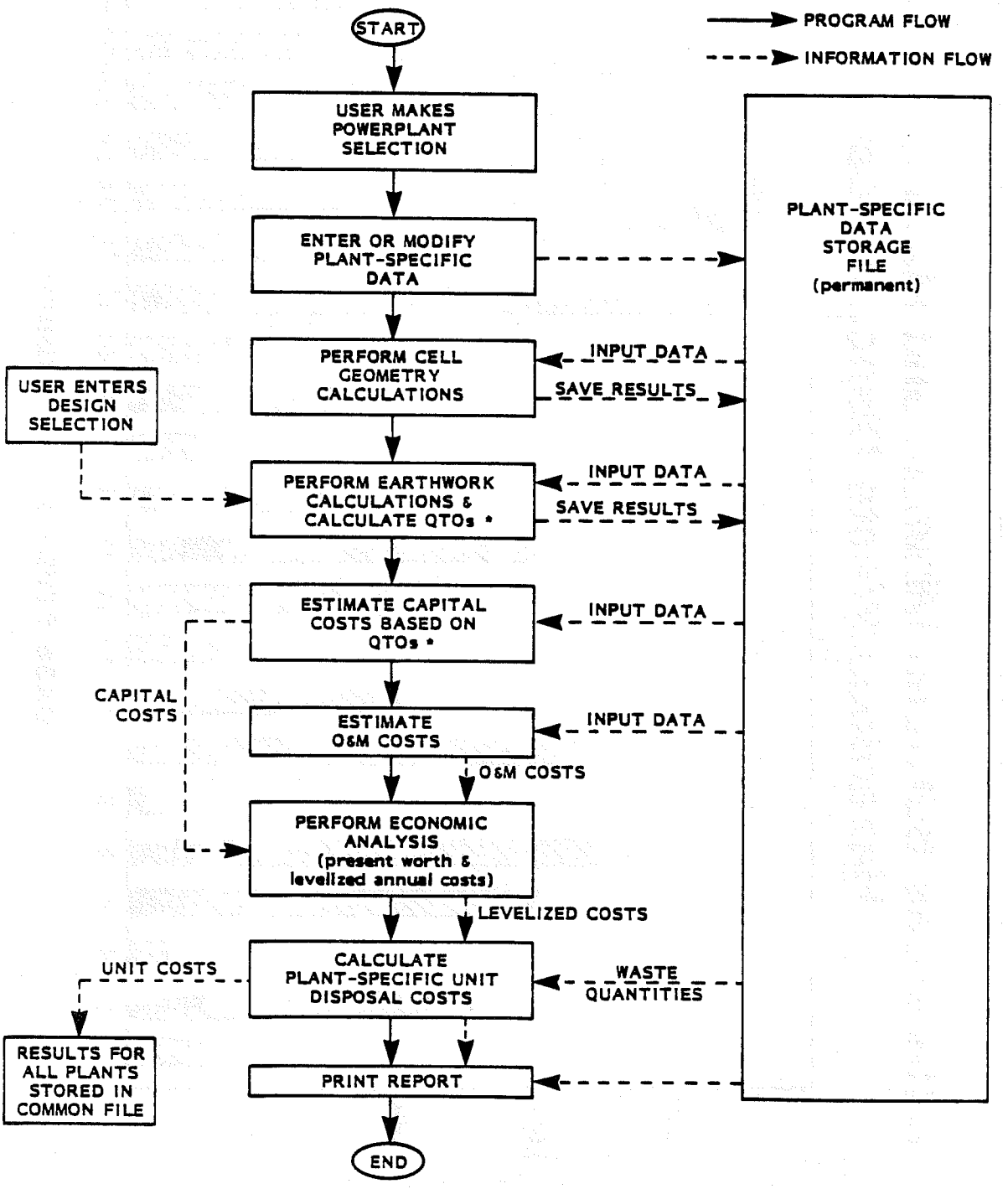
LFDESIGN Flow Diagram - Current Practice & Non-Hazardous Waste Disposal



* QTO - Quantity Take Off

FIGURE 4.8

LFDESIGN Flow Diagram – Hazardous Waste Disposal



* QTO - Quantity Take Off

FIGURE 4.9

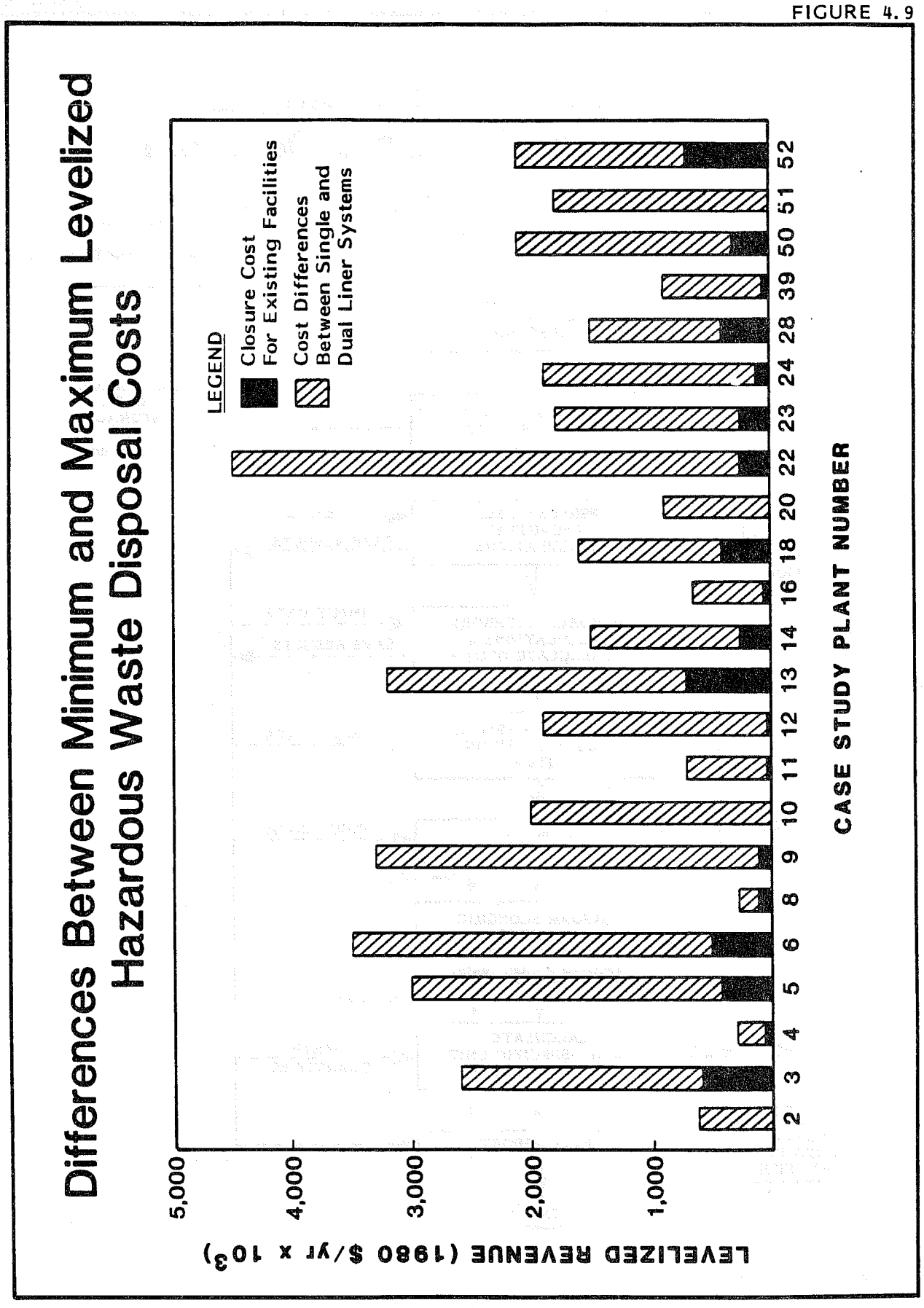

Differences Between Minimum and Maximum Levelized Hazardous Waste Disposal Costs
LEGEND
Closure Cost For Existing Facilities
Cost Differences Between Single and Dual Liner Systems
LEVELIZED REVENUE (1980 $/yr x 10³)
5,000
4,000
3,000
2,000
1,000
2 3 4 5 6 8 9 10 11 12 13 14 16 18 20 22 23 24 28 39 50 51 52
CASE STUDY PLANT NUMBER

FIGURE 4.10

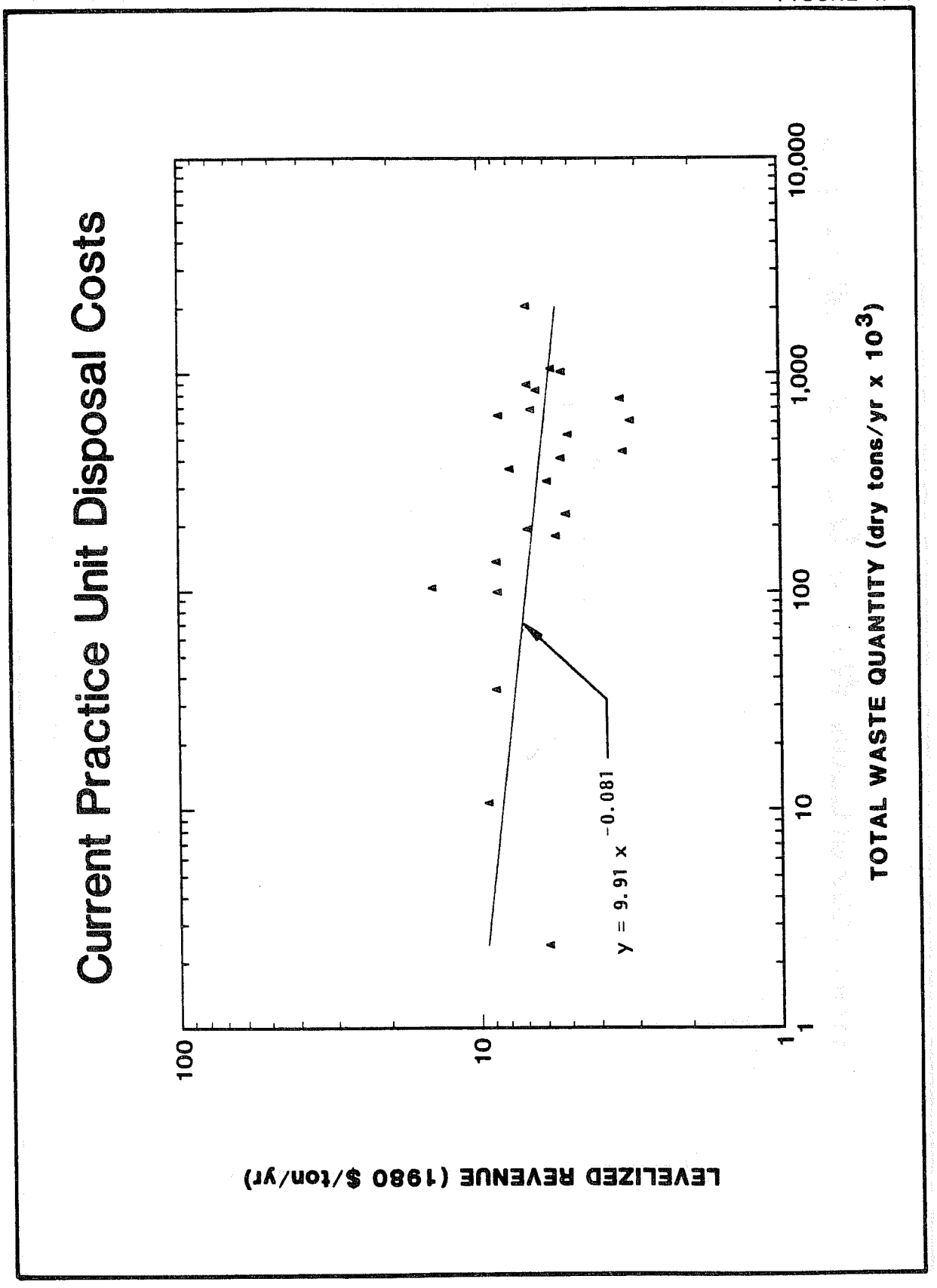

Current Practice Unit Disposal Costs
LEVELIZED REVENUE (1980 $/ton/yr)
100
10
1
1
10
100
1,000
10,000
TOTAL WASTE QUANTITY (dry tons/yr x 10^3)
y = 9.91 x^-0.081

FIGURE 4.11

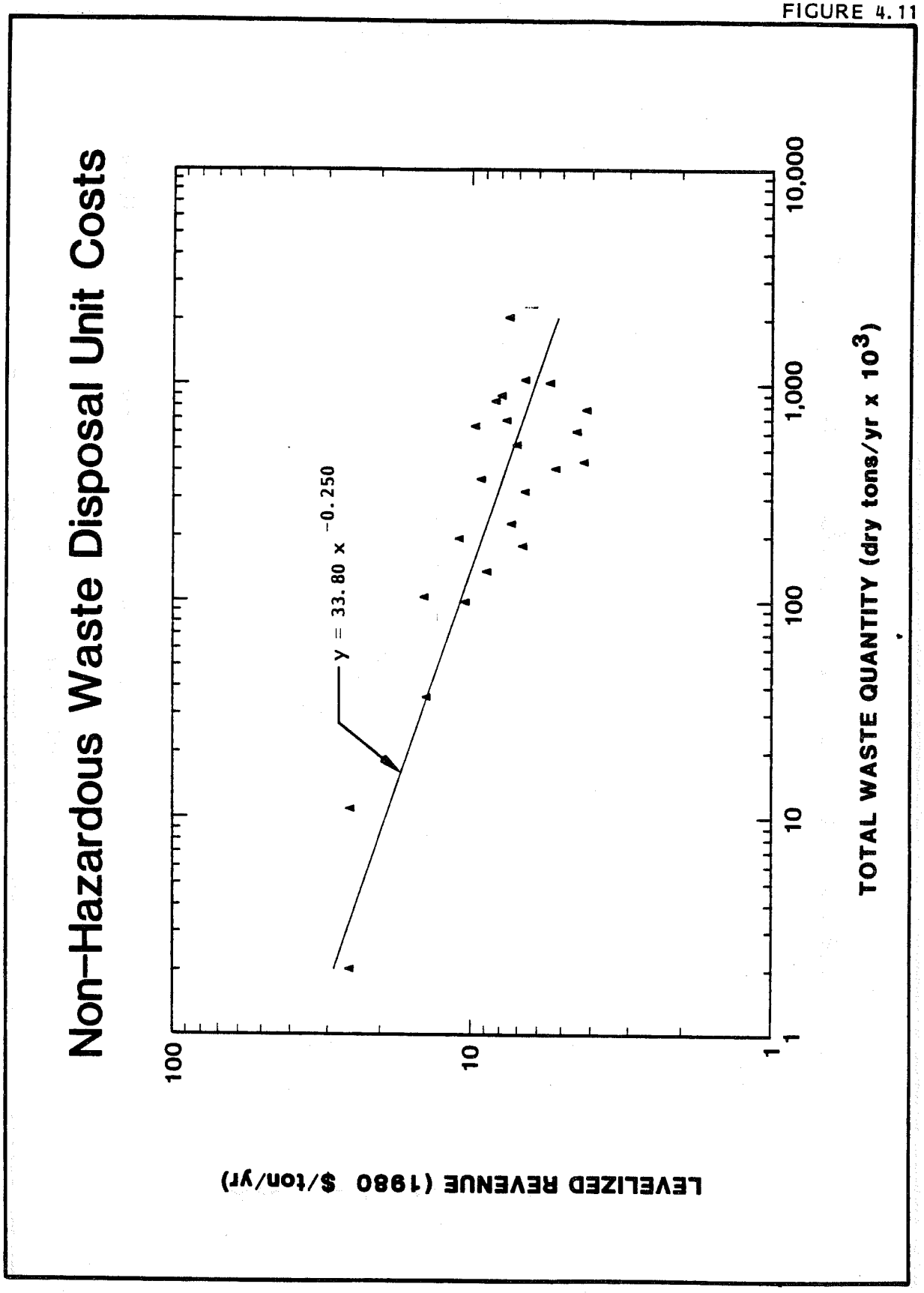

Non-Hazardous Waste Disposal Unit Costs
y = 33.80 x -0.250
LEVELIZED REVENUE (1980 $/ton/yr)
100
10
1
1
10
100
1,000
10,000
TOTAL WASTE QUANTITY (dry tons/yr x 10^3)

FIGURE 4.12

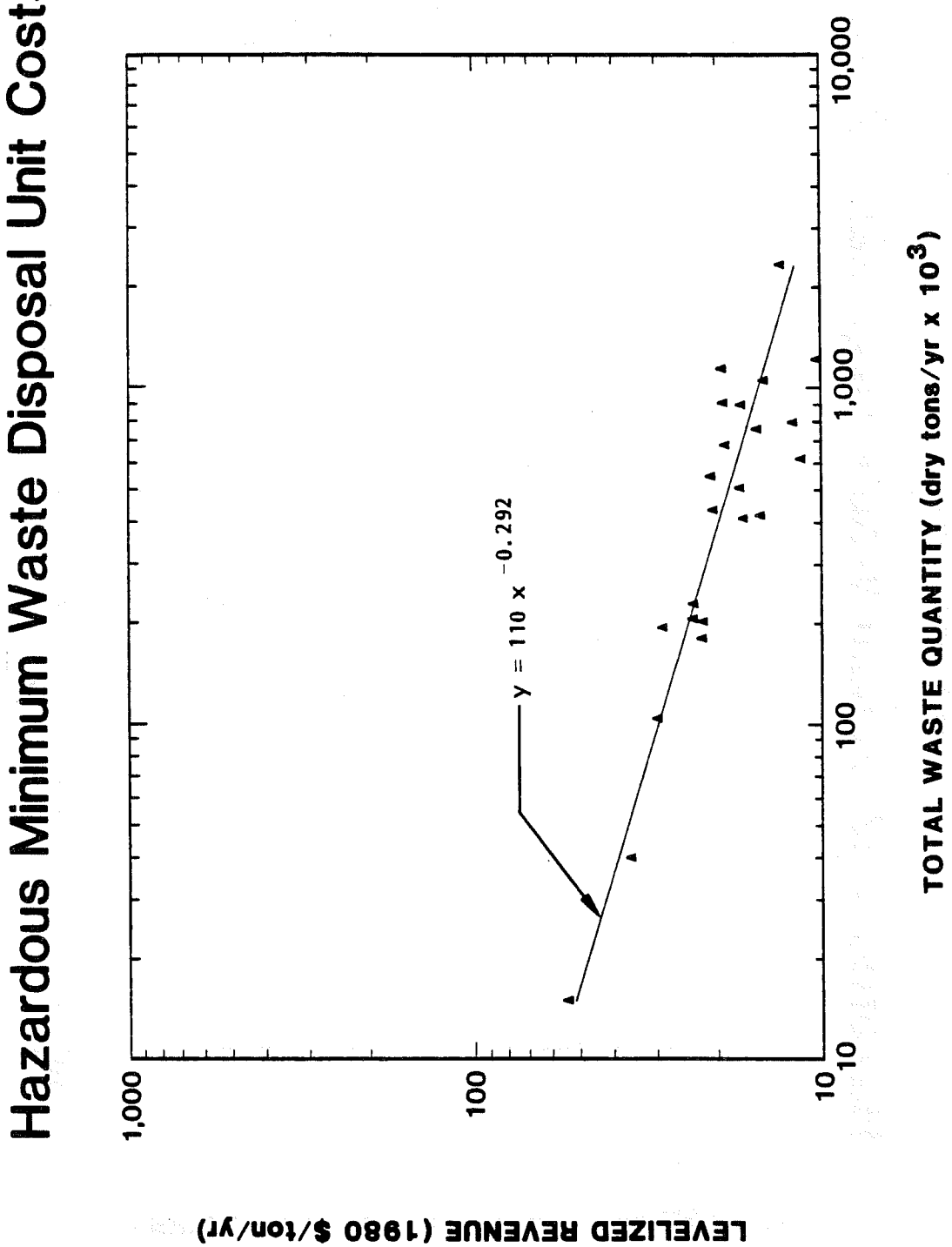

Hazardous Minimum Waste Disposal Unit Costs
LEVELIZED REVENUE (1980 $/ton/yr)
1,000
100
10
y = 110 x -0.292
10
100
1,000
10,000
TOTAL WASTE QUANTITY (dry tons/yr x 10^3)

FIGURE 4.13

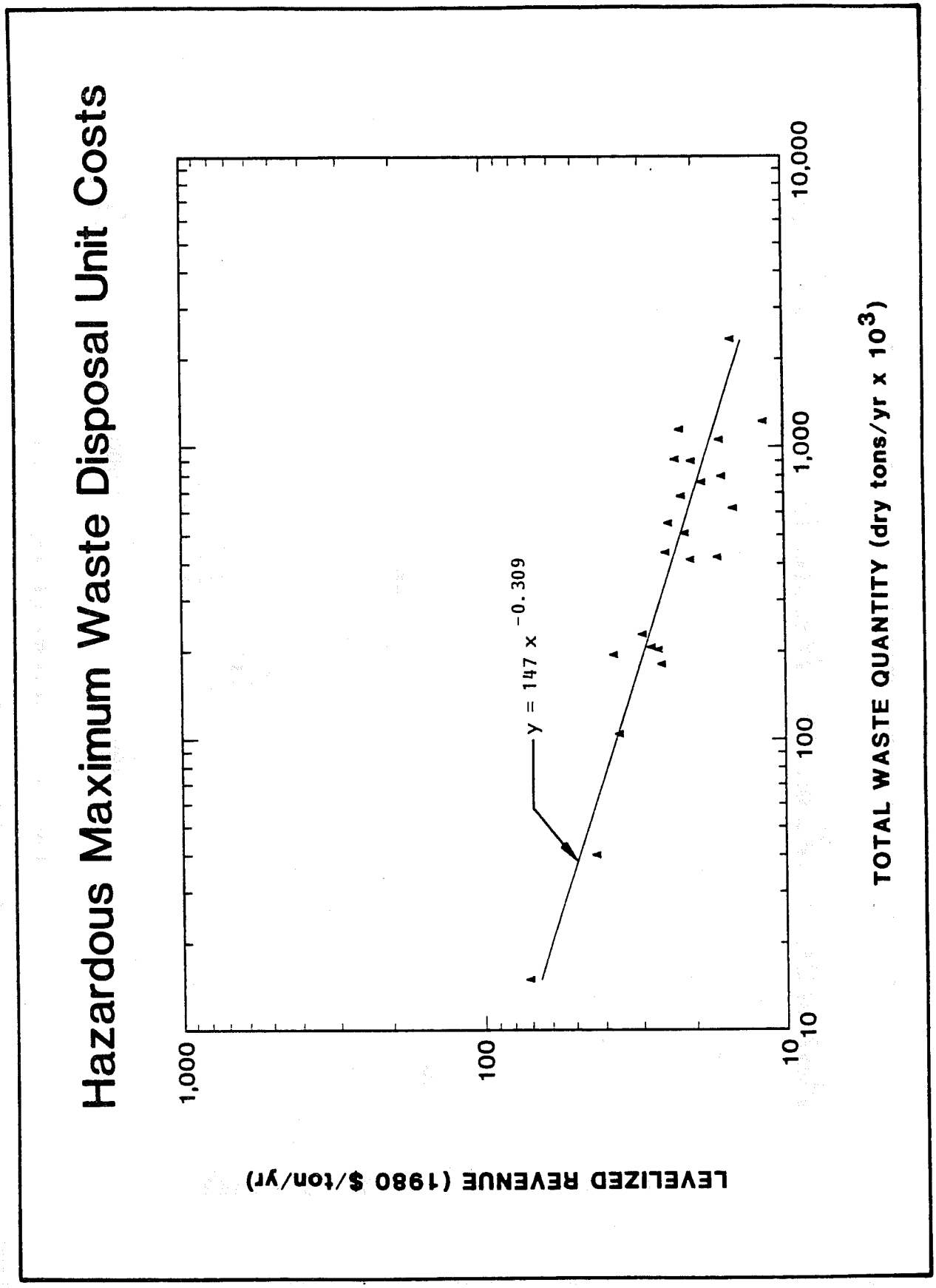

Hazardous Maximum Waste Disposal Unit Costs
LEVELIZED REVENUE (1980 $/ton/yr)
1,000
100
10
y = 147 x^-0.309
10
100
1,000
10,000
TOTAL WASTE QUANTITY (dry tons/yr x 10^3)

TABLE 4.1

SUMMARY OF DESIGN INFORMATION FOR CASE STUDY SITES

Design Information	Case Study Plant Number																						
	2	3	4	5	6	8	9	10	11	12	13	14	16	18	20	22	23	24	28	39	50	51	52
Current Practice																							
Waste Disposal Quantity (1000 ton/yr)	104	686	2.4	893	841	10.8	770	610	410	35.7	527	228	180	194	137	2059	1056	321	365	99.4	643	1022	441
Wet Handling	No	No	Yes	Some	Some	Yes	Some	Yes	No	No	Yes	Some	Yes	Yes	No	Some	Yes	No	Yes	Some	Some	No	Yes
On-Site Disposal	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Some	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of First Capital Improvement	NR	1981	NR	1981	1981	NR	2006	2006	NR	1992	1989	1988	1988	1980	NR	1986	1986	NR	1982	1991	1984	NR	1984
Additional Land Required	No	No	No	Yes	Yes	No	No	No	No	No	Yes	No	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	No	No
Clay Liner Used in Existing Facilities	No	No	No	No	No	No	Yes	Yes	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No
Non-Hazardous Designs																							
Waste Disposal Quantity (1000 ton/yr)	104	686	2.4	893	841	10.8	770	610	410	35.7	527	228	180	194	137	2059	1056	321	365	99.4	643	1022	441
Wet Handling	No	No	Yes	Some	Some	Yes	Some	Yes	No	No	Yes	Some	Yes	Yes	No	Some	Yes	No	Yes	Some	Some	No	Yes
On-Site Disposal	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Some	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of First Capital Improvement	NR	1981	NR	1981	1981	NR	2006	2006	NR	1992	1989	1988	1988	1980	NR	1986	1986	NR	1982	1991	1984	NR	1984
Additional Land Required	No	No	No	Yes	Yes	No	No	No	No	No	Yes	No	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	No	No
Clay Liner Used in Existing Facilities	No	No	No	No	No	No	Yes	Yes	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No
Clay Liner Specified for New Facilities	No	Yes	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	No
Ground-Water Monitoring for Existing Facilities	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hazardous Designs																							
Waste Disposal Quantity (1000 ton/yr)	104	756	39.8	893	905	15.0	1145	616	418	547	792	228	180	194	206	2343	1056	434	410	202	677	1222	505
On-Site Disposal	No	Yes	No	No	No	No	No	Yes	Yes	No	Yes	No	No	No	No	Yes	Yes	Yes	No	Yes	No	Yes	No
Site Area (acres)	220	978	220	1000	1420	100	1515	724	937	856	1328	660	760	647	480	2275	1085	1776	1098	463	1550	1090	900
Waste Disposal Unit	L	L	L	L	L*	L	L	SI	L	L	SI	L	L	L	L	L*	L*	L	L	L	L	L*	L
Distance to Landfill (Mi)	40	2	7.5	5	3	3	3	1.25	3	5	1	10	5.5	4	6.5	4	4	4	4	1	6	1	7
Ground-Water Limits Design	Yes	No	No	Yes	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes	Yes	No	No	No	No	No	Yes	No	No
Clay Available On-Site	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes	No	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Sand Available On-Site	No	No	No	Yes	No	No	No	Yes	No	Yes	No	No	No	No	Yes	No	Yes	Yes	Yes	No	No	No	No
Waste Depth (ft.)	40	40	25	35	40	20	40	30	40	35	35	40	40	40	25	40	40	40	40	40	30	40	40
Width of Dike (ft.)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
No. of Cells	7	10	7	14	15	3	14	7	9	8	7	8	7	7	7	20	15	12	7	7	12	18	10
Cell Life (years)	5	3.5	5	2.5	2.3	11.7	2.5	5	3.9	4.4	5	4.4	5	5	5	1.75	2.3	2.9	5	5	2.9	1.9	3.5

LEGEND:

NR - None Required thru the year 2014 L* - Landfill in Active Stripmine L - Landfill SI - Surface Impoundment

TABLE 4.2
CURRENT PRACTICE COST SUMMARY

Plant Number	35-Year Avg. Annual Waste (tons/yr x 10^3)	Total 35-year Waste Qty. (tons x 10^3)	Levelized Annual Revenue (1980 $/yr)					Present Worth (1980 $)				
			Capital Cost ($000)	O&M Cost ($000)	Total Revenue Req. ($000)	Unit Cost ($/ton)	Unit Cost ($/cu.yd.)	Capital Cost ($000)	O&M Cost ($000)	Total Cost ($000)	Unit Cost ($/ton)	Unit Cost ($/cu.yd.)
2	104	3,641	0	1,493	1,493	14.35	12.88	0	36,437	36,437	10.00	8.97
3	686	24,000	402	4,211	4,613	6.73	6.99	5,435	102,791	108,226	4.51	4.69
4	2	84	8	6	14	5.96	6.34	110	148	258	3.07	3.26
5	893	31,252	342	5,790	6,132	6.92	7.61	4,617	141,346	145,963	4.67	5.17
6	841	29,446	295	5,143	5,438	6.46	7.15	3,991	125,536	129,527	4.40	4.87
8	11	378	13	88	101	9.43	7.00	180	2,152	2,332	6.17	4.61
9	770	26,934	228	2,388	2,616	3.40	4.31	3,084	58,297	61,381	2.28	2.88
10	610	21,346	247	1,672	1,919	3.15	3.37	3,341	40,809	44,150	2.07	2.20
11	410	14,350	0	2,195	2,195	5.35	5.52	0	53,577	53,577	3.73	3.84
12	36	1,250	146	170	316	8.86	7.67	1,974	4,147	6,121	4.90	4.24
13	527	18,438	1,364	1,304	2,668	5.06	4.44	18,439	31,825	50,264	2.73	2.39
14	228	7,963	349	827	1,176	5.17	3.75	4,723	20,185	24,908	3.13	2.26
16	180	6,304	606	399	1,005	5.58	5.09	8,191	9,747	17,938	2.84	2.60
18	194	6,776	199	1,142	1,342	6.93	5.76	2,692	27,887	30,579	4.51	3.75
20	137	4,792	0	1,205	1,205	8.80	8.45	0	29,418	29,418	6.14	5.89
22	2,059	72,069	367	13,945	14,313	6.95	6.92	4,962	340,415	345,377	4.79	4.77
23	1,056	36,974	1,500	4,579	6,079	5.75	7.77	20,267	111,786	132,053	3.57	4.83
24	321	11,246	40	1,873	1,913	5.95	3.28	537	45,726	46,263	4.11	2.26
28	365	12,772	906	1,982	2,889	7.92	8.02	12,248	48,387	60,635	4.75	4.81
39	99	3,479	178	690	868	8.74	8.49	2,404	16,851	19,255	5.53	5.37
50	643	22,498	662	4,864	5,526	8.60	8.68	8,953	118,730	127,683	5.67	5.72
51	1,022	35,770	0	5,431	5,431	5.31	5.60	0	132,567	132,567	3.71	3.91
52	441	15,418	484	981	1,465	3.33	2.41	6,540	23,949	30,489	1.98	1.44

Note: Tons expressed on dry weight basis.

TABLE 4.3
NON-HAZARDOUS COST SUMMARY

Plant Number	35-Year Avg. Annual Waste (tons/yr x 10^3)	Total 35-year Waste Qty. (tons x 10^3)	Levelized Annual Revenue (1980 $/yr)					Present Worth (1980 $)				
			Capital Cost ($000)	O&M Cost ($000)	Total Revenue Req. ($000)	Unit Cost ($/ton)	Unit Cost ($/cu.yd.)	Capital Cost ($000)	O&M Cost ($000)	Total Cost ($000)	Unit Cost ($/ton)	Unit Cost ($/cu.yd.)
2	104	3,641	1	1,499	1,500	14.42	12.94	6	36,603	36,609	10.05	9.02
3	686	24,000	1,052	4,227	5,279	7.70	8.00	14,213	103,189	103,203	4.30	4.47
4	2	84	46	15	61	25.36	26.97	621	357	978	11.64	12.36
5	893	31,252	1,288	5,813	7,100	8.01	8.81	17,399	141,893	159,292	5.10	5.66
6	841	29,446	1,891	5,159	7,051	8.38	9.27	25,555	125,943	151,498	5.14	5.70
8	11	378	177	95	272	25.29	18.78	2,397	2,316	4,713	12.47	9.31
9	770	26,934	818	2,397	3,215	4.18	5.30	11,048	58,523	69,571	2.58	3.28
10	610	21,346	1,054	1,689	2,743	4.50	4.81	14,243	41,234	55,477	2.60	2.78
11	410	14,350	3	2,162	2,165	5.28	5.44	44	52,772	52,816	3.68	3.79
12	36	1,250	325	179	504	14.13	12.23	4,387	4,380	8,767	7.01	6.08
13	527	18,438	2,406	1,344	3,751	7.12	6.25	32,519	32,817	65,336	3.54	3.11
14	228	7,963	841	844	1,686	7.41	5.37	11,369	20,614	31,983	4.02	2.91
16	180	6,304	810	415	1,225	6.80	6.20	10,949	10,130	21,079	3.34	3.06
18	194	6,776	977	1,160	2,138	11.04	9.19	13,210	28,329	41,539	6.13	5.10
20	137	4,792	10	1,214	1,225	8.95	8.59	139	29,646	29,785	6.22	5.96
22	2,059	72,069	1,858	13,697	15,555	7.55	7.52	25,115	334,349	359,464	4.99	4.96
23	1,056	36,974	2,425	4,628	7,053	6.68	9.01	32,776	112,964	145,740	3.94	5.32
24	321	11,246	232	1,914	2,146	6.68	3.68	3,138	46,713	49,851	4.43	2.45
28	365	12,772	1,419	1,996	3,416	9.36	9.48	19,182	48,734	67,916	5.32	5.39
39	99	3,479	339	707	1,046	10.53	10.23	4,587	17,252	21,839	6.28	6.09
50	643	22,498	1,420	4,884	6,304	9.80	9.90	19,186	119,222	138,408	6.15	6.20
51	1,022	35,770	125	5,520	5,646	5.52	5.82	1,693	134,757	136,450	3.81	4.02
52	441	15,418	811	1,067	1,878	4.26	3.09	10,962	26,054	37,016	2.40	1.74

Note: Tons expressed on dry weight basis.

TABLE 4.4
HAZARDOUS MINIMUM COST SUMMARY

Plant Number	35-Year Avg. Annual Waste (tons/yr x 10^3)	Total 35-year Waste Qty. (tons x 10^3)	Levelized Annual Revenue (1980 $/yr)					Present Worth (1980 $)				
			Capital Cost ($000)	O&M Cost ($000)	Total Revenue Req. ($000)	Unit Cost ($/ton)	Unit Cost ($/cu.yd.)	Capital Cost ($000)	O&M Cost ($000)	Total Cost ($000)	Unit Cost ($/ton)	Unit Cost ($/cu.yd.)
2	104	3,641	1,841	1,261	3,102	29.80	32.18	24,874	43,311	68,185	18.73	20.21
3	756	26,453	7,829	3,751	11,580	15.32	19.16	105,793	128,792	234,585	8.87	11.09
4	40	1,393	1,028	389	1,417	35.60	46.29	13,889	13,364	27,253	19.56	25.45
5	893	31,252	10,148	5,054	15,202	17.03	20.60	137,141	173,525	310,666	9.94	12.02
6	905	31,661	13,042	4,314	17,356	19.19	22.29	176,239	148,127	324,366	10.24	11.91
8	15	525	664	149	813	54.23	48.32	8,972	5,130	14,102	26.86	23.92
9	1,145	40,090	16,221	5,953	22,174	19.36	25.92	219,206	204,376	423,582	10.57	14.14
10	616	21,549	5,788	1,257	7,045	11.44	12.21	78,217	43,160	121,377	5.63	6.02
11	418	14,630	3,715	2,558	6,273	15.01	18.52	50,204	87,812	138,016	9.43	11.64
12	547	19,159	8,052	3,363	11,416	20.85	22.43	108,818	115,480	224,298	11.71	12.60
13	792	27,710	7,852	1,684	9,536	12.05	10.57	106,109	57,828	163,937	5.92	5.19
14	228	7,963	4,040	1,294	5,334	23.44	20.40	54,591	44,426	99,017	12.43	10.80
16	180	6,304	2,865	1,130	3,995	22.19	24.27	38,711	38,802	77,513	12.30	13.46
18	194	6,776	4,336	1,239	5,575	28.80	28.76	58,596	42,543	101,439	14.97	14.96
20	206	7,214	3,402	1,448	4,850	23.53	27.46	45,971	49,714	95,685	13.26	15.47
22	2,343	82,019	19,118	11,438	30,556	13.04	15.13	258,358	392,691	651,049	7.94	9.20
23	1,056	36,974	9,701	5,769	15,469	14.64	19.77	131,092	198,057	329,149	8.90	12.01
24	434	15,194	6,731	2,197	8,928	20.56	14.01	90,956	75,424	166,380	10.95	7.46
28	410	14,350	4,330	2,573	6,903	16.83	20.46	58,516	88,329	146,845	10.23	12.51
39	202	7,070	2,927	1,518	4,445	22.00	25.29	39,553	52,111	91,664	12.96	14.90
50	677	23,685	8,304	4,532	12,836	18.97	23.09	112,223	155,595	267,818	11.31	13.76
51	1,222	42,770	7,793	4,747	12,540	10.26	12.72	105,305	162,994	268,299	6.27	7.77
52	505	17,679	6,205	2,490	8,695	17.21	15.02	83,850	85,483	169,333	9.58	8.35

Note: Tons expressed on dry weight basis.

TABLE 4.5
HAZARDOUS MAXIMUM COST SUMMARY

Plant Number	35-Year Avg. Annual Waste (tons/yr x 10^3)	Total 35-year Waste Qty. (tons x 10^3)	Levelized Annual Revenue (1980 $/yr)					Present Worth (1980 $)				
			Capital Cost ($000)	O&M Cost ($000)	Total Revenue Req. ($000)	Unit Cost ($/ton)	Unit Cost ($/cu.yd.)	Capital Cost ($000)	O&M Cost ($000)	Total Cost ($000)	Unit Cost ($/ton)	Unit Cost ($/cu.yd.)
2	104	3,641	2,469	1,261	3,730	35.83	38.70	33,365	43,311	76,676	21.06	22.72
3	756	26,453	10,451	3,751	14,202	18.79	23.50	141,229	128,792	270,021	10.21	12.76
4	40	1,393	1,314	389	1,703	42.78	55.63	17,752	13,365	31,117	22.34	29.05
5	893	31,252	13,129	5,054	18,183	20.36	24.64	177,421	173,525	350,946	11.23	13.59
6	905	31,661	16,529	4,314	20,843	23.04	26.77	223,359	148,127	371,486	11.73	13.63
8	15	525	920	149	1,069	71.32	63.54	12,434	5,130	17,564	33.45	29.80
9	1,145	40,090	19,516	5,953	25,469	22.24	29.77	263,735	204,376	468,111	11.68	15.64
10	616	21,549	7,792	1,257	9,049	14.78	15.68	105,298	43,160	148,458	6.89	7.36
11	418	14,630	4,460	2,524	6,984	16.70	20.62	60,266	86,656	146,922	10.04	12.40
12	547	19,159	9,962	3,363	13,325	24.34	26.17	134,617	115,481	250,098	13.05	14.04
13	792	27,710	11,080	1,684	12,764	16.12	14.15	149,732	57,828	207,560	7.49	6.57
14	228	7,963	5,506	1,294	6,800	29.89	26.01	74,407	44,426	118,833	14.92	12.98
16	180	6,304	3,512	1,130	4,642	25.78	28.20	47,463	38,802	86,265	13.68	14.98
18	194	6,776	5,961	1,239	7,200	37.19	37.15	80,548	42,543	123,091	18.17	18.14
20	206	7,214	4,291	1,448	5,739	27.85	32.49	57,991	49,714	107,705	14.93	17.42
22	2,343	82,019	23,595	11,438	35,032	14.95	17.35	318,846	392,691	711,537	8.67	10.06
23	1,056	36,974	11,527	5,769	17,295	16.37	22.10	155,768	198,057	353,825	9.57	12.92
24	434	15,194	8,622	2,197	10,819	24.92	16.98	116,518	75,424	191,942	12.63	8.60
28	410	14,350	5,866	2,573	8,438	20.58	25.01	79,267	88,329	167,596	11.68	14.18
39	202	7,070	3,811	1,518	5,329	26.38	30.32	51,497	52,111	103,608	14.65	16.84
50	677	23,685	10,387	4,532	14,919	22.04	26.83	140,368	155,595	295,963	12.50	15.21
51	1,222	42,770	9,560	4,747	14,307	11.71	14.51	129,191	162,994	292,185	6.83	8.46
52	505	17,679	8,345	2,490	10,835	21.45	18.71	112,773	85,483	198,256	11.21	9.79

Note: Tons expressed on dry weight basis.

TABLE 4.6

COMPARISON OF CAPITAL AND O&M COSTS AS A PERCENTAGE OF TOTAL COST

Plant Number	Current Practice		Non-Hazardous		Hazardous Minimum		Hazardous Maximum	
	Capital Cost	O&M Cost	Capital Cost	O&M Cost	Capital Cost	O&M Cost	Capital Cost	O&M Cost
2	0	100	<1	>99	38	62	45	55
3	5	95	13	87	46	54	54	46
4	35	65	57	43	53	47	60	40
5	3	97	12	88	45	55	52	48
6	3	97	17	83	55	45	61	39
8	6	94	48	52	67	33	74	26
9	4	96	12	88	53	47	57	43
10	6	94	21	79	65	35	72	28
11	0	100	<1	>99	37	63	42	58
12	32	68	49	51	50	50	55	45
13	38	62	50	50	66	34	74	26
14	19	81	34	66	57	43	64	36
16	46	54	51	49	52	48	57	43
18	9	91	31	69	60	40	67	33
20	0	100	<1	>99	49	51	55	45
22	1	99	8	92	40	60	45	55
23	17	83	23	77	42	58	46	54
24	<1	>99	5	95	56	44	62	38
28	22	78	30	70	41	59	49	51
39	13	87	20	80	45	55	51	49
50	7	93	14	86	43	57	49	51
51	0	100	<1	>99	40	60	45	55
52	23	77	29	71	51	49	59	41
Median Vales	7	93	21	79	50	50	55	45

TABLE 4.7

COMPARISON OF COST COMPONENTS FOR TYPICAL WASTE DISPOSAL FACILITIES

Cost Component	Current Practice (% of Total Cost)		Non-Hazardous (% of Total Cost)		Hazardous Minimum (% of Total Cost)		Hazardous Maximum (% of Total Cost)	
	Plant 18	Plant 13	Plant 18	Plant 13	Plant 18	Plant 13	Plant 18	Plant 13
Capital Costs								
Earthwork	1	7	2	5	19	12	20	10
Sand & Filter Fabric	0	0	0	0	11	15	12	19
Synthetic Membrane & Clay	0	0	9	3	16	28	18	30
Leachate Collection System (Piping, Sump & Treatment)	0	0	0	0	3	0	3	1
Land	<1	4	<1	3	2	3	2	2
Closure	5	9	18	27	2	4	7	8
Miscellaneous	2	18	2	12	6	4	5	3
Totals	9	38	32	50	59	66	67	73
O&M Costs								
Ash Handling	43	62	32	49	17	27	13	21
Transportation	0	0	0	0	5	0	4	0
Land Disposal Operation	48	0	35	0	5	0	4	0
Administrative	0	0	0	0	3	3	3	3
Post Closure	0	0	0	0	6	4	5	3
Miscellaneous	0	0	<1	1	5	0	4	0
Totals	91	62	68	50	41	34	33	27

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SECTION 5

REGIONAL AND NATIONAL WASTE DISPOSAL COSTS

INTRODUCTION

The objective of Phase I of this project is to determine the national costs for disposing of coal combustion residues from utility owned power plants for the year 1980. These disposal costs are based on projected cost impacts from RCRA and other pertinent Federal environmental regulations (described in Section 2) and the waste disposal costs estimated for the 23 case study plants (presented in Section 4).

The methodology used to develop national disposal costs was to generate four mathematical models (one for each regulatory scenario, e.g., current practice, etc.) using a regression analysis. The model variables were based on waste quantity and disposal cost data from the 23 case study plants. Thereafter, the models were evaluated using statistical techniques (analysis of variance, residual analysis and outlier analysis) to substantiate the fact that the variables selected for the models accounted for the majority of the observed variability and that none of the individual case studies exerted an undue influence on the models. The specifics of the above methodology are presented in the following section.

RCRA UTILITY COST MODELS

As described in Section 3, a total of 23 case study sites were carefully selected by the Utility Advisory Task Force to be representative of the broad range of conditions prevalent in the coal-fired utility industry. This was done to permit extrapolation of the cost estimates presented in Section 4 to the entire population of 396 coal-fired power plants with capacities of greater than 25 MW. A detailed comparison of the case study plant characteristics of the utility industry as a whole, is presented in Section 3.

A variety of common statistical approaches were investigated in order to develop RCRA utility cost models which would be most representative of the actual waste disposal costs for all 396 coal-fired utility power plants. The objectives were to find a model that (1) was reasonably representative of the 23 data points, (2) used a relatively simple mathematical relationship, and (3) used the same mathematical form for all four waste disposal scenarios (current practice, non-hazardous, and hazardous minimum and hazardous maximum).

Alternative Mathematical Forms

Several alternative cost models were developed using a linear least squares regression analysis of waste quantity and cost estimates for the 23 case study plants. The regression models were derived and evaluated in the following successive steps:

1. Total utility annual waste quantity (in terms of dry weight) was selected as the most applicable independent variable. Total annual levelized costs for waste disposal was selected as the most applicable dependent variable. Various data transformations were tested to determine which of the first order regression models that were examined provided the best fit.
2. Analysis of variance (ANOVA) and residual analysis were performed on the best fit models to determine if they adequately described the data.
3. The data were evaluated for outliers and for data points that might bias or disproportionately influence the regression model parameters.
4. An analysis was performed to define final cost model equations after exclusion of any outlying data points and/or points that exerted disproportionate influence.

The following equations are four commonly used first order regression models. Each of these four equations were evaluated to identify the equation of best fit:

- Linear: $y = ax + b$
- Exponential: $y = a(10^{bx})$

- Logarithmic: $y = a + b(\log_{10}x)$
- Power: $y = ax^b$

where:

y = Total levelized annual revenue or present worth requirement to recover all solid waste disposal costs (capital and O&M) for individual plants, expressed in terms of thousands of 1980 dollars/year (levelized annual revenue) or in terms of thousands of 1980 dollars (present worth). "y" is the dependent variable within the models.

x = total average annual waste disposed of by a given plant (excluding wastes utilized or sold) expressed in terms of thousands of dry tons per year. "x" is the independent variable within the models.

a,b = model regression constants determined through linear least squares regression. "a" and "b" have different numerical values for each regression model.

Model Analysis

The four regression models (linear, exponential, logarithmic and power) were screened for effectiveness using coefficients of determination (r^2) as an evaluation criteria. The r^2 measure is useful for this purpose because it provides a direct measure of the variability of the dependent variable that can be accounted for by the regressional model and the extent of linear association between independent (x) and dependent (y) variables.

A value for r^2 of 1.0 indicates a perfect fit, whereas an r^2 of zero indicates no correlation between the independent and dependent variable. Similarly, an r^2 of 0.9 would indicate that 90 percent of the variability of the dependent variable can be explained by the regression model. The results of the coefficient of determination screening procedure are presented below:

SCREENING OF FIRST ORDER REGRESSION MODELS
USING
COEFFICIENTS OF DETERMINATION (r^2)

Regulatory Scenario	MODEL r^2			
	Linear	Exponential	Logarithmic	Power
Current Practice	0.919	0.533	0.452	0.949
Non-Hazardous	0.922	0.617	0.479	0.947
Hazardous Minimum	0.899	0.665	0.666	0.955
Hazardous Maximum	0.884	0.658	0.682	0.954

The model screening procedure revealed that for all four cases (current practice, non-hazardous, hazardous minimum and hazardous maximum) the power curve achieved the best fit with respect to the r^2 coefficients. Cost relationships have traditionally been modeled as power curves and displayed in a linear form on log-log scale graphs. Thus, these cost relationships correspond with the manner in which economic relationships have been traditionally modeled. For all cases, r^2 values for the power curve models were greater than 0.90, indicating that at least 90 percent of the variability in the data can be accounted for using a power curve model.

Final Model Determination

The power curve model was identified as the model which best describes the data based on the coefficient of determination screening criteria. Regression models based on the power curve model were then generated for each disposal scenario and a detailed evaluation of the "goodness of fit" of each model was performed. These detailed evaluations are described in Appendix F and include an analysis of variance (ANOVA), "T" tests, outliers analysis and influence analysis.

These evaluations confirmed that the models did indeed represent a "good" fit of the data. Through influence analysis, Plant 4 was found to be strongly influential with respect to the current practice model. It was also identified as being atypical because of the large quantity (94%) of ash sold. Plant 4 highly biased the current practice data, was not representative of the data base, and was located in an area of the

curve generated by the model that was of little interest to the study. Therefore, it was decided to delete Plant 4 from the current practice data set. Plant 4, however, was retained for the non-hazardous, hazardous minimum and hazardous maximum cases since more uniform design standards and disposal costs reduced the influence of Plant 4 on these models. The final RCRA levelized cost and present worth cost curves are presented in Figures 5.1 and 5.2 and are presented below:

Regulatory Scenario	MODEL AND COEFFICIENT OF DETERMINATION(r^2) Levelized Revenue	r^2	Present Worth	r^2
Current Practice	$y= 14.98X^{0.851}$	0.92	$y= 304X^{0.869}$	0.90
Non-Hazardous	$y= 37.78X^{0.750}$	0.95	$y= 537X^{0.796}$	0.94
Hazardous Minimum	$y= 110.0X^{0.708}$	0.96	$y= 1937X^{0.727}$	0.95
Hazardous Maximum	$y= 146.9X^{0.691}$	0.95	$y= 2422X^{0.712}$	0.95

It can be seen that the coefficients of determination were all 0.92 or greater for levelized revenue relationship and 0.90 or above for present worth relationship. These values are considered to represent an excellent correlation for this type of data. It should also be noted that the coefficient of determination generally increases from current practice to hazardous maximum. This is to be expected since the design requirements become more uniform going from current practice to the hazardous maximum case.

NATIONAL AND REGIONAL WASTE QUANTITIES

After developing the RCRA Utility Cost Models, the next step was to determine the waste quantities produced by each of the 396 coal-fired power plants with capacities of at least 25 MW. The annual waste quantities from each power plant could then be entered into the RCRA Utility Cost Models to determine its disposal costs under current practice, non-hazardous, hazardous minimum, and hazardous maximum scenarios.

An extensive literature search was conduced to compile relevant background data for coal-fired utility power plants. The information

was obtained primarily from governmental agencies and private research organizations. In addition, the Utility Data Institute (UDI) compiled data from coal-fired generating facilities over 25 megawatts throughout the nation. Information furnished by UDI (under subcontract to ES) addressed specific operating characteristics of each power plant, significant environmental characteristics of the areas within and adjacent to the facility, quantities and characteristics of the wastes generated at their facilities, and solid waste handling and disposal methods. Because of the volume of this information, a separate background data report was prepared which contains all of the support information which was utilized by ES on this project (R5.1).

From the information compiled by UDI, a utility waste inventory was created for all 396 coal-fired power plants in the United States. A summary of this inventory, based on 1980 data is presented in Table 5.1. As indicated by these studies, the total solid wastes generated by coal-fired utilities in the United States was approximately 75 million tons, 92 percent of which was ash. Of that amount, approximately 9.3 million tons, or 12 percent of the total waste, was utilized for cement, concrete, road deicing, and other uses. The remaining 66 million tons of waste required disposal.

1980 WASTE DISPOSAL COSTS

The utility waste inventory described in the previous subsection provided plant-by-plant waste quantities which were entered into the RCRA Utility Cost Models (Figures 5.1 and 5.2) to compute waste disposal costs for each plant, as shown in Appendix G. These costs were then aggregated by FERC region as shown in Table 5.2. These projected costs represent the annual levelized cost for each plant to continue to produce waste for the next 35 years at an average rate equivalent to their 1980 waste generation rate. The following chart is a summary of the 1980 national disposal costs for the four regulatory scenarios investigated (expressed in constant 1980 dollars):

Regulatory Scenarios	Annual Levelized Revenue ($/yr. x 10^6)	($/Ton)	Total Present Worth ($ x 10^6)
Current Practice	418	6.38	9,370
Non-Hazardous	596	9.03	11,000
Hazardous Minimum	1,540	20.53	30,100
Hazardous Maximum	1,870	24.93	34,600

For this study, disposal costs have been presented as total present worth and annual levelized revenue. A real discount rate of 2.3 percent per year over the 35-year waste disposal facility design period was used for the present worth cost analysis. The method for calculating the levelized revenue included the use of the present values. Detailed information on the levelization procedure is presented in Appendix E - Section 4.0.

Implementation of the non-hazardous regulations on the coal-fired utility industry would result in a cost increase of approximately 17% percent compared to the current disposal practices. Compliance with RCRA hazardous disposal regulations would represent a 220 to 270 percent increase over current practice disposal costs.

IMPACTS OF OTHER FEDERAL ENVIRONMENTAL REGULATIONS

As described in Section 2, the laws which could significantly affect costs for disposal of coal-combustion wastes under non-hazardous or hazardous scenarios are the Clear Air Act and Clean Water Act. The potential impacts of these regulations are listed below and described in the remainder of this section:

(1) The Clean Air Act requires pollution control equipment which generates FGD sludge that would be disposed of in accordance with RCRA requirements if classified as hazardous.

(2) The Clean Water Act would require that leachate collected from hazardous waste disposal facilities be treated prior to discharge.

(3) The treatment of leachate to conform to the Clean Water Act would result in the generation of sludges which must be disposed of in accordance with RCRA requirements.

Costs for Disposal of FGD Sludge

In 1980, utility owned fossil fuel fired facilities generated slightly over 6 million tons of FGD sludge (see Table 5.1). FGD sludge is codisposed with bottom ash and fly ash in all of the regulatory scenarios previously evaluated. Therefore, it was possible to use the RCRA Utility Cost Models to compute FGD sludge disposal costs for the regulatory scenarios of interest. For the 6 million tons of sludge generated in 1980, the levelized annual revenue requirements are approximately $61 and $69 million per year for the current practice and non-hazardous scenarios, respectively. Hazardous minimum and hazardous maximum levelized revenue for FGD disposal is $225 and $309 million per year for 1980 sludge quantities. Cost for the hazardous maximum scenario is over 5 times higher than current practice disposal costs.

Costs for Leachate Treatment Facilities

It was assumed under the hazardous disposal scenario that leachate treatment plants (LTP's) conforming to Figure 4.6 (Section 4) would be constructed and operated at hazardous waste disposal facilities. Leachate was not collected under the current practice and non-hazardous scenarios. LTP costs were generated for the 23 case study plants and were thus included in the total disposal cost models previously discussed. National costs associated with leachate treatment were estimated by disaggregating these costs from the 23 case study sites (see Appendix H).

LTP costs are dependent on leachate flows which are a function of both the local rainfall amount and the disposal cell size. Since disposal cell size is proportional to plant waste production rate, it was assumed that LTP costs could be related to the product of rainfall and waste generation rate for the 23 case study sites. It was found that a second order polynomial equation provided the best correlation with the data. A regression analysis produced the following equation and constants:

$$y = 325{,}000 + 0.000414x - (4.31 \times 10^{-5})\, x^{2}$$

where:

y = levelized annual cost for LTP capital and O&M expressed in 1980 $/year

x = plant waste generation rate (dry tons/yr) multiplied by local average rainfall (in/yr)

Leachate treatment costs for the hazardous minimum and maximum disposal scenarios were estimated for the year 1980 based on (1) the above RCRA cost model, and (2) the waste quantities presented in Table 5.1. For the year 1980, the total levelized annual revenue requirements for leachate treatment is $125 million for each of the hazardous regulatory scenarios. Based on this analysis, leachate treatment costs account for 6.6 to 8.1 percent of the total hazardous waste disposal costs for the year 1980.

Costs for Disposal of Leachate Treatment Plant Sludge

The wastewater treatment technologies assumed for the leachate treatment plants (Figure 4.6) generate sludge which must be disposed. It was assumed for the purposes of this study that LTP sludges would be co-disposed with the other utility solid wastes.

As described earlier, costs associated with leachate treatment were expressed as a function of plant waste generation rate multipled by the local average rainfall. Based on this assumption, cost models were developed from estimated sludge quantities and disposal costs for the 23 case study sites. Two different cost models were necessary because the costs for disposing of the sludge are dependent on the unit disposal costs ($/ton) for the individual landfills which differ between the hazardous minimum and maximum scenarios. These models are presented as follows:

$$y\ min = 0.142x^{0.519}$$

$$y\ max = 0.207x^{0.507}$$

where:

y = annual levelized revenue requirements in 1980 $/yr

x = plant waste generation rate (tons/yr) multiplied by local average rainfall (in/yr)

The levelized annual revenue requirements for LTP sludge disposal range from $166,000 (hazardous minimum) to $200,000 (hazardous maximum). The above range of costs represent less than 0.1 percent of total hazardous waste disposal costs for 1980, an obviously insignificant amount.

COMPARISON OF RESULTS WITH OTHER STUDIES

The utility industry initiated two parallel studies to quantify the economic impacts of RCRA because of the potential impacts on utility waste disposal practices. One study was undertaken by the Electric Power Research Institute (EPRI)(R5.3) and other by the Utility Solid Waste Advisory Group (USWAG)(R5.2). In addition, as explained in Section 1, the Solid Waste Disposal Act Amendments of 1980 required EPA to undertake a study to evaluate any adverse effects on human health and the environment associated with the disposal of coal combustion residues. The EPA study, which will be submitted to Congress, has a very broad scope which includes the collection of ground-water data and evaluating the danger to health or the environment from the disposal of utility residues. The EPA report was issued in draft by mid 1986. The scope of the USWAG report parallels many of the tasks which were included in the EPA study while the EPRI and ES/DOE studies do not have as a goal the collection of ground-water data nor do they prejudge the degree of hazard associated with the disposal of coal combustion residues.

It is useful to compare the final results of the three projects which have been completed. Table 5.3 summarizes the major assumptions and results from each of the three projects. However, caution should be used when comparing bottom line costs since many diverse and opposing assumptions were made in each of the three reports.

The USWAG study estimated disposal costs for nine case study plants, calculated average unit disposal costs (in dollars per ton), then applied these unit costs to each of the 412 utility sites in their overall data base. This is in contrast to the cost curve approach used in this ES/DOE study in which the disposal cost was calculated as a function of waste volume. Another major difference was the design life of the disposal facilities, which was calculated by USWAG as the actual

booklife of the units compared to a uniform 35 years used in this study. Finally, capital and O&M costs were kept separate by USWAG, but combined in this study.

A major difference between the approach used by EPRI compared to this study was the method of extrapolating cost data from the case study sites to the entire coal-fired utility industry. In contrast to the cost curve approach used for the ES/DOE study, EPRI divided the 255 plants in their overall data base into groups, each represented by a case study site. The unit disposal costs from each case study were then extrapolated to the plants within the group represented by that case study site. Another major difference was the more stringent design criteria assumed by EPRI for non-hazardous disposal.

Of the three studies, only the ES/DOE report addresses the most recent hazardous waste land disposal regulations (July 26, 1982). EPRI concluded that the July 26, 1982 regulations were significantly different than previously proposed regulations used for their report. As a result, EPRI issued a report supplement which was available in mid-1983. USWAG, after reviewing the EPA guidance documents during the final stages of their report preparation, concluded that their reported costs "...would probably be lower than the costs incurred if EPA's guidance information were more closely followed..." (R5.2). However, no follow-up supplement was planned.

The disposal costs reported in the ES/DOE and EPRI reports are similar for both current practice and hazardous disposal scenarios, but EPRI estimated a considerably higher cost for non-hazardous disposal. The USWAG estimates for hazardous waste disposal appear to be quite close to comparable ES/DOE estimates. The USWAG report did not include estimated costs of non-hazardous disposal.

FIGURE 5.1

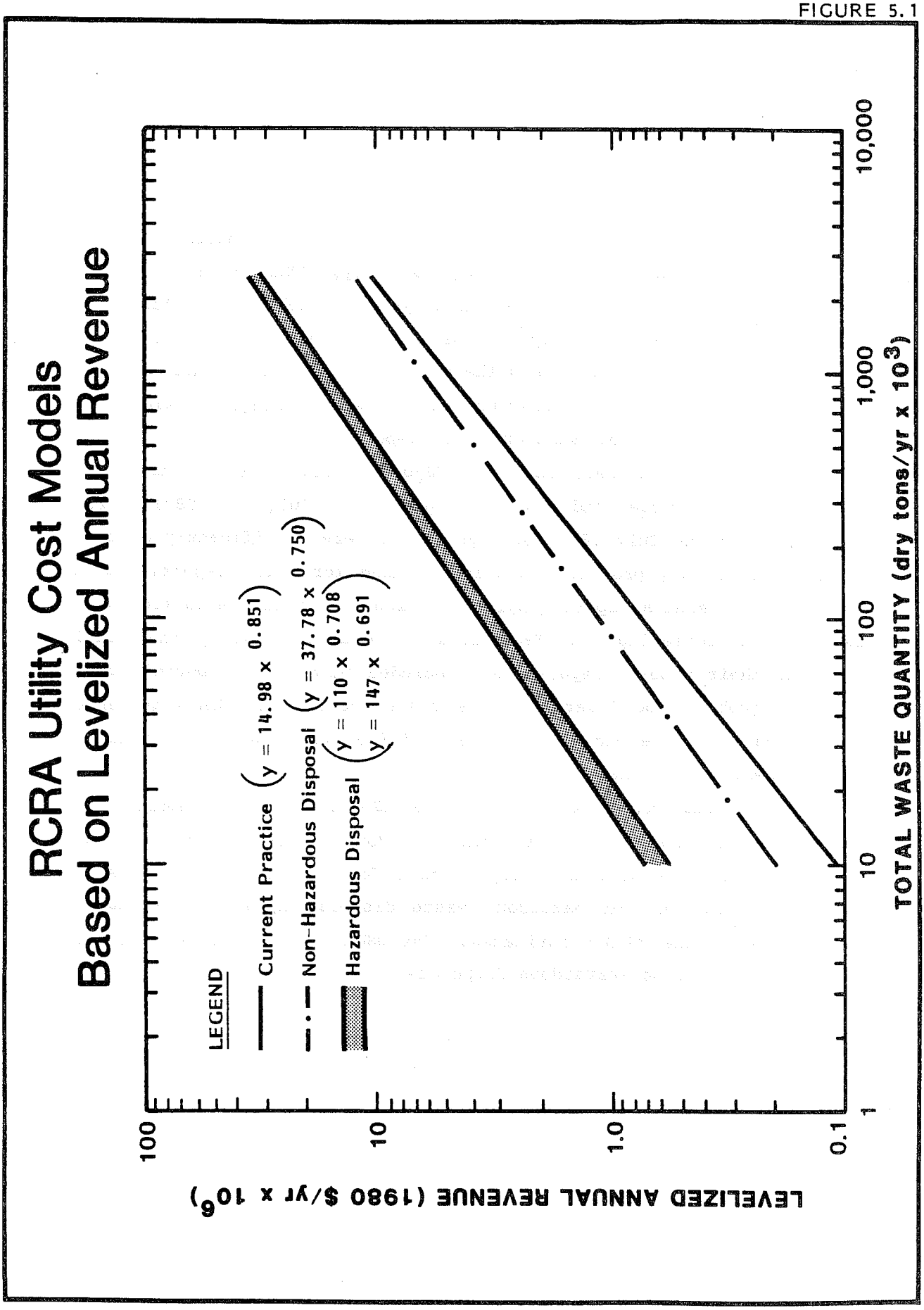
RCRA Utility Cost Models
Based on Levelized Annual Revenue
LEGEND
Current Practice (y = 14.98 x 0.851)
Non-Hazardous Disposal (y = 37.78 x 0.750)
Hazardous Disposal (y = 110 x 0.708)
(y = 147 x 0.691)
LEVELIZED ANNUAL REVENUE (1980 $/yr x 10^6)
100
10
1.0
0.1
1
10
100
1,000
10,000
TOTAL WASTE QUANTITY (dry tons/yr x 10^3)

FIGURE 5.2

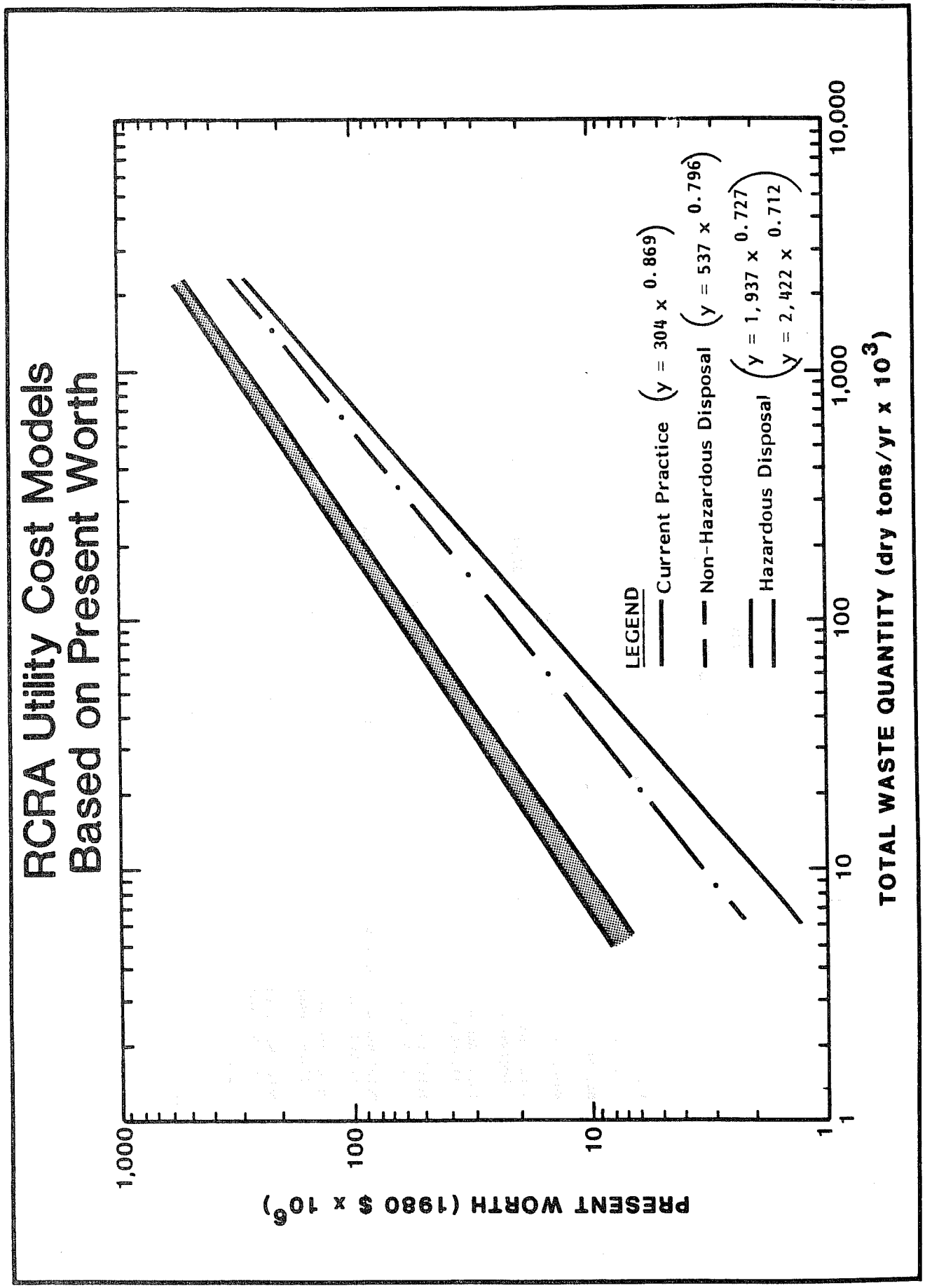
RCRA Utility Cost Models
Based on Present Worth
PRESENT WORTH (1980 $ x 10^6)
1,000
100
10
1
TOTAL WASTE QUANTITY (dry tons/yr x 10^3)
1
10
100
1,000
10,000
LEGEND
Current Practice (y = 304 x^0.869)
Non-Hazardous Disposal (y = 537 x^0.796)
Hazardous Disposal (y = 1,937 x^0.727, y = 2,422 x^0.712)

TABLE 5.1

1980 UTILITY WASTE QUANTITIES

FERC Region	1	2	3	4	5	6	7	8	9	Total
No. of Plants	1	41	120	80	64	39	16	33	2	396
Number of Boilers	2	101	389	207	180	141	33	79	3	1,135
Total Installed Megawatts	500	24,100	71,500	31,000	52,000	35,200	16,400	21,100	1,900	253,700
Total Ash Generated (1,000 tons)	80	8,030	17,450	7,530	13,230	9,250	5,780	6,900	800	69,050
Total FGD Sludge Generated (1,000 tons)	0	1,570	850	970	170	1,370	620	500	0	6,050
Total Waste Generated (1,000 tons)	80	9,600	18,300	8,500	13,400	10,620	6,400	7,400	800	75,100
Total Ash Sold (1,000 tons)	70	900	1,590	1,830	2,580	300	1,020	690	290	9,270
Total Waste Disposed (1,000 tons)	10	8,700	16,710	6,670	10,820	10,320	5,380	6,710	510	65,830

TABLE 5.2
TOTAL WASTE DISPOSAL COSTS FOR
COAL-FIRED UTILITY POWER PLANTS >25 MW CAPACITY

FERC Region	Total Levelized Revenue (1980 $/yr 10^6)				Total Present Worth (1980 $ x 10^6)			
	Current Practice	Non-hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-hazardous	Hazardous Minimum	Hazardous Maximum
1	0.1	0.2	3.0	3.1	1.9	2.8	47	55
2	54	75	189	229	1,213	1,398	3,707	4,250
3	110	160	405	494	2,452	2,918	7,884	9,096
4	46	69	198	242	1,020	1,242	3,841	4,445
5	72	104	287	348	1,598	1,899	5,602	6,446
6	63	86	201	243	1,410	1,608	3,962	4,532
7	29	38	99	118	662	721	1,963	2,226
8	41	59	146	176	935	1,083	2,856	3,277
9	3.3	4.6	13.8	16.6	74.9	85.5	275	312
Total	418	596	1,542	1,870	9,367	10,957	30,137	34,639

TABLE 5.3
COMPARISON OF DOE, USWAG AND EPRI REPORTS

Parameter	ES/DOE Report	USWAG Report (R5.2)	EPRI Report (R5.3)
Utility Data Base Utilized			
Data Source	UDI	EEI	Questionnaire
Base year	1980	1980	1979
No. of Plants	396	412	255
Minimum Size (MW)	25	25	200
Total Installed MW	253,700	258,900	200,500
Quantities of Waste to be Disposed (Dry tons/yr x 10^6)			
Year 1979	-	-	63.4
Year 1980	75.1	68.1	-
Basis for Design of Waste Disposal Facilities			
RCRA Regulations Used	7/26/82	Pre 7/26/82	12/31/80
No. of Site Visits	23	9	7
Facility Design Life (yrs.)	35	20 (1)	30
Financial Assumptions Used to Develop Waste Disposal Costs			
Amortization Period (yrs.)	35	20	30
Capital Levelizing Factor	0.074	0.141	0.180
O&M Levelizing Factor	0.041	1.0 (2)	1.886
Cost Base	1980	12/81	1980
Increased Levelized Revenue Requirements Compared to Current Practice			
Non-hazardous ($/yr x 10^9)	0.12	-	1.8
Hazardous ($/yr x 10^9)	1.12-1.45	-	2.6
Increased Present Worth Costs Compared To Current Practice			
Hazardous ($ x 10^6)	23,000	16,784 (3)	-

(1) Design life was based on actual book life of units, calculated as 35 years minus number of years in service. Average for 9 sites was 20 years.

(2) Reflects discounting of inflation when preparing estimates of future costs.

(3) Includes only capital costs. O&M costs which were estimated at $277 million per year are not included.

CITED REFERENCES

R5.1 "Background Data on Utility Sector Fossil Fuel-Fired Facilities", U.S. DOE, Prepared by Engineering-Science, Draft--April 1983.

R5.2 Report and Technical Studies on the Disposal and Utilization of Fossil-Fuel Combustion By-products. Prepared by Utility Solid Waste Activities Group, Edison Electric Institute, and the National Rural Electric Cooperative Asociation, Volumes I, II and III, October 26, 1982.

R5.3 Engineering Evaluation of Projected Solid Waste Disposal Practices - Volumes I and II. Electric Power Research Institute EPRI CS-2627; September, 1982.

SECTION 6

MAJOR ASSUMPTIONS AND FINDINGS

The following are major assumptions and findings which were determined during the course of the study. The major study elements discussed below are regulatory requirements, case study disposal costs, and regional and national disposal costs.

REGULATIONS

This study considers the interaction of various federal environmental regulations affecting residue disposal from coal-fired utility power plants. The regulations which were specifically addressed included the following:

- Resource Conservation and Recovery Act; including non-hazardous and hazardous waste regulations.
- Clean Water Act; including the National Pollution Discharge Elimination System (NPDES).
- Clean Air Act.
- Safe Drinking Water Act; including the Underground Injection Control (UIC) Program.
- Surface Mining Control & Reclamation Act (SMCRA).
- Toxic Substances Control Act (TSCA).
- Marine Protection Research and Sanctuaries Act.
- Consolidated Permit Program.

The RCRA non-hazardous waste regulations used in this study included Part 241 (Landfill Disposal Guidelines, proposed on March 26, 1979) and Part 257 (Facility Classification and Practices, promulgated on September 13, 1979). Hazardous waste regulations included Parts 260 through 264 as published in the Federal Register through July 26, 1982.

A review of the above regulations yielded the following major findings and observations:

1. The federal non-hazardous waste disposal regulations are in the form of guidelines to be used by the states as development criteria for the preparation of their Solid Waste Management Plans. The regulations do not explicitly require the industry to modify its typical current waste handling practices but pose a series of environmental concerns which should be addressed. The application of the non-hazardous regulations to the disposal of coal combustion residues therefore required that a number of interpretations be made which would be uniformly applied throughout the study.
2. The hazardous waste regulations were much more specific than the non-hazardous regulations; however, considerable discretion is still provided to the permit writer. It was therefore necessary to establish design criteria for this study which described a range of possibilities from the least probable cost to the maximum probable cost of compliance.
3. Other than RCRA, only two of the environmental regulations investigated significantly affect the costs of coal combustion waste disposal. The Clean Air Act requires the installation of air pollution control equipment which substantially increases solid waste disposal volumes, and greatly increases disposal costs regardless of whether these wastes are declared hazardous. The Clean Water Act increases the costs of hazardous waste disposal by requiring treatment of leachates prior to discharge.

CASE STUDY DISPOSAL COSTS

A total of 23 coal-fired power plants were selected as being representative of all 396 plants in the U.S. with a generating capacity of greater than 25 MW. With the aid of a computer-assisted design and costing technique known as "LFDESIGN", waste disposal costs were estimated for each of the following four regulatory scenarios:

- Current practice, continuation of existing waste disposal practices (a baseline case),
- Non-hazardous waste disposal, as specified in 40 CFR Parts 241 and 257,

- Hazardous waste disposal, as specified in 40 CFR Parts 260 through 264, consisting of designs which required the least probable cost of compliance, and
- Hazardous waste disposal as specified in 40 CFR Parts 260 through 264, consisting of designs which required the maximum probable cost of compliance.

The results of these engineering estimates are summarized below:

1. Current practice unit disposal costs (based on levelized revenue) varied between $3.15 and $14.35 per ton. Current practice cost variability was attributed principally to the existing design life of the facility and the varying distances required for off-site disposal.
2. Non-hazardous disposal costs (based on levelized revenue) varied between $4.18 and $25.36 per ton. Interpretation of the non-hazardous regulations included (1) ground-water monitoring for all sites, (2) clay lining of newly constructed facilities, and (3) a selected, standardized closure of newly constructed or existing disposal facilities at the end of the design period (based on RCRA guidelines).
3. Hazardous minimum unit disposal costs ranged from $10.26/ton (based on levelized revenue) to $54.23/ton. The use of surface impoundments to meet the hazardous minimum design criteria resulted in the lowest unit disposal costs, while the smaller plants, which required off-site disposal, had the highest unit costs.
4. For the hazardous maximum design, the range of costs (based on levelized revenue) was from $11.71 to $71.32 per ton. The lowest cost was for a plant which disposed of solid wastes in RCRA approved landfill cells constructed in an active strip mine area. The highest cost was for a smaller size plant which disposed of its wastes off-site.

REGIONAL AND NATIONAL DISPOSAL COSTS

A model was developed to relate total levelized revenue to the quantity of annual waste disposed. This model was tested for accuracy

by standard statistical techniques and found to have an excellent "fit" to the data ($r^2 > 0.9$ for all cases). Both "influence" and "outlier" analyses were also conducted to identify data points which were overly influential and to determine the confidence limits for prediction, respectively. As a result of these analyses, only one data point was deleted from the current practice analysis because it clearly exerted undue influence on the current practice cost model. This data point was included in the other three models (non-hazardous, hazardous minimum and hazardous maximum) because more uniform design requirements reduced the leverage of this data point on the rest of the data.

A parallel activity to the model development was the compilation of detailed information regarding waste disposal from all 396 plants. The 396 plant data base was used as input into the models in order to predict regional and national waste disposal costs for each of the four scenarios (current practice, non-hazardous, hazardous minimum and hazardous maximum). The following is a summary of major findings based on the 396 plant survey and the regional/national cost estimates:

1. In 1980, coal-fired utilities generated approximately 75.1 million tons of solid waste. Of that amount, about 9.3 million tons or 12 percent of the total waste was utilized for cement, concrete, road deicing and other uses.
2. The 1980 cost estimates in terms of both Annual Levelized Revenue and Present Worth associated with the four regulatory scenarios are as follows:

Regulatory Scenario	Annual Levelized Revenue ($/year x 10^6)	Annual Levelized Revenue ($/Ton)	Total Present Worth ($ x 10^6)
Current Practice	418	6.38	9,370
Non-Hazardous	596	9.03	11,000
Hazardous Minimum	1,540	20.53	30,100
Hazardous Maximum	1,870	24.93	34,600

The annual levelized cost represents the cost for each plant to continue to produce waste for the next 35 years at an average rate equivalent to their 1980 waste generation rate. All dollars are expressed in 1980 constant dollars.

3. Based on 1980 data, the regions incurring the greatest disposal costs are FERC Regions 3 (East North Central) and 5 (South Atlantic). Regions 1 (New England) and 9 (Pacific) are minimally affected because of the small amount of coal burned in those regions.

4. The 1980 estimates of FGD sludge disposal costs are approximately $61 and $69 million per year for the current practice and non-hazardous scenarios, respectively. The 1980 costs for the hazardous scenario range from $225 to $309 million per year. These latter costs represent approximately 15 to 17% of the total disposal costs presented previously in item 2.

5. If coal combustion wastes were declared hazardous, leachate treatment costs to conform to the Clean Water Act would be $125 million in 1980 (based on levelized revenue requirements, in terms of 1980 dollars) and constitute approximately 10% of the total disposal costs presented previously in item 2.

6. The results of this study were compared to similar studies sponsored by EPRI and USWAG. Costs reported in the ES/DOE and EPRI reports are quite similar for both current practice and hazardous disposal scenarios; however, EPRI estimated a considerably higher cost for non-hazardous disposal. It appears that the USWAG cost estimates for hazardous waste disposal are also relatively close to the ES/DOE estimates. (USWAG did not estimate non-hazardous disposal costs.)

Appendix A

Environmental Regulations

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SECTION 1

HISTORICAL DEVELOPMENT OF RCRA AND ITS REGULATIONS

In the early 1960's, federal solid waste regulatory officials were concerned about the health and environmental effects of solid waste disposal activities in high population density areas and regions with shallow ground-water tables. As a result, Congress passed the Solid Waste Disposal Act (SWDA) of 1965, enacted by PL89-272. This legislation directed the Secretary of the Department of Health, Education and Welfare to (1) conduct and support research on the nature and scope of the solid waste problem, evaluate methods of more safely and efficiently collecting and disposing the wastes and techniques for recovering materials from solid waste (2) provide training and financial assistance to State agencies in the planning, development and conducting solid waste management programs and (3) support specific projects which demonstrate new and improved methods of collection, handling and disposal.

THE RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

In the late 1960's and early 1970's, it was obvious that there was little continuity in the solid waste requirements between state regulatory agencies and in some states open dumps continued to be used for the disposal of solid waste. Chemical (hazardous) wastes also posed a major environmental concern since there was no national policy on their safe disposal.

To address these needs, RCRA was passed by Congress in 1976 to address non-hazardous and hazardous waste disposal and, resource recovery and reuse. RCRA was divided into 8 subtitles, as shown in Table A.1, three of which are directly pertinent to this study, namely:

- Subtitle A - General Provisions
- Subtitle C - Hazardous Waste Management
- Subtitle D - State or Regional Solid Waste Plans

Table A.2 contains a summary of pertinent details from RCRA Subtitles A, C and D. Subtitle A addresses general provisions of the law, prescribes time schedules and defines the language of the Act. Subtitles C and D are described in more detail in the following text.

STATE OR REGIONAL SOLID WASTE PLANS (SUBTITLE D)

On July 31, 1979, EPA issued under Subtitle D proposed Criteria for Classification of Solid Waste Disposal Facilities and Practices (40 CFR Part 257). These regulations contained minimum criteria for determining solid waste disposal facilities and practices which pose a reasonable probability of adverse effects on health or the environment. On September 13, 1979, EPA promulgated the criteria with only minor wording revisions.

On March 26, 1979, landfill disposal guidelines were issued by EPA to assist state agencies in evaluating whether specific disposal operations are designed to protect public health and the environment. These proposed guidelines were meant to replace the guidelines issued on August 14, 1974 which were issued under the Resource Recovery Act of 1970 (an amendment of the SWDA). The proposed guidelines are more quantitative than the existing guidelines. The status of the guidelines is that they have been put aside by EPA because of limited manpower availability and not been reissued since March 26, 1979.

HAZARDOUS WASTE MANAGEMENT (SUBTITLE C)

Regulations which have been promulated under Subtitle C of the RCRA set forth criteria for both the identification anad management of hazardous wastes. The regulations, excluding interim status standards, are organized as follows under Title 40 of the Code of Federal Regulations:

Part 260 - Hazardous Waste Management System.

Part 261 - Identification and Listing of Hazardous Wastes.

Part 262 - Standards Applicable to Generators of Hazardous Waste.

Part 263 - Standards Applicable to Transporters of Hazardous Wastes.

Part 264 - Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities.

A more detailed listing of the individual section within Parts 260 through 263 are presented in Table A.3.

Table A.4 contains a summary of the major subparts of the Standards For Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities which are contained in Part 264 of EPA's regulations. Specific subparts in Table A.4 which do not have a direct bearing on this project have been identified, but no additional breakdown of the regulations has been presented, e.g., Subpart O-Incinerators.

Part 260 - Hazardous Waste Management System

This part provides definitions of terms, general standards and overview information applicable to Parts 261 through 264.

Part 261 - Identification and Listing of Hazardous Wastes

On December 18, 1978, EPA published regulations stating that wastes generated from utility coal combustion would be classified as "special wastes" under Section 3001. These "special wastes" were to be exempt from some of the treatment and disposal standards under Section 3004 until final disposal standards for these wastes could be developed. After receiving extensive technical input from the utility industry, EPA temporarily exempted coal combustion wastes (fly ash, bottom ash, flue gas desulfurization wastes) from classification as a hazardous waste on May 19, 1980. In addition, the Solid Waste Disposal Act Amendments of 1980 enacted by PL 96-482 on October 21, 1980 specifically required EPA to conduct a detailed and comprehensive study and submit a report on the adverse effects on human health and the environment, if any, of the disposal and utilization fly ash waste, bottom ash waste, slag waste, flue gas emission control waste, and other byproduct materials generated primarily from the combustion of coal or other fossil fuels. A draft of the report should be released by EPA for comment during the fall of 1983.

The temporary coal combustion waste exemption did not completely relieve the utilities from being regulated under Subtitle C, since the utility industry still had a large number of low volume wastes that were cooling tower blowdown, pyrites and demineralizer regenerant. These wastes would have to be tested to determine whether they exhibited any hazardous characteristics. The Utility Solid Waste Activities Group

(USWAG, an informal consortium of 65 electric utility operating companies formed to coordinate responses to EPA on RCRA) formally requested that EPA address the extent of the exemption.

In January, 1981, Gary N. Dietrich (then EPA Deputy Assistant Administrator, Office of Solid Waste) wrote a letter to USWAG indicating that boiler cleaning solutions, boiler blowdown, demineralizer regenerants, pyrites, and cooling tower blowdown would be deferred from regulation under the hazardous waste provisions of RCRA subject to EPA's final determination of the status of all high volume exempted wastes.

Part 262 - Standards Applicable to Generators of Hazardous Waste

The Part 262 regulations include manifesting, packaging and labeling, and recordkeeping. Standards for generators were promulgated on February 26, 1980 and have been amended with both technical and administrative changes to clarify the regulations. The Part 262 regulations as applied to the utility industry will reqire that additional administrative costs are incurred but these costs are not significant when compared to the total waste disposal costs.

Part 263 - Standards Applicable to Transporters of Hazardous Wastes

These regulations would apply to utilities transporting hazardous wastes from the generating plant to the disposal site and include manifesting and recordkeeping. Like Part 262 above, Part 263 requires an additional administrative cost to be incurred but the amount is insignificant in relation to the Part 264 regulations which govern the actual disposal requirements imposed on the utility.

Part 264 - Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities

Land disposal regulations were first proposed as detailed technical design and operating standards on December 18, 1978 (3 Fed. Reg. 58982). On February 5, 1981, these rigid technical standards were modified in favor of a site-specific risk assessment program that called for the collection of detailed site information and prediction of potential ground-water contamination by the permit applicant (46 Fed. Reg. 11126). During the following public comment period, EPA concluded that the proposed ground-water modeling approach would require costly technical evalutions, the results of which would be technically questionable.

TABLE A.1
RESOURCE CONSERVATION AND RECOVERY ACT
(PUBLIC LAW 94-580)

Section Outline	
Subtitle A - General Provisions	
Sec. 1001.	Short title and table of contents.
Sec. 1002.	Congressional findings.
Sec. 1003	Objectives
Sec. 1004.	Definitions
Sec. 1005.	Governmental cooperation.
Sec. 1006.	Application of Act and integration with other Acts.
Sec. 1007.	Financial disclosure.
Sec. 1008.	Solid waste management information and guidelines.
Subtitle B - Office of Solid Waste; Authorities of Administrator	
Sec. 2001.	Office of Solid Waste.
Sec. 2002.	Authorities of Administrator.
Sec. 2003.	Resource recovery and conservation panels.
Sec. 2004.	Grants for discarded tire disposal.
Sec. 2005.	Annual report.
Sec. 2006.	General authorization.
Subtitle C - Hazardous Waste Management	
Sec. 3001.	Identification and listing of hazardous waste.
Sec. 3002.	Standards applicable to generators of hazardous waste.
Sec. 3003.	Standards applicable to transporters of hazardous waste.
Sec. 3004.	Standards applicable to owners and operators of hazardous waste treatment, storage and disposal facilities.
Sec. 3005.	Permits for treatment, storage, or disposal of hazardous waste.
Sec. 3006.	Authorized State hazardous waste programs.
Sec. 3007.	Inspections.
Sec. 3008.	Federal enforcement.
Sec. 3009.	Retention of State authority.
Sec. 3010.	Effective date.
Sec. 3011.	Authorization of assistance to States.
Subtitle D - State or Regional Solid Waste Plans	
Sec. 4001.	Objectives of subtitle.
Sec. 4002.	Federal guidelines for plans.
Sec. 4003.	Minimum requirements for approval of plans.
Sec. 4004.	Criteria for sanitary landfills; sanitary landfills required for all disposal.
Sec. 4005.	Upgrading open dumps.
Sec. 4006.	Procedure for development and implementation of State plan.
Sec. 4007.	Approval of State plan; Federal assistance.

TABLE A.1
(Continued)
RESOURCE CONSERVATION AND RECOVERY ACT
(PUBLIC LAW 94-580)

Section Outline	
Sec. 4008.	Federal assistance.
Sec. 4009.	Rural communities assistance.
Subtitle E -	Duties of the Secretary of Commerce in Resource and Recovery
Sec. 5001.	Functions
Sec. 5002.	Development of specifications for secondary materials.
Sec. 5003.	Development of markets for recovered materials.
Sec. 5004.	Technology.
Subtitle F -	Federal Responsibilities
Sec. 6001.	Application of Federal, State, and local law to Federal facilities.
Sec. 6002.	Federal procurement.
Sec. 6003.	Cooperation with Environmental Protection Agency.
Sec. 6004.	Applicability of solid waste disposal guidelines to executive agencies.
Subtitle G -	Miscellaneous Provisions
Sec. 7001.	Employee Protection.
Sec. 7002.	Citizen suits.
Sec. 7003.	Imminent hazard.
Sec. 7004.	Petition for regulations; public participation.
Sec. 7005.	Separability.
Sec. 7006.	Judicial review.
Sec. 7007.	Grants or contracts for training projects.
Sec. 7008.	Payments.
Sec. 7009.	Labor standards.
Subtitle H -	Research, Development, Demonstration and Information
Sec. 8001.	Research, demonstrations, training, and other activities.
Sec. 8002.	Special studies; plans for research, development and demonstrations.
Sec. 8003.	Coordination, collection, and dissemination of information.
Sec. 8004.	Full-scale demonstration facilities.
Sec. 8005.	Special study and demonstration projects on recovery of useful energy and materials.
Sec. 8006.	Grants for resource recovery systems and improved solid waste disposal facilities.
Sec. 8007.	Authorization of appropriations.

TABLE A.2
PERTINENT SECTIONS OF RCRA

SUBTITLE A - GENERAL PROVISIONS
Solid Waste Management
Information & Guidelines

Section 1008(a)(1+2)

Provide a technical and economic description of the level of performance that can be attained by various available solid waste management practices.

Describe levels of performance including appropriate methods and degrees of control that provide protection of public health and welfare--protection of quality of ground waters and surface waters from leachates-protection of the quality of surface waters from runoff through compliance with effluent limitations under FWPCA--protection of ambient air quality--safety and esthetics.

Section 1008(a)(3)

Provide minimum criteria to be used by the States to define those solid waste management practices which constitute the open dumping of solid waste or hazardous waste and are to be prohibited under subtitle D of this Act.

SUBTITLE D - SOLID OR
REGIONAL WASTE PLANS
Criteria for Sanitary
Landfills

Section 4004

Promulgate regulations containing criteria for determining which facilities shall be classified as sanitary landfills and which shall be classified as open dumps within the meaning of this Act. At the minimum, such criteria shall provide that a facility may be classified as a sanitary landfill and not an open dump only if there is no reasonable probability of adverse effects on health or the environment from disposal of solid waste at such facility.

TABLE A.2
(Continued)
PERTINENT SECTIONS OF RCRA

SUBTITLE C - HAZARDOUS WASTE MANAGEMENT

Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities

Section 3004

Promulgate regulations establishing such performance standards, applicable to owners and operators of facilities for the treatment, storage, or disposal of hazardous waste identified or listed under this subtitle, as may be necessary to protect human health and the environment. Such standards shall include, but need not be limited to, requirements respecting -

(1) maintaining records of all hazardous waste identified or listed under this title which is treated, stored, or disposed of, as the case may be, and the manner in which such wastes were treated, stored, or disposed of;

(2) satisfactory reporting, monitoring, inspection and compliance with the manifest system referred to in section 3002(5);

(3) treatment, storage, or disposal of all such waste received by the facility pursuant to such operating methods, techniques, and practices as may be satisfactory to the Administrator;

(4) the location, design, and construction of such hazardous waste treatment, disposal, or storage facilities;

(5) contingency plans for effective action to minimize unanticipated damage from any treatment, storage, or disposal of any such hazardous waste;

(6) the maintenance of operation of such facilities and requiring such additional qualifications as to ownership, continuity of operation, training for personnel, and financial responsibility as maybe necessary or desirable; and

(7) compliance with the requirements of section 3005 respecting permits for treatment, storage, or disposal.

No private entity shall be precluded by reason of criteria established under paragraph (6) from the ownership or operation of facilities providing hazardous waste treatment storage, or disposal services where such entity can provide assurances of financial responsibility and continuity of operation consistent with the degree and duration of risks associated with the treatment, storage, or disposal of specified hazardous waste.

TABLE A.3

PARTS 260 THROUGH 263 - PERTINENT SECTIONS OF THE RCRA HAZARDOUS WASTE REGULATIONS

PART 260-HAZARDOUS WASTE MANAGEMENT SYSTEM

Subpart A - General
260.1 Purpose, scope and applicability.
260.2 Availability of information; confidentiality.
260.3 Use of number and gender.

Subpart B - Definitions
260.10 Definitions.
260.11 References.

Subpart C - Rulemaking Petitions.
260.20 General.
260.21 Petiticons for equivalent testing or analytical methods.
260.22 Petitions to amend Part 261 to exclude a waste produced at a particular facility.

PART 261-IDENTIFICATION AND LISTING OF HAZARDOUS WASTE

Subpart A - General
261.1 Purpose and scope.
261.2 Definition of solid waste.
261.3 Definition of hazardous waste produced by small quantity generators.
261.4 Exclusions.
261.5 Special requirements for hazardous waste produced by small quantity generators.
261.6 Special requirements for hazardous waste which is used, reused, recycled or reclaimed.
261.7 Residues of hazardous waste in empty containers.

Subpart B - Criteria for Identifying the Characteristics of Hazardous Waste and for Listing Hazardous Wastes
261.10 Criteria for identifying the characteristics of hazardous wastes.
261.11 Criteria for listing hazardous waste.

Subpart C - Characteristics of Hazardous Waste
261.20 General.
261.21 Characteristics of ignitability.
261.22 Characteristic of corrosivity.
261.23 Characteristic of reactivity.
261.24 Characteristic of EP toxicity.

Subpart D - Lists of Hazardous Wastes
261.30 General.
261.31 Hazardous wastes from non-specific sources.
261.32 Hazardous wastes from specific sources.
261.33 Discarded commercial chemical products, off-specification species, container residues, and spill residue thereof.

PART 262-STANDARDS APPLICABLE TO GENERATORS OF HAZARDOUS WASTE

Subpart A - General
262.10 Purpose, scope and applicability.
262.11 Hazardous waste determination.
262.12 EPA identification numbers.

Subpart B - The Manifest
262.20 General requirements.
262.21 Required information.

Subpart C - Pretransport Requirements
262.30 Packaging.
262.31 Labeling.
262.32 Marking.
262.33 Placarding.
262.34 Accumulation time.

Subpart D - Record Keeping and Reporting
262.40 Record keeping.
262.41 Annual reporting.
262.42 Exception reporting.
262.43 Additional Reporting.

Subpart E - Special Conditions
262.50 International shipments.
262.51 Farmers.

PART 263 - STANDARDS APPLICABLE TO TRANSPORTERS OF HAZARDOUS WASTE

Subpart A - General
263.10 Scope.
263.11 EPA identification number.
263.12 Transfer facility requirements.

Subpart B - Compliance With the Manifest System and Record Keeping
263.20 The manifest system.
263.21 Compliance with the manifest.
263.22 Record keeping.

Subpart C - Hazardous Waste Discharges
263.30 Immediate Action.
263.31 Discharge clean up.

TABLE A.4

PART 264-STANDARDS FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES

Subpart A - General

Subpart B - General Facility Standards
264.10 Applicability.
264.11 Identification Number.
264.12 Required notices.
264.13 General waste analysis.
264.14 Security.
264.15 General inspection requirements.
264.16 Personnel training.
264.17 General requirements for ignitable, re-active, or incompatible wastes.
264.18 Location standards
264.19-264.29 (Reserved)

Subpart C - Preparedness and Prevention

Subpart D - Contingency Plan and Emergency Procedures

Subpart E - Manifest System, Recordkeeping, and Reporting

Subpart F - Ground-water Protection
264.90 Applicability.
264.91 Required programs.
264.92 Ground-water protection standard.
264.93 Hazardous constituents.
264.94 Concentration limits.
264.95 Point of compliance.
264.96 Compliance period.
264.97 General ground-water monitoring requirements.
264.98 Detection monitoring program.
264.99 Compliance monitoring program.
264.100 Corrective action program.
264.101-264.109 (Reserved)

Subpart G - Closure and Post-Closure
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264.111 Closure performance standard.
264.112 Closure plan; amendment of plan.
264.113 Closure; time allowed for closure.
264.114 Disposal of decontamination of equipment.
264.115 Certification of closure.
264.116 (Reserved)
264.117 Post-closure care and use of property.
264.118 Post-closure plan; amendment of plan.
264.119 Notice to local land authority.
264.120 Notice in deed to property.

Subpart H - Financial Requirements

Subpart I - Use and Management of Containers

Subpart J - Tanks

Subpart K - Surface Impoundments
264.220 Applicability.
264.221 Design and operating requirments.
264.222 Double-lined surface impoundments; Exemption from Subpart F ground-water protection requirements.
264.223-264.225 (Reserved)
264.226 Monitoring and inspection.
264.227 Emergency repairs; contingency plans.
264.228 Closure and post-closure care.
264.229 Special requirements for ignitable or reactive waste.
264.230 Special requirements for incompatible wastes.
264.231-264.249 (Reserved)

Subpart L - Waste Piles

Subpart M - Land Treatment

Subpart N - Landfills
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264.301 Design and operating requirements.
264.302 Double-lined landfills: Exemption for Subpart F ground-water protection requirements.
264.303 Monitoring and inspection.
264.304-264.308 (Reserved)
264.309 Surveying and record keeping.
264.310 Closure and post-closure care.
264.311 (Reserved)
264.312 Special requirements for ignitable or reactive waste.
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264.315 Special requirements for containers.
264.316 Disposal of small containers of hazardous waste in overpacked drums (lab packs).
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SECTION 2
CLEAN AIR ACT

PURPOSE AND SCOPE

Although the Federal government was involved in air pollution control in a limited way before 1970, it was the passage of the Clean Air Act (CAA) in 1970 that created the current regulatory structure. Major elements of the 1970 CAA include the following:

- National ambient air quality standards (NAAQS)
- State implementation plans (SIP)
- New source performance standards (NSPS)

Each of these major requirements of the CAA affects air pollution control at coal-fired power plants.

The 1970 CAA established the air quality approach as the guiding philosophy of air pollution control in the United States. According to this approach, the primary emphasis of a control program should be to achieve specific levels of pollutant concentrations at which human health and welfare would be adequately protected. Thus, the EPA was directed by the CAA to promulgate two sets of NAAQS, primary and secondary. Primary standards are designed to protect human health and are based on epidemiological and health effects studies. Secondary standards are promulgated to protect human welfare and to limit deleterious effects such as vegetation damage, visibility impairment, metal corrosion and soiling. Originally, the CAA required that all NAAQS be attained in 1975.

Although the 1970 CAA vastly expanded the role of the Federal government in air pollution control, basic authority for designing and implementing strategies for attaining the NAAQS was reserved to the states through the SIP process. The CAA required that all of the states

develop an SIP which would attain the NAAQS in 1975. EPA was given the task of reviewing and approving all SIP's. If EPA found a particular state's implementation plan to be deficient, EPA could develop a new plan for the state. When an SIP was approved by EPA, its provisions became federally enforceable. Yet, the specific emission limitations for particular sources within a state were established by that state's air pollution control agency in the SIP. During the early 1970's, the states required all of their major sources to submit plans and schedules for complying with the applicable specific emission limitations. These compliance schedules were enforceable as part of the SIP's.

NSPS were another major element of the 1970 CAA. NSPS represent a technology based approach to air pollution control as opposed to the air quality standards philosophy. The basic idea behind NSPS was that major new sources of air pollution should be controlled when they are constructed rather than after their emissions have caused or exacerbated an air quality problem. Since control technology can be less expensive and more effective when installed from the beginning on new sources than when retrofitted onto old sources, NSPS could require more stringent controls on new sources than the SIP's required on existing sources. Finally, NSPS were to be "technology-forcing". As a result of meeting very stringent NSPS requirements, industry would develop better technology for controlling existing sources as well. Coal-fired electric power plants were included in one of the first NSP's to be issued. Historically, two sets of control technology became commonplace at coal-fired power plants. High efficiency electrostatic precipitators (ESP) were used to control particulate emissions. Flue gas desulfurization (FGD) systems or scrubbers were used to control sulfur dioxide emissions. However, the use of FGD was limited because many utilities sought to meet the regulations to control sulfur dioxide emissions by burning low-sulfur coal. Some utilities invested heavily in new low-sulfur coal mining operations to ensure a captive supply for their plants. Others continued to resist sulfur dioxide controls by proposing to use tall stacks and intermittent controls such as plant operation at a lower load during adverse atmospheric dispersion conditions. Such efforts were opposed by EPA and were ultimately defeated.

As the deadline for attainment of the NAAQS approached, it became obvious that there would be many areas of the country in which the standards would not be attained. The 1970 CAA, however, did not provide a clear basis for EPA to respond to these continuing nonattainment problems. EPA's response to these problems included the following measures:

- Development of an offset policy that required new sources in nonattainment areas to obtain emission reductions from existing sources that exceeded the increase in emissions.
- Investigation of control technology for nontraditional fugitive particulate sources.
- Promulgation of a program to prevent significant deterioration (PSD). EPA developed this program in response to its defeat in a litigation brought against EPA in 1972 by environmentalist groups.
- Review of control technology requirements in SIP's to ensure that all states were requiring stringent controls.

In 1977 the Congress amended the CAA. Among major changes in the CAA enacted by Congress in 1977 were the following:

- EPA was required to designate nonattainment areas. SIP's for these areas were to be revised so that the NAAQS could be attained by the end of 1982. Extensions to 1987 could be obtained for ozone and carbon monoxide nonattainment areas.
- All major point sources affecting a nonattainment area were required to have reasonably available control technology (RACT).
- New sources located in nonattainment areas were subjected to review and required to obtain emissions offsets or be accommodated in the SIP by more stringent regulations against existing industry.
- PSD was incorporated into the CAA. EPA's program was modified to make it more stringent.

In addition, several measures were included in the CAA that directly affected coal-fired power plants. EPA was required to develop a new NSPS that would, in effect, mandate FGD and prohibit the use of low sulfur coal as a means of meeting NSPS requirments. States were required to use only the stack height recognized as "good engineering practice" to develop SIP regulations. Thus, the bias on the part of EPA for encouraging and requiring FGD was reinforced.

During the period after the 1977 CAA amendments, EPA and the states concentrated on implementing the new provisions. EPA designated nonattainment are-s in March 1978. For these areas, revised SIPs were to be promulgated by July 1, 1979. By this deadline, EPA had taken final action only on Wyoming's plan revision. All other revisions have since then been working their way though the system and EPA is still processing SIP revisions. In those nonattainment areas for which a SIP revision was not approved by the deadline, EPA imposed a ban on construction of new major sources. When a SIP revision is approved for a particular nonattainment area, EPA lifts the ban in that area. Sanctions have been imposed on a few states that have failed to meet commitments to enact and implement motor vehicle inspection/maintenance programs.

In general, the 1979 SIP revisions did not impose new requirements upon coal-fired power plants. Many states had already imposed emission limits that were judged by EPA to be RACT before 1979. Particulate nonattainment problems in many areas were due to nontraditional fugitive sources. EPA required states to commit to a schedule for controlling these sources but did not insist upon specific measures.

REVISIONS TO THE CLEAN AIR ACT

During the past two years, the U.S. Congress has been considering changes to the CAA. One of these changes is in the area of acid rain control. During the past few years, Canada and some northeastern states have become concerned about the effects of acid rain. Although no causal relationship has been clearly established, it is generally believed that the acid rain problem is due to sulfur dioxide and oxides of nitrogen emissions from coal-fired power plants in the Midwest. EPA and other agencies are currently undertaking studies to define a causal relationship, but the results of these studies will not be available for

some time. Nevertheless, the Senate committee responsible for amending the Act adopted a measure in 1982 to require further reductions in sulfur dioxide emissions in order to reduce acid rain.

This measure would require utilities in 31 states east of and bordering the Mississippi River to reduce sulfur dioxide emissions by eight million tons over 12 years. Such a reduction would probably mandate FGD for most existing coal-fired power plants in the region that do not currently have it. Thus, there would be a tremendous increase in solid waste from FGD systems.

SECTION 3

CLEAN WATER ACT OF 1977

PURPOSE AND SCOPE

On October 18, 1972, the Federal Water Pollution Control Act (FWPCA) was enacted as PL 92-500. Specific goals of the Act were as follows:

- It was the national goal that the discharge of pollutants into navigable waters be eliminated by 1985.
- It was the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983.
- It is the national policy that discharge of toxic pollutants in toxic amounts be prohibited. Under the FWPCA, EPA is responsible for establishing limitations for municipal discharges, industrial discharges, industrial users of municipal treatment works and effluent limits for toxic substances. Standards promulgated or proposed by EPA in 40 CFR, Parts 402 through 699 prescribe effluent limitation guidelines for existing sources, standards of performance for new sources, and pretreatment for new and existing sources.

FWPCA has been amended every year since its passage with a major amendment being enacted on December 28, 1977, by PL 95-217, which is termed the Clean Water Act (CWA) of 1977. Under Section 306 of the CWA, EPA is required to promulgate specific effluent limitations for steam electric power plants.

REGULATIONS

Effluent guidelines and standards for steam electric power generating are contained in 40 CFR, Part 423. These effluent limitations control the amount of pollutants in any point source discharge from a utility power plant. Specific effluent limitations also apply to discharges of coal pile runoff. The pH of all discharges must be within

the range of 6.0 to 9.0 and the maximum concentration of total suspended solids (TSS) must not exceed 50 mg/l in coal pile runoff. Although EPA has the authority under CWA to regulate leachate discharges, no Federal effluent criteria for leachate treatment plants have yet been promulgated. For similar situations, EPA ordinarily would utilize treatment technologies from an industry producing a similar contaminant, such as the metal plating industry, to set an effluent limitation for metals in a leachate stream.

SECTION 4

SAFE DRINKING WATER ACT OF 1974

PURPOSE AND SCOPE

The Safe Drinking Water Act (SDWA) of 1974 was enacted by PL 93-523, December 16, 1974. The purpose of the act is to assure that the public is provided safe drinking water, to provide for the protection of underground sources of drinking water, to assure that there will be an adequate supply of chemicals needed to treat public water systems, and to establish the National Drinking Water Advisory Council to make recommendations to the EPA about matters relating to this act.

The Safe Drinking Water Act is divided into three parts which are as follows:

Title	Scope
Part A - Definitions	
Part B - Public Water Systems	Requires EPA to publish primary and secondary drinking water standards
Part C - Protection of Underground Sources of Drinking Water	Requires EPA to publish proposed regulations for states to control underground injection

Under Part C [Section 1424(e)], EPA is required to identify areas which should be designated as sole or principal source aquifers and which, if contaminated, would create a significant hazard to public health. After publication of this designation in the Federal Register, no commitment for Federal financial assistance (through a grant, contract, loan guarantee or otherwise) may be entered into for any project which EPA determines may contaminate the recharge zone so as to create a significant hazard to public health. This is the only section of the act which specifically prevents the EPA from delegating this responsibility to the individual states. This was an ammendment which was added to the act specifically to require Federal involvement in the regulation of sole source aquifers.

REGULATIONS

In 1975, under the Safe Drinking Water Act, EPA adopted National Interim Primary Drinking Water Regulations specified in 40 CFR, Part 141. The regulations specify maximum levels for several organic and inorganic contaminants, microbiological contamination and turbidity. In March 1977, National Secondary Drinking Water Regulations were proposed and added to 40 CFR, Part 143. These regulations control contaminants in drinking water that primarily affect the aesthetic qualities relating to the public acceptance of drinking water. At considerably higher concentrations of these contaminants, health implications as well as aesthetic degradation may also exist. These regulations are not Federally enforceable but are intended as guidelines for the individual states.

Part C of the Safe Drinking Water Act authorized EPA to set up criteria and standards for an underground injection control program to be adminstered by the individual states affected. On September 25, 1978 (43 FR 4320) EPA issued a list of 22 states required to formulate regulations to protect underground drinking water supplies from contamination of deep well injection of toxic substances. Integral to the program are the classification of four types of injection wells which are classified as follows:

Class I - Wells used to inject hazardous waste beneath the lowermost formation containing, within one quarter (1/4) mile of the well bore, an underground source of drinking water. Other industrial and muncipal disposal wells which inject fluids beneath the lowermost formation containing, within one quarter mile of the well bore, an underground source of drinking water.

Class II - Wells which inject liquids (1) which are brought to the surface in connection with conventional oil or natural gas production, (2) for enhanced recovery of oil or natural gas; and (3) for storage of hydrocarbons which are liquid at standard temperature and pressure.

Class III - Wells which inject for extraction of minerals including sulfur, salt, potash or uranium.

Class IV - (1) Wells used to dispose of hazardous waste or radioactive waste into a formation which is within one quarter (1/4) mile of the well and contains an underground source of drinking water or (2)

Wells used to dispose of hazardous waste or radioactive waste above a formation which is within one quarter (1/4/) mile of the well and contains an underground source of drinking water.

Underground injection wells are unique among waste management units in that they are specifically regulated under a separate statute as well as under RCRA. Under the SDWA, EPA regulates the subsurface injection of wastes into wells through the Underground Injection Control program (UIC). When the liquids injected are hazardous wastes, there is an overlapping jurisdiction in the UIC program and the RCRA hazardous waste program.

Because of the overlapping jurisdiction between SDWA and RCRA, EPA has promulgated a permit-by-rule for injection wells as contained in 40 CFR 122.26(b). That section provides that the owner or operator of an injection well disposing of hazardous wastes will be deemed to have a RCRA permit if he (1) has and complies with a UIC permit, and (2) complies with special requirements in 40 CFR 122.45 for wells injecting hazardous waste.

The development of UIC standards under SDWA addressing the injection of hazardous wastes is not yet complete as of July 26, 1982.

SECTION 5

SURFACE MINING CONTROL AND RECLAMATION ACT OF 1977

PURPOSE AND SCOPE

The Surface Mining Control and Reclamation Act (SMCRA) of 1977 was enacted by P.L. 95-87, August 3, 1977. The purpose of the act was to:

- establish a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations;
- assure that the rights of surface land owners and other persons with a legal interest in the land are fully protected from such operations;
- assure that surface mining operations are not conducted where reclamation as required by this Act is not feasible;
- assure that surface coal mining operations are so conducted as to protect the environment;
- assure that adequate procedures are undertaken to reclaim surface areas as contemporaneously as possible with the surface coal mining operations;
- assure that the coal supply essential to the nation's energy requirements and to its economic and social well-being is provided and strike a balance between protection of the environment and agricultural productivity and the nation's need for coal as an essential source of energy;
- assist the States in developing and implementing a program to achieve the purposes of this Act;
- promote the reclamation of mined areas left without adequate reclamation prior to the enactment of this Act and which continue, in their unreclaimed condition, to substantially degrade the quality of the environment, prevent or damage the beneficial use of land or water resources, or endanger the health or safety of the public.

The Office of Surface Mining Reclamation and Enforcement (OSM) was established in the Department of the Interior to administer the regulations under the Act.

REGULATIONS

The regulations in Chapter VII of 30 CFR, consist of Parts 700-899, establishing procedures through which the Secretary of the Interior will implement SMCRA. Chapter VII is divided into thirteen subchapters. Of particular interest to this project is Subchapter K, Permanent Program Performance Standards. The objective of this subchapter is to insure that coal exploration and surface coal mining and reclamation operations are conducted in a manner which is compatible with the environmental, social and aesthetic needs of the nation. Accordingly, the performance standards provide for the following:

- Protection of the health, safety and general welfare of mine workers and the public;
- Prompt reclamation of all affected areas to conditions that are capable of supporting the premining land uses;
- Minimizing, to the extent possible using the best technology currently available, disturbances and adverse impacts on fish, wildlife and other related environmental values;
- Minimum disturbance to the prevailing hydraulic balance at the mine site and associated off-site areas;
- Confinement of surface coal mining and reclamation operation including spoil disposal areas to lands within the permit area;
- Striking a balance between the protection of the environment and agricultural productivity, and the nation's need for coal;
- Protection of endangered and threatened species and their critical habitats as determined by the Endangered Species Act of 1973.

SECTION 6

TOXIC SUBSTANCES CONTROL ACT OF 1976

PURPOSE AND SCOPE

The Toxic Substances Control Act (TSCA) was enacted by PL 94-469, October 11, 1976. The act addresses the following policy issues:

- Adequate data should be developed with respect to the affect of chemical substances and mixtures on health and the environment and that the development of such data should be the responsibility of those who manufacture and process such chemical substances and mixtures.
- Adequate authority should exist to regulate chemical substances and mixtures which present an unreasonable risk of injury to health or the environment and to take action with respect to chemical substances and mixtures which are imminent hazards.
- Authority over chemical substances and mixtures should be exercised in such a manner so as not to impede unduly or create unnecessary economic barriers to technological innovation while fulfilling the primary purposes of the act.

Under the Act, EPA is charged with requiring chemical manufacturers to evaluate substances for their potential to cause long-range physiological and ecological effects, particularly cancer, gene mutations and birth defects. The risk of injury may be increased because of a compound's stability and persistence, so this also is a factor to be investigated. Under the act, EPA cannot require testing of every chemical, but must first find that there may be a risk or that there may be extensive human or environmental exposure if that information is lacking and testing is necessary.

REGULATIONS

Regulations addressing TSCA are contained in 40 CFR, Part 761. To date, only one substance has been regulated under TSCA which would be

applicable within the utility industry. That substance is polychlorinated biphenyl (PCB). In the past, PCB was a component of the dielectric fluid in transformers and capacitors. Under TSCA, EPA has issued a ban on the manufacturing, processing, and distribution of products containing PCBs. EPA currently has specific disposal options identified for the disposal of wastes contaminated with PCB. Wastes which contain PCB in excess of 500 ppm must be burned in a high-temperature incinerator. Liquids containing more than 50 ppm and less than 500 ppm may be incinerated, burned in a high-efficiency boiler or disposed of in an approved chemical landfill. To date, there have been 8 chemical landfills throughout the United States which have been approved to receive PCB contaminated wastes.

Regulations contained in 40 CFR, Part 761.41 address the criteria which should be utilized for the design of an approved chemical waste landfill to receive PCB waste. The technical requirements as specified in the regulations address the following areas:

- Soils
- Synthetic Membrane Liners
- Hydrologic Conditions
- Flood Protection
- Topography
- Monitoring System
- Leachate Collection

The regulations, as written, require that the chemical waste landfill be approved by the EPA Regional Administrator.

SECTION 7

MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT OF 1972

PURPOSE AND SCOPE

The Marine Protection, Research, and Sanctuaries Act was enacted by P.L. 92-532, October 23, 1972. The act protects the ocean waters by the regulation of transportation and the dumping of material into ocean waters. The act mandates a comprehensive and continuing research program into the effects of pollution, overfishing, and other man-induced ecological effects on the marine environment. Under the act, the Secretary of Commerce is given the authority to designate areas of the ocean as marine sanctuaries. Once an area has been designated as a marine sanctuary, the activities in that area are regulated by the Secretary of Commerce in order to preserve and restore its conservation, recreational, ecological, and aesthetic values.

REGULATIONS

Subchapter H establishes procedures and criteria for the issuance of permits by EPA pursuant to Section 102 of the Act. Subchapter H also establishes the criteria to be applied by the Corps of Engineers in its review of activities involving the transportation of dredged material for the purpose of dumping it in ocean waters pursuant to Section 103 of the Act. Section 102 of the Act requires that criteria for the issuance of ocean disposal permits be promulgated after consideration of the environmental effect of the proposed dumping operation, the need for ocean dumping, alternatives to ocean dumping, and the effect of the proposed action on aesthetic, recreational and economic values and on other uses of the ocean. The Criteria of Part 227 deal with the evaluation of proposed dumping of materials on a case-by-case basis from information supplied by the applicant or otherwise available to EPA or the Corps of Engineers concerning the characteristics of the waste and other considerations relating to the proposed dumping.

Subpart B sets specific environmental impact prohibitions, limits, and conditions for the dumping of materials into ocean waters. If the applicable prohibitions, limits, and conditions are satisfied, it is the

determination of EPA that the proposed disposal will not unduly degrade or endanger the marine environment and that the disposal will present:

a) No unacceptable adverse effects on human health and no significant damage to the resources of the marine environment;
b) No unacceptable adverse effect on the marine ecosystem;
c) No unacceptable adverse persistent or permanent effects due to the dumping of the particular volumes or concentrations of these materials; and
d) No unacceptable adverse effect on the ocean for other uses as a result of direct environmental impact.

Wastes which may be generally approved for ocean dumping include the following:

a) Solid wastes consisting of inert natural minerals or material compatible with the ocean environment provided they are insoluble above the applicable trace or limiting permissible concentrations and are rapidly and completely settleable, or they are of particle size and density deposited or rapidly dispersed without damage to benthic, demersal, or pelagic biota.
b) Persistent inert synthetic or natural materials which have been processed in such a fashion that they will sink to the bottom and remain in place.
c) Dredged material determined to be environmentally acceptable for dumping.

SECTION 8

CONSOLIDATED PERMIT PROGRAM

PURPOSE AND SCOPE

In the fall of 1978, EPA initiated rule making for the consolidated permit program and published regulations in the Federal Register for comment on June 14, 1979. The purpose of the consolidated permit program was to expedite the review and processing of five environmental permits, namely, the RCRA permit, underground injection control (UIC) under the Safe Drinking Water Act, the NPDES permit, Dredge or Fill Program under Section 404 of the Clean Water Act and the PSD program under the Clean Air Act. The consolidation of these permit programs into one set of regulations is authorized by Sections 101(f) and 501(a) of CWA, Sections 1006 and 2002 of RCRA, Section 1450 of the SDWA, and Section 301 of the CAA. The purpose of the program is to integrate these laws and to avoid duplication in the permitting process.

REGULATIONS

The Consolidated Permit Program regulations are incorporated into three parts of Title 40 of the Code of Federal Regulations:

- Part 122. This Part contains definitions for all of the programs except PSD. It also contains basic permitting requirements for EPA-administered RCRA, UIC, and NPDES programs, such as application requirements, standard permit conditions, and monitoring and reporting requirements.
- Part 123. This Part describes what States must do to obtain EPA approval of their RCRA, UIC, NPDES, or 404 programs. It also sets forth the minimum requirements for administering these permit programs, after approval.
- Part 124. This Part establishes the procedures for EPA issuance of RCRA, UIC, NPDES, and PSD permits. It also establishes the procedures for administrative appeals of EPA permit decisions.

Under the consolidated permit program, a general form covering all programs has been developed plus several program specific forms. Although application forms have been consolidated, they, like the permits, have been coordinated without losing their separate legal identities. There is no "consolidated permit." Each permit and application under the program is a separate document. Most of the information requested on these application forms (other than Form 5 for PSD) is required by the regulations.

The five permit programs which are covered in these consolidated permit regulations each have separate additional regulations that contain technical requirements for those programs. These separate regulations are used by permit-issuing authorities to determine what requirements must be placed in permits if they are issued. These separate regulations are located as follows:

RCRA	40 CFR Parts 260-266
UIC	40 CFR Part 146
NPDES	40 CFR Parts 125, 129, 133, 136
	40 CFR Subchapter N (Parts 400-460)
404	40 CFR Part 230
PSD	40 CFR Part 52

U.S. DEPARTMENT OF ENERGY
Fossil Energy
Washington, D.C.

Form Approved
OMB No. 1901-0241
(Expires 1/31/82)

RESOURCE CONSERVATION AND RECOVERY ACT UTILITY IMPACT VERIFICATION DOCUMENT

GENERAL INFORMATION

I. Purpose

Form FE-735A is designed to enable the Department of Energy (DOE) to make evaluations and determinations relative to potential impacts deriving from regulatory requirements for compliance with the Resource Conservation and Recovery Act of 1976 (RCRA) and related environmental regulations.

II. Who Must Submit

Participating coal fired utilities greater than 25 megawatts must submit form FE-735A.

III. When to Submit

Submit form FE-735A within 15 days of receipt.

IV. Where to Submit

Send the completed form to:

Engineering Science, Inc.
Suite 590
57 Executive Park South, N.E.
Atlanta, Georgia 30329

If you have any questions concerning this form, call either Dr. Kenneth Crumrine of VERSAR at (703) 750-3000, or Mr. David Burstein, P.E. of Engineering-Science at (404) 325-0770.

V. Sanctions

This verification document is submitted to you for completion under the authority of the Department of Energy Organization Act, Public Law 95-91, and the Federal Nonnuclear Energy Research and Development Act of 1974, Public Law 93-577. While you are not required to respond, your response is needed to ensure that results are comprehensive, accurate and timely.

VI. Provisions for Confidentiality of Information

Data submitted on this form are not considered to be confidential.

GENERAL INSTRUCTIONS

I. Where the particular element is "not applicable", indicate with "NA". If data does exist, but is currently "unavailable", indicate by writing "unavailable" or "U".

II. Certain elements may appear to be repetitive based upon some plant configurations. Provide information for the element requiring the greatest detail and reference the number of the element you consider repetitive.

III. The flow sheets requested in Part XI may be engineering drawings or blueprints of the facility, if they are readily available, non-sensitive and can be transferred to DOE. Simple hand-drawn block diagrams or schematics are acceptable and preferable. Elaborate diagrams or artwork are unnecessary.

IV. Attach additional sheets if the alloted space for any response is insufficient.

U.S. DEPARTMENT OF ENERGY
Fossil Energy
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PART I – IDENTIFICATION DATA

1. Company Name	2. Name of contact person in company to whom questions may be directed regarding this Form	
3. Contact's Telephone Number	4. Plant Name	
5. Plant's Street Address	6. County	
7. City	8. State	9. Zip Code
10. Name of contact person in plant to whom questions may be directed regarding this Form	11. Contact's Telephone Number	
12. Name of Person Completing This Form	13. Position	14. Date Completed Form

PART II – TYPES OF FUEL

1. Indicate the coal rank used on a plant-wide basis. *(Mark "X" in all that apply)*	☐ Bituminous Coal ☐ Sub-bituminous Coal ☐ Lignite ☐ Anthracite
2. Enter the coal source(s) and their locations. *(Indicate mine, state, contract or spot purchase; attach additional page if necessary)*	_____ _____ _____ _____ _____ _____ _____ _____
3. Enter the in-plant live storage capacity.	_____ (tons)
4. Enter the outdoor plant storage capacity.	_____ (sheltered, tons) _____ (unsheltered, tons)

PART II – TYPES OF FUEL (Continued)	
5. Is the feed stock blended on-site from various coal storage piles representing various coal sources?	☐ Yes . . . *Answer Item 6* ☐ No . . . *Skip to Item 7*
6. Describe the blending specifications.	_____ _____ _____ _____ _____ _____ _____ _____
7. Is there a feed stock sampling system on the feed conveyor(s) before coal is pulverized?	☐ Yes . . . *Skip to Item 9* ☐ No . . . *Answer Item 8*
8. Is there some other accessible sampling point?	☐ Yes . . . *Indicate location on plant schematic (Part XI, Item 1)* ☐ No
9. Is there a feed stock sampling system between the pulverizer discharge and the boiler inlet?	☐ Yes . . . *Skip to Item 11* ☐ No . . . *Answer Item 10*
10. Is there some other accessible sampling point?	☐ Yes . . . *Indicate location on plant schematic (Part XI, Item 1)* ☐ No
11. Is the runoff from the coal pile and transfer area (unloading areas, crusher house drainage, etc.) collected?	☐ Yes ☐ No
12. Are these areas lined?	☐ Yes ☐ No
13. Estimate the annual runoff discharge and, if treated, describe the treatment process.	_____ _____ _____ _____ _____ _____ _____ _____ _____

RESOURCE CONSERVATION AND RECOVERY ACT UTILITY IMPACT VERIFICATION DOCUMENT

PART III – FURNACE-BOILER DESCRIPTION						
▶ Boiler Unit Number ▶	1st Unit	2nd Unit	3rd Unit	4th Unit	5th Unit	6th Unit
1. Specify the type of service. *(Mark "X" in one box)*	☐ Base Load ☐ Load Following (cyclic) ☐ Peaking	☐ Base Load ☐ Load Following (cyclic) ☐ Peaking	☐ Base Load ☐ Load Following (cyclic) ☐ Peaking	☐ Base Load ☐ Load Following (cyclic) ☐ Peaking	☐ Base Load ☐ Load Following (cyclic) ☐ Peaking	☐ Base Load ☐ Load Following (cyclic) ☐ Peaking
2. Enter the Service Entry Date (Month, Year)						
3. Specify the firing mode. *(Either mark "X" in one box or specify one of the firing modes)*	☐ Stoker ☐ Pulverized Coal-Dry Ash Furnace ☐ Pulverized Coal-Slag Tap Furnace	☐ Stoker ☐ Pulverized Coal-Dry Ash Furnace ☐ Pulverized Coal-Slag Tap Furnace	☐ Stoker ☐ Pulverized Coal-Dry Ash Furnace ☐ Pulverized Coal-Slag Tap Furnace	☐ Stoker ☐ Pulverized Coal-Dry Ash Furnace ☐ Pulverized Coal-Slag Tap Furnace	☐ Stoker ☐ Pulverized Coal-Dry Ash Furnace ☐ Pulverized Coal-Slag Tap Furnace	☐ Stoker ☐ Pulverized Coal-Dry Ash Furnace ☐ Pulverized Coal-Slag Tap Furnace
– Other *(Specify; for example, cyclone, fluidized bed, etc.)*						
– Combustion modification *(Specify; for example, additives, staged combustion, etc.)*						
4. Enter the following boiler characteristics:						
a. Gross Electric Capacity (Nameplate) (MWe)						
b. Gross Generation for 1980 (MWe)						
c. Steam Rating (Nameplate) (lb./hr. x 10^3)						
d. Net Heat Rate (10^6 Btu/Kwh) at Full-Load *(Specify whether Btu or Kwh is used)*						
e. Percent Availability 1981 (Jan. – Jun.)/ (Jul. – Dec.)	% / %	% / %	% / %	% / %	% / %	% / %
f. Percent Availability 1980 (Jan. – Jun.)/ (Jul. – Dec.)	% / %	% / %	% / %	% / %	% / %	% / %

Enter any additional information here:

RESOURCE CONSERVATION AND RECOVERY ACT UTILITY IMPACT VERIFICATION DOCUMENT

PART III – FURNACE-BOILER DESCRIPTION (Continued)						
▶ Boiler Unit Number ▶	1st Unit	2nd Unit	3rd Unit	4th Unit	5th Unit	6th Unit
4. Enter the following boiler characteristics (Continued):						
g. Days on line 1980						
h. Projected Outages (for example, maintenance, boiler cleaning equipment installation – *Give initiation dates/termination dates.)*						
5. Identification of Fuel Characteristics						
Fuel Consumption for 1980:						
a. Enter the quantity of coal (tons x 10^3)						
b. Enter the type of oil (grade) (excluding start-up and flame stabilization fuel)						
c. Enter the quantity of oil (Bbl. x 10^3)						
d. Enter the quantity of gas (Mcf) (excluding start-up and flame stabilization fuel)						
e. Other						
Start-up and Flame Stabilization Fuel Burned in 1980:						
f. Enter the quantity of oil (Bbl. x 10^3)						
g. Enter the quantity of gas (Mcf)						
h. Other *(Specify)*						
6. Projected Coal Consumption (1985) (tons x 10^3)*						
7. Projected Coal Consumption (2000) (tons x 10^3)*						
8. Principal Coal Rank						

*Quantities projected for future years must reflect yearly totals, not cumulative totals.

Enter any additional information here:

PART III – FURNACE-BOILER DESCRIPTION (Continued)						
▶ Boiler Unit Number ▶	1st Unit	2nd Unit	3rd Unit	4th Unit	5th Unit	6th Unit
9. Answer the following data regarding the analysis of principal coal:						
Moisture (%)						
Ash (% – dry)						
Ash Composition (wt. %) *(If available, attach additional sheet)*						
Volatile Matter (% – dry)						
Total Sulfur (% – dry)						
Heating Value as Burned (Btu/lb.)						
10. Enter the following data concerning mass balance (for a typical daily coal feed rate, estimate the ash and waste production rates based upon principal coal used):						
Flow Rates (tons/hr.):						
Coal Feed						
Fly Ash						
Bottom Ash/Slag						
Scrubber Sludge						
Flue Gas Desulfurization Sludge						
Other (for example, waste water treatment sludge, boiler cleaning, wastes)						

Enter any additional information here:

PART III – FURNACE-BOILER DESCRIPTION (Continued)		
11. Enter the annual waste generation data for the plant.	Tons/year (x 10^3)	Feet^3/year (as disposed)
a. Fly Ash Quantity		
b. Bottom Ash Quantity		
c. Scrubber Sludge Quantity		
d. FGD Sludge Quantity		
e. Wastewater Treatment Sludge Quantity		
f. Boiler Cleaning Wastes (gal./yr.) Quantity		
g. Describe the method employed for disposal of boiler cleaning wastes.		

RESOURCE CONSERVATION AND RECOVERY ACT UTILITY IMPACT VERIFICATION DOCUMENT

PART IV – PARTICULATE CONTROL DEVICES						
▶ Boiler Unit Number ▶	1st Unit	2nd Unit	3rd Unit	4th Unit	5th Unit	6th Unit
Indicate the presence or absence of the following devices by responding yes or no. If yes, include pertinent information requested beneath each device.						
1. Electrostatic Precipitator	☐ Yes, *answer a & b* ☐ No, *skip to 2*	☐ Yes, *answer a & b* ☐ No, *skip to 2*	☐ Yes, *answer a & b* ☐ No, *skip to 2*	☐ Yes, *answer a & b* ☐ No, *skip to 2*	☐ Yes, *answer a & b* ☐ No, *skip to 2*	☐ Yes, *answer a & b* ☐ No, *skip to 2*
a. Manufacturer and Model						
b. Operating Efficiency (wt. %)						
2. Fabric Filter, Baghouse	☐ Yes, *answer a,b & c* ☐ No, *skip to 3*	☐ Yes, *answer a,b & c* ☐ No, *skip to 3*	☐ Yes, *answer a,b & c* ☐ No, *skip to 3*	☐ Yes, *answer a,b & c* ☐ No, *skip to 3*	☐ Yes, *answer a,b & c* ☐ No, *skip to 3*	☐ Yes, *answer a,b & c* ☐ No, *skip to 3*
a. Manufacturer and Model						
b. Gas – Cloth Ratio						
c. Operating Efficiency (wt. %)						
3. Mechanical Dust Collector (for example, cyclone)	☐ Yes, *answer a & b* ☐ No, *skip to 4*	☐ Yes, *answer a & b* ☐ No, *skip to 4*	☐ Yes, *answer a & b* ☐ No, *skip to 4*	☐ Yes, *answer a & b* ☐ No, *skip to 4*	☐ Yes, *answer a & b* ☐ No, *skip to 4*	☐ Yes, *answer a & b* ☐ No, *skip to 4*
a. Manufacturer and Model						
b. Operating Efficiency (wt. %)						
4. Wet Venturi Scrubber	☐ Yes, *answer a & b* ☐ No, *skip to bottom*	☐ Yes, *answer a & b* ☐ No, *skip to bottom*	☐ Yes, *answer a & b* ☐ No, *skip to bottom*	☐ Yes, *answer a & b* ☐ No, *skip to bottom*	☐ Yes, *answer a & b* ☐ No, *skip to bottom*	☐ Yes, *answer a & b* ☐ No, *skip to bottom*
a. Manufacturer and Model						
b. Operating Efficiency (wt. %)						

Enter any additional information here:

PART IV – PARTICULATE CONTROL SERVICES						
▶ Boiler Unit Number ▶	1st Unit	2nd Unit	3rd Unit	4th Unit	5th Unit	6th Unit
Enter below the type of planned additional particulate control capacity to be added to the facility. Estimate the quantity of waste to be produced in tons per year (For example, ESP producing 100,000 tons/year)						
5. Planned Additional Control Devices (1985)						
Estimated Quantity of Waste (tons)						
6. Planned Additional Control Devices (2000)						
Estimated Quantity of Waste (tons)						
PART V – FLUE GAS DESULFURIZATION						
1a. Indicate the classification of waste.	☐ Wet ☐ Dry ☐ Throw-away ☐ Regenerative, *answer 1b*	☐ Wet ☐ Dry ☐ Throw-away ☐ Regenerative, *answer 1b*	☐ Wet ☐ Dry ☐ Throw-away ☐ Regenerative, *answer 1b*	☐ Wet ☐ Dry ☐ Throw-away ☐ Regenerative, *answer 1b*	☐ Wet ☐ Dry ☐ Throw-away ☐ Regenerative, *answer 1b*	☐ Wet ☐ Dry ☐ Throw-away ☐ Regenerative, *answer 1b*
b. Describe the regenerative process.						
2. List the reactants used.						
Enter any additional information here:						

RESOURCE CONSERVATION AND RECOVERY ACT UTILITY IMPACT VERIFICATION DOCUMENT

PART V – FLUE GAS DESULFURIZATION						
▶ Boiler Unit Number ▶	1st Unit	2nd Unit	3rd Unit	4th Unit	5th Unit	6th Unit
Indicate below the type of planned FGD control capacity anticipated to be added at the facility. Estimate the quantity of waste to be produced in tons. Indicate wet or dry disposal.						
3. Projected Additional FGD Systems (1985)						
Estimated Quantity of Waste (tons)						
4. Projected Additional FGD Systems (2000)						
Estimated Quantity of Waste (tons)						

PART VI – ADDITIVES USED TO ENHANCE GAS STREAM CLEANUP	
1. Enter the chemical name of additive	
2. Enter the frequency of use (1980)	
3. Enter the quantity used (gal./month)	
4. Describe the point of injection	
5. Indicate any anticipated changes in additive type, point of injection, quantity, etc.	

Enter any additional information here:

RESOURCE CONSERVATION AND RECOVERY ACT UTILITY IMPACT VERIFICATION DOCUMENT

PART VII – SOLID WASTE DISPOSAL PRACTICES

1. Describe the ash disposed on-site.

a. Amount (tons/year)	b. Cost to Dispose ($/year)	c. Distance from Plant (miles)

2. Describe the ash disposed off-site.

a. Amount (tons/year)	b. Cost to Dispose ($/year)	c. Distance from Plant (miles)

3. Answer the following items regarding ash sold, reclaimed, or reused as:

a.(1) Contract Sales _____ (tons/year)	a.(2) Total Value _____ ($/year)
b.(1) Pozzolan _____ (tons/year)	b.(2) Total Value _____ ($/year)
c.(1) Structural Fill _____ (tons/year)	c.(2) Total Value _____ ($/year)
d.(1) Roadbase _____ (tons/year)	d.(2) Total Value _____ ($/year)
e.(1) Aggregate _____ (tons/year)	e.(2) Total Value _____ ($/year)

f.(1) Others *(Identify)*	f.(2) Quantity	f.(3) Total Value
	_____ (tons/year)	_____ ($/year)

g. Total Cost Credits From All Sales, Reclamation, or By-Products _____ ($/year)	4. Indicate the current disposal practice. a. Wet Disposal (ponding (tons/year)) _____ (tons/year)
b. Dry Disposal (landfill) _____ (tons/year)	c. Contracted Disposal _____ (tons/year)

Enter any additional information here:

PART VII – SOLID WASTE DISPOSAL PRACTICES (Continued)

5. Specify any fixation techniques employed:

a. IUCS (tons/year) _____

b. Dravo (tons/year) _____

c. Stabilex (tons/year) _____

d. Chemfix (tons/year) _____

e. Research Cottrell (tons/year) _____

f.(1) Other *(Specify)* _____

f.(2) (tons/year) _____

6a. Indicate the type of disposal pond/landfill liner used. *(Check all boxes that apply)*

☐ None
☐ Clay
☐ Membrane
☐ Other *(Specify)* _____

6b. Is there any runoff/leachate collection?
☐ Yes
☐ No

7a. Enter the total waste inventory at active disposal site. _____ (cu. ft., acre-ft.)

b. At inactive disposal site. _____ (cu. ft., acre-ft.)

8. Enter the projected total remaining capacity of current disposal sites. _____ (cu. ft., acre-ft.)

9. Enter the planned new disposal site capacity. _____ (cu. ft., acre-ft.)

10. Enter the waste disposal pond additives and quantity on an annual basis.

a. None _____

b. Flocculants _____

c. Acid _____

d. Lime _____

e.(1) Other *(Specify)* _____

e.(2) Quantity of Other _____

11. Is pond effluent recycled to power plant?
☐ Yes ☐ No

12. Are there groundwater monitoring wells around the pond?
☐ Yes ☐ No

13a. Do you have or anticipate purchase of liability insurance for "sudden" and "non-sudden" accidents or injuries associated with treatment, storage, or disposal operations?
☐ Yes . . . *Answer 13b* ☐ No . . . *Skip to 14*

13b. What is the cost or anticipated cost of this insurance?

14. Enter miscellaneous comments regarding waste disposal practices here.

PART VIII – FLUE GAS EMISSION CONTROL REGULATIONS

1. Emission Source	Stack 1	Stack 2	Stack 3	Stack 4	Stack 5	Stack 6
2. Identify the most stringent air quality regulation under which the site is operating. *(Indicate Federal, State, Local)*						
3. Enter the maximum air emissions allowable:						
a. Particulates (lbs/MMBtu)						
b. SO_2 (ppm or lbs SO_2/MMBtu)						
c. NO_2 (tons/year)						
d. CO (ppm)						
e. Other *(Specify)*						

Enter any comments regarding air emission controls here.

PART IX – WASTEWATER TREATMENT PRACTICES

1. Indicate the applicable effluent discharge permit(s) under which the site is operating. *(Mark "X" in all boxes that apply)*
   - ☐ NPDES
   - ☐ Local
   - ☐ State

2. Specify the effluent discharge requirements:

a. Suspended Solids	b. BOD	c. COD	d. Fe	e. Cu	f. pH
_____ (ppm, mg/l)	_____ (ppm, mg/l)	_____ (ppm, mg/l)	_____ (ppm, mg/l)	_____ (ppm, mg/l)	_____ (units)

g. TDS	h. TSS	i.(1) Other *(Specify type)*	i.(2) Discharge Requirement *(Specify unit)*
_____ (ppm, mg/l)	_____ (ppm, mg/l)	_____	_____

Enter any additional information here:

PART IX – WASTEWATER TREATMENT PRACTICES (Continued)

3. Indicate the wastewater treatment technology(ies) being utilized: *(Mark "X" in all boxes that apply)*

- ☐ None
- ☐ Settling Ponds
- ☐ Coagulation
- ☐ Biological Treatment
- ☐ Filtration
- ☐ Other *(Specify)* _____

4. Enter any comments regarding the wastewater treatment.

PART X – PHYSICAL CHARACTERISTICS OF POWER PLANT AND DISPOSAL SITES

1. Is suitable land available for waste disposal within a 10-mile radius of plant?
   - ☐ Yes
   - ☐ No

2. Is the location of the plant site within an environmentally sensitive area (ESA)?

Yes	No		Yes	No	
☐	☐	Sole Source Aquifier	☐	☐	Wetland
☐	☐	Active Fault Zone	☐	☐	Endangered Species/Critical Habitat
☐	☐	100-Year Flood Plain	☐	☐	Coastal High Hazard Area

3a. Are there clay deposits suitable for a liner within a 10-mile radius?
- ☐ Yes, *answer 3b*
- ☐ No, *skip to 4*

b. Cost to Purchase Clay _____ ($/yd^3)

4a. Is there adequate waste transportation available by:

	Yes	No			Average Haulage Cost ($/ton/mile)
(1)	☐	☐	Truck *(If yes, answer (1))*	(1)	_____
(2)	☐	☐	Rail *(If yes, answer (2))*	(2)	_____
(3)	☐	☐	Barge *(If yes, answer (3))*	(3)	_____

5. What is the depth to groundwater? (Feet from surface at plant site)

6. What is the depth to bedrock? (Feet from surface at plant site)

7. Is a percolation test available for inspection?
   - ☐ Yes
   - ☐ No

8. What is the net evaporation rate? _____ (inches/year)

9. What is the average annual precipitation? _____ (inches)

10. Describe the physiographic location (for exemple, Appalachian Plateau).

11. Enter any comments regarding the geophysical characteristics of the site.

PART XI – ATTACHMENTS

Provide the following attachements:

1. Plant Schematic

Provide a currently available block diagram or hand-drawn schematic of the plant, including coal feed system, boilers, pollution control devices, and waste handling systems. Detail the ash handling operations for each boiler unit listed in Part III. If available, include:

•a topographic map of plant site
•existing and potential waste disposal areas and groundwater monitoring wells
•soil and hydrogeologic information

Attach additional page(s) if necessary.

2. Fly Ash Handling

Describe the fly ash handling system for each unit outlined in the Plant Schematic (Part XI, Item 1). Detail the ash handling operations from the point the flue gases enter the collection device (ESP, mechanical dust collector, baghouse, etc.) to its final disposal point (ash pond, landfill). Include a description of any accessible sampling points within these handling systems. This description can be provided in a currently available schematic or hand-drawn schematic similar to the Plant Schematic (Part XI, Item 1). Attach additional page(s) if necessary.

3. Bottom Ash/Boiler Slag Handling

Describe the bottom ash/boiler slag handling system for each unit outlined in the Plant Schematic (Part XI, Item 1). Detail the ash handling operations from each boiler to the point where the ash is finally disposed. Include a description of any accessible sampling points within these handling systems. This description can be provided in a currently available schematic or hand-drawn schematic similar to the Plant Schematic (Part XI, Item 1). Attach additional page(s) if necessary.

4. Wet Scrubber and/or Gas Desulfurization Waste Handling

Describe the scrubber waste handling system for each unit outlined in the Plant Schematic (Part XI, Item 1). Detail the sludge handling operations from the point the flue gases enter the control/device to its final disposal point (landfill, stabilized, etc.). Include a description of any accessible sampling points within these handling systems. This description can be provided in a currently available schematic or hand-drawn schematic similar to the Plant Schematic (Part XI, Item 1). Attach additional page(s) if necessary.

Plant Name_____ Plant ID No._____

TABLE OF CONTENTS
DATA MANAGEMENT PLAN

1. General Case Study Requirements
   A. Site Visit Checklist
   B. Subject/Source Matrix
   C. Site Visit Confirmation Letter
   D. Case Study Report Outline

2. Pre-Visit Case Study Data
   A. FPC form 67 for 1980, Review Other Federal Forms (4,123,etc.)
   B. Verification Document

3. Site Visit Interview Sheet
   A. Plant Description
   B. Power Generation Equipment
   C. Characteristics of Principal Coal Used in 1980
   D. Air Emission Control Equipment
   E. Waste Quantities and Characteristics
   F. Current Waste Storage Practices
   G. Current Waste Treatment Practices
   H. Current Waste Disposal Practices
   I. Design Data for Current Disposal Facilities
   J. Design Data for Future Disposal Facilities
   K. Impacts of Other Regulations on Waste Disposal
   L. Local Jurisdictional/Geo-Political Constraints
   M. Checklist of Supplemental Case Study Information

4. Case Study Design and Cost Estimating Model
   A. Flow Sheets
   B. Model Description
   C. Input Forms
   D. Output Formats

5. Data Management for 400-Plant Verification Documentation
   A. Flow Sheet
   B. Data Entry Instructions
   C. Output Formats

Plant Name _____ Plant ID No. _____

SECTION 1A
SITE VISIT CHECK LIST

	ACTIVITY	DATE
A1.	Compile FPC 67 Data for 1980	
A2.	Transpose A1 data to Verification Document (FE-735A)	_____
A3.	Address transmittal letter for Briefing Documents	_____
A4.	Mail Briefing Documents (including A2 and A3) to primary utility contact	_____
A5.	Call primary utility contact	_____
	A5.1 Verify receipt of documents	_____
	A5.2 Obtain verbal approval of plant's cooperation	_____
	A5.3 Verify suitability of plant for site visit	_____
	A5.4 Request written approval for ES and Versar site visits be sent to ES	_____
	A5.5 Identify points of contact (Section 1B)	_____
A6.	Telex Art Jung, Larry Jackson and Val Weaver upon obtaining verbal approval	
A7.	Send log of A5 to Versar, Larry Jackson (LETC) and Val Weaver	_____
A8.	Find out Versar schedule dates for visits	_____
A9.	Fill in target dates for remainder of this form	_____
A10.	Receive filled-in Verification Document	_____
A11.	Send copy of A10 to Ken Crumrine.	_____
A12.	Receive confirmation letter from utility	_____
A13.	Send copy of confirmation letter to Ken Crumrine, Val Weaver and Larry Jackson	_____
A14.	Check A9 for internal inconsistencies	_____
A15.	Fill in Case Study Background Data (as much as possible)	_____
A16.	Divide Responsibilities for Collecting Site Visit Data	_____
A17.	Collect Site Visit Data	_____
	A17.1 Plant	_____
	A17.2 Health Departments	_____
	A17.3 Highway Department	_____
	A17.4 SCS (Soil Conservation Service)	_____
	A17.5 WRD (Water Resources Department)	_____
	A17.6 SGS (State Geologic Society)	_____
	A17.7 P&Z (County Planning & Zoning Department)	_____

Plant Name_____ Plant ID No._____

SECTION 1A
SITE VISIT CHECK LIST
(Continued)

ACTIVITY		DATE
A18.	Review responses to identify discrepancies and data gaps	_____
A19.	Resolve discrepancies and data gaps identified in Step A18	_____
A20.	Consolidate responses into a single set	_____
A21.	Send copy of consolidated documents and raw interview sheets to primary contact for confirmation	_____
A22.	Obtain written confirmation for Step A21	_____
A23.	File all relevant information in 3111 files	_____
A24.	Prepare preliminary designs	_____
A25.	Prepare cost estimates	_____
A26.	Send Draft Site Visit Reports to plant Val Weaver	_____
A27.	Obtain plant concurrences of A26	_____
A28.	Send Final Site Visit Report	_____

DATA SOURCE _____

PLANT ID NO. _____

SECTION 1B
SUBJECT/PERSONNEL MATRIX

SUBJECT AREA	KEY PERSONNEL 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3A Plant Description															
3B Power Generation Equipment															
3C Characteristics of Principal Coal (1980)															
3D Air Emission Control Equipment															
3E Waste Quantities and Characteristics															
3F Current Waste Storage Practices															
3G Current Waste Treatment Practices															
3H Current Waste Disposal Practices															
3I Design Data for Future Disposal Facilities															
3J Administrative Requirements for Waste Disposal															
3K Impacts of Other Regulations on Waste Disposal															
3L Local Jurisdictional/Societal Constraints															

KEY PERSONNEL

	(Name)	(Organization)	(Title)	(Phone)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

PLANT NAME _____ PLANT ID NO. _____

SECTION 1D
CASE STUDY REPORT OUTLINE

Section 1: Summary of Current Conditions

- A. Plant Description
- B. Power Generation Equipment
- C. Characteristics of Principal Coal Used in 1980
- D. Air Emission Control Equipment
- E. Waste Quantities and Characteristics
- F. Waste Storage Practices
- G. Waste Treatment Practices
- H. Waste Disposal Practices

Section 2: Design of Future Disposal Facilities

- A. Design Approach
- B. Basic Design Data
- C. Disposal Facilities Conforming to Current Practice
- D. Disposal Facilities Conforming to RCRA Non-Hazardous Requirements.
- E. Disposal Facilities Conforming to RCRA Hazardous Requirements

Section 3: Cost Estimates for Future Disposal Facilities

- A. Cost Estimating Approach
- B. Costs for Facilities Conforming to Current Practice
- C. Costs for Facilities Conforming to RCRA Non-Hazardous Requirements
- D. Costs for Facilities Conforming to RCRA Hazardous Requirements.

Section 4: Non-Quantifiable Impacts

- A. Impacts of Other Regulations on Waste Disposal
- B. Local Jurisdictional/Geo-Political Constraints

Appendices:

- A. Composition of Typical Ash Sample
- B. Ash Emission Permit(s)
- C. Wastewater Discharge Permit(s)
- D. Boring Logs in General Area of Proposed Disposal Facilities
- E. Percolation Tests in General Area of Proposed Disposal Facilities
- F. Site Photos
- G. Other Plant-Specific Data

DATA SOURCE _____ PLANT ID NO. _____

SECTION 1D
CASE STUDY REPORT OUTLINE
(Continued)

LIST OF FIGURES

1.1 Power Plant Location Map
1.2 Plant Schematic Flow Diagram
1.3 Mass Balance of 1980 Coal Feed and Waste Production
1.4 Current Waste Disposal Facilities (site plans, schematics, cross-sections, etc.)
1.5 Schematic Flow Diagram of Existing Wastewater Treatment Facilities (inch sizes)
2.1 Schematic Flow Diagram for Facilities Conforming to Current Practice
2.2 Typical Plan and Sections for Facilities Conforming to Current Practice
2.3 Proposed Location for Facilities Conforming to Current Practice
2.4 Schematic Flow Diagram for Facilities Conforming to RCRA Non-Hazardous Requirements
2.5 Typical Plan and Sections for Facilities Conforming to RCRA Non-Hazardous Requirements
2.6 Proposed Location for Facilities Conforming to RCRA Non-Hazardous Requirements
2.7 Schematic Flow Diagram for Facilities Conforming to RCRA Hazardous Requirements
2.8 Typical Plan and Sections for Facilities Conforming to RCRA Hazardous Requirements
2.9 Proposed Location for Facilities Conforming to RCRA Hazardous Requirements

Note: Some figures may be omitted or additional figures added based on site-specific considerations.

PLANT ID NO. _____

DATA SOURCE _____

SECTION 3A
PLANT IDENTIFICATION DATA

3A.1 Plant Name _____

3A.2 Mailing Address _____
(P.O.Box) (Street) (City) (County) (State) (Zip Code)

3A.3 Utility Owner _____
(Name) (Address) (City) (State) (Zip Code)

3A.4 Dates of Visits: Versar Preliminary _____
Versar Final _____
ES _____

3A.5 Key Personnel Providing Data

(Name)	(Organization)	(Title)	(Phone No.)
	Engineering-Science		
	Engineering-Science		
	Versar	Team Leader	

DATA SOURCE _____

PLANT ID NO. _____

SECTION 3A
PLANT IDENTIFICATION DATA
(Continued)

3A.6 Physiographic Location _____

3A.7 Surrounding Metropolitan Areas _____ _____ _____

_____ _____ _____

_____ _____ _____

_____ _____ _____

(Names of Surrounding Areas) (Radius) (Total Population)

3A.8 Coordinates sites (from quad sheets) (D.M.S.)

PLANT

N _____

E _____

DISPOSAL AREA(S)

N _____

E _____

3A.9 Comments _____

_____

_____

_____

_____

_____

_____

_____

PLANT ID NO. _____

DATA SOURCE _____

SECTION 3B
POWER GENERATION EQUIPMENT

									Total Plant
3B.0	Boiler Unit Number	____	____	____	____	____	____	____	
3B.1	Type of Service (check one)								
	3B.1.1 Base Load	____	____	____	____	____	____	____	____ *
	3B.1.2 Load Following	____	____	____	____	____	____	____	____ *
	3B.1.3 Peaking	____	____	____	____	____	____	____	____ *
3B.2	Service Entry Date	____	____	____	____	____	____	____	____
3B.3	Firing Mode (check one)								
	3B.3.1 Stoker	____	____	____	____	____	____	____	____
	3B.3.2 Pulverized Coal-Dry Ash Furnace	____	____	____	____	____	____	____	____
	3B.3.3 Pulverized Coal-Slag Tap Furnace	____	____	____	____	____	____	____	____
	3B.3.4 Other _____	____	____	____	____	____	____	____	____
	3B.3.5 Other _____	____	____	____	____	____	____	____	____
3B.4	Combustion Modification								
	3B.4.1 Additives _____	____	____	____	____	____	____	____	____
	3B.4.2 Staged Combustion	____	____	____	____	____	____	____	____
	3B.4.3 Fly Ash Reinjection	____	____	____	____	____	____	____	____
	3B.4.4. Coal Beneficiation	____	____	____	____	____	____	____	____
	3B.4.5 Coal Precleaning	____	____	____	____	____	____	____	____
	3B.4.6 Other _____	____	____	____	____	____	____	____	____
3B.5	Boiler Capacity								
	3B.5.1 Nameplate Gross Electric Capacity (MW_e)	____	____	____	____	____	____	____	____
	3B.5.2 Nameplate Steam Rating (lbs/hr)	____	____	____	____	____	____	____	____
	3B.5.3 Net Heat Rate at Full Load (Btu/Kwh)	____	____	____	____	____	____	____	____
3B.6	Operating Data								
	3B.6.1 Gross Power Generation (MW_e)	____	____	____	____	____	____	____	____
	3B.6.2 1980 Availability Jan-June/July-Dec(%/%)	____	____	____	____	____	____	____	____
	3B.6.3 1981 Availability Jan-June/July-Dec(%/%)	____	____	____	____	____	____	____	____
	3B.6.4 Total Days on Line in 1980	____	____	____	____	____	____	____	____
	3B.6.5 Projected Outages - Initiation and Termination Dates	____	____	____	____	____	____	____	____

DATA SOURCE _____

PLANT ID NO. _____

SECTION 3B
POWER GENERATION EQUIPMENT
(Continued)

									Total Plant
	Boiler Unit Number	____	____	____	____	____	____	____	
3B.6	Operating Data (Continued)								
	3B.6.6 1980 Coal Consumption (tons x 10^3)	____	____	____	____	____	____	____	____
	3B.6.7 1980 Oil Consumption - Excluding start-up and flame stabilization (bbls x 10^3)	____	____	____	____	____	____	____	____
	3B.6.8 Oil Grade	____	____	____	____	____	____	____	____
	3B.6.9 1980 Gas Consumption - Excluding start-up and flame stabilization (cu.ft. x 10^6)	____	____	____	____	____	____	____	____
	3B.6.10 Other Fuel Consumed in 1980 _____	____	____	____	____	____	____	____	____
3B.7	Start-Up and Flame Stabilization Fuel - 1980								
	3B.7.1 Oil Consumption (bbls x 10^3)	____	____	____	____	____	____	____	____
	3B.7.2 Gas Consumption (cu.ft. x 10^6)	____	____	____	____	____	____	____	____
	3B.7.3 Other - Specify _____	____	____	____	____	____	____	____	____
3B.8	Projected 1985 Coal Consumption (tons x 10^3)	____	____	____	____	____	____	____	____
3B.9	Projected Year 2000 Coal Consumption (tons x 10^3)	____	____	____	____	____	____	____	____
3B.10	Principal Coal Rank _____								
3B.11	Typical Daily Mass Balance - Tons/hr								
	Coal Feed	____	____	____	____	____	____	____	____
	Fly Ash	____	____	____	____	____	____	____	____
	Bottom Ash/Slag	____	____	____	____	____	____	____	____
	Scrubber Sludge	____	____	____	____	____	____	____	____
	FGD Sludge	____	____	____	____	____	____	____	____
	Other	____	____	____	____	____	____	____	____

3B.12 Other: _____

*Weighted average based on 1980 fuel consumption data.

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3-C
CHARACTERISTICS OF PRINCIPAL COAL USED IN 1980

		SOURCE 1*	SOURCE 2*	SOURCE 3*	SOURCE 4*	TOTAL PLANT
3C.1	Percent of Coal Used	_____	_____	_____	_____	_____
3C.2	Contract or Spot	_____	_____	_____	_____	_____
3C.3	Coal Rank	_____	_____	_____	_____	
3C.4	Moisture %	_____	_____	_____	_____	_____
3C.5	Ash % Dry	_____	_____	_____	_____	_____
3C.6	Volatile Matter % Dry	_____	_____	_____	_____	_____
3C.7	Total sulfur % Dry	_____	_____	_____	_____	_____
3C.8	Heating Value (as Burned) BTU/LB	_____	_____	_____	_____	_____
3C.9	Grindability (Hargreave)	_____	_____	_____	_____	_____
3C.10	Mesh Size (as received)	_____	_____	_____	_____	_____

3C.11 In-plant live storage _____ tons

3C.12 Outdoor plant storage _____ sheltered, tons
_____ unsheltered, tons

3C.13 Is feed stock blended _____yes _____no

3C.14 Discribe blending _____
_____
_____
_____

3C.15 Is there a feed stock sampling system on the feed conveyor before coal is pulverized _____yes _____no

3C.16 Is there some other accessible sampling point _____yes _____no

3C.17 Is there a feed stock sampling system between the pulverizer discharge and boiler inlet _____yes _____no

3C.18 Is there some other accessible sampling point _____yes _____no

*Source 1 = _____

*Source 2 = _____

*Source 3 = _____

*Source 4 = _____

DATA SOURCE _____

PLANT ID NO. _____

SECTION 3D
AIR EMISSION CONTROL EQUIPMENT

									Total Plant
3D.0	Boiler Unit Number								
3D.1	Existing Equipment								
3D.1.1	Electrostatic Precipitator*								
3D.1.2	Manufacturer and Model								
3D.1.3	Operating Efficiency (wt.%)								
3D.1.4	Baghouse Filter								
3D.1.5	Manufacturer and Model								
3D.1.6	Operating Efficiency (wt.%)								
3D.1.7	Mechanical Dust Collector (e.g., Cyclone)								
3D.1.8	Manufacturer and Model								
3D.1.9	Operating Efficiency (wt.%)								
3D.1.10	Wet Scrubber								
3D.1.11	Manufacturer and Model								
3D.1.12	Operating Efficiency (wt.%)								
3D.1.13	Dry Scubber								
3D.1.14	Manufacturer and Model								
3D.1.15	Operating Efficiency (wt.%)								
3D.1.16	Other _____								
3D.2	Overall Particulate Collection Efficiency (%)								
3D.3	Projected Additional Control Devices by 1985								
3D.3.1	Electrostatic Precipitator								
3D.3.2	Baghouse Filter								
3D.3.3	Mechanical Dust Collector								
3D.3.4	Wet Scrubber								
3D.3.5	Dry Scrubber								
3D.4	Projected Additional Control Devices by 2000								
3D.4.1	Electrostatic Precipitator								
3D.4.2	Baghouse Filter								
3D.4.3	Mechanical Dust Collector								

DATA SOURCE _____

PLANT ID NO. _____

SECTION 3D
AIR EMISSION CONTROL EQUIPMENT
(Continued)

									Total Plant
	Boiler Unit Number								
3D.4	Projected Additional Control Devices by 2000 (Continued)								
	3D.4.4	Wet Scrubber							
	3D.4.5	Dry Scrubber							
3D.5	Existing Flue Gas Desulfurization								
	3D.5.1	Waste Classification - Wet							
	3D.5.2	Waste Classification - Dry							
	3D.5.3	Waste Classification - Throwaway							
	3D.5.4	Waste Classification - Regenerative							
	3D.5.5	Describes Regenerative Process							
	3D.5.6	Reactants Used							
	3D.5.7	Other							
	3D.5.8	Projected FGD System (1985)							
	3D.5.9	Future Waste Quantity (tons)							
	3D.5.10	Projected FGD System (2000)							
	3D.5.11	Future Waste Quantity (tons)							

3D.6 Additives Used to Enhance Gas Stream Cleanup

3D.6.1 Chemical Name of Additive _____

3D.6.2 Frequency of Use - 1980 _____

3D.6.3 Quantity Used (gal/mo) _____

3D.6.4 Point of Injection _____

3D.6.5 Indicate any anticipated changes in additive type, point of injection quantity _____

3D.7 Comments _____

* E - Electrical; C - Combination Electrical/Mechanical

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3E
WASTE QUANTITIES & CHARACTERISTICS

WASTE MATERIAL		TOTAL WEIGHT (TONS/YR)	MOISTURE (%)	DENSITY (LBS/FT^3)	VOLUME (FT^3/YR)	VOLUME (GALS/YR)
3E.1	Waste Generation in 1980 (avg. year)					
3E.1.1	Fly Ash					
3E.1.2	Bottom Ash					
3E.1.3	Scrubber Sludge					
3E.1.4	FGD Sludge					
3E.1.5	Wastewater Sludge					
3E.1.6	Waterside Boiler Cleaning Wastes					
3E.1.7	Coal Pile Runoff					
3E.1.8	Cooling Tower Blowdown					
3E.1.9	Water Treatment Sludge					
3E.1.10	Describe Disposal of Boiler Cleaning Wastes					
3E.1.11	Total Waste Volumes					
3E.2	Projected 1985 Waste Generation					
3E.2.1	Fly Ash					
3E.2.2	Bottom Ash					
3E.2.3	Scrubber Sludge					
3E.2.4	FGD Sludge					
3E.2.5	Wastewater Sludge					
3E.2.6	Waterside Boiler Cleaning Wastes					
3E.2.7	Coal Pile Runoff					
3E.2.8	Cooling Tower Blowdown					
3E.2.9	Water Treatment Sludge					
3E.2.10	Other _____					
3E.2.11	Total Waste Volumes					
3E.3	Projected 2000 Waste Generation					
3E.3.1	Fly Ash					
3E.3.2	Bottom Ash					
3E.3.3	Scrubber Sludge					
3E.3.4	FGD Sludge					
3E.3.5	Wastewater Sludge					
3E.3.6	Waterside Boiler Cleaning Wastes					
3E.3.7	Coal Pile Runoff					
3E.3.8	Water Treatment Sludge					
3E.3.9	Other _____					
3E.3.10	Total Waste Volumes					

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3E

WASTE QUANTITIES & CHARACTERISTICS

(Continued)

3E.4 Comments _____

DATA SOURCE _____

PLANT ID NO. _____

SECTION 3F
CURRENT WASTE STORAGE PRACTICES

3F.1 Wastes Stored for More than 90 Days (Yes or No) _____

3F.2 Describe Existing Storage Facilities _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3G
CURRENT WASTE TREATMENT PRACTICES

3G.1 Fixation Techniques Employed

3G.1.1 IUCS _____ tons/yr

3G.1.2 Dravo _____ tons/yr

3G.1.3 Stablex _____ tons/yr

3G.1.4 Research Cottrell _____ tons/yr

3G.1.5 Chemfix _____ tons/yr

3G.1.6 Other _____ _____ tons/yr

Name Quantity

3G.2 Pond Additives (Identify Chemicals and Quantities)

3G.2.1 None _____

3G.2.2 Flocculants _____ _____/yr

3G.2.3 Acid _____ _____ gals/yr

3G.2.4 Lime _____ _____ tons/yr

3G.2.4 Caustic _____ _____ gals/yr

3G.2.5 Other _____ _____/yr

3G.3 Wastewater Treatment Processes (Check as Appropriate)

3G.3.1 None _____

3G.3.2 Settling Ponds _____

3G.3.3 Coagulation _____

3G.3.4 Biological Treatment _____

3G.3.5 Filtration _____

3G.3.6 Neutralization _____ (acid _____, caustic _____)

3G.4 Water Treatment Processes

3G.4.1 Coagulation _____

3G.4.2 Sedimentation _____

3G.4.3 Ion Exchange _____

3G.4.4 Reversal Osmosis _____

3G.4.5 Other _____

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3G
CURRENT WASTE TREATMENT PRACTICES
(Continued)

3G.5 Comments _____

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3H
CURRENT (1980) WASTE DISPOSAL PRACTICES

		QUANTITY (tons/year)	COST ($/year)	
3H.1	Ash Disposal Methods			
3H.1.1	On-Site Wet Disposal	_____	_____	Miles From Plant _____
3H.1.2	On-Site Dry Disposal	_____	_____	Miles From Plant _____
3H.1.3	Off-Site Wet Disposal	_____	_____	Miles From Plant _____
3H.1.4	Off-Site Dry Disposal	_____	_____	Miles From Plant _____
3H.1.5	Total Ash Disposed	_____	_____	Miles From Plant _____

3H.2 Ash Sold, Reclaimed or Reused

3H.2.1 Contract Sales _____ tons/yr Total Value _____ $/yr

3H.2.2 Pozzolan _____ tons/yr Total Value _____ $/yr

3H.2.3 Structural Fill _____ tons/yr Total Value _____ $/yr

3H.2.4 Roadbase _____ tons/yr Total Value _____ $/yr

3H.2.5 Aggregate _____ tons/yr Total Value _____ $/yr

3H.2.6 Other _____ tons/yr Total Value _____ $/yr

3H.2.7 Total Annual Cost Credits $ _____

3H.2.8 Contracted Disposal _____ tons/yr

3H.3 Disposal Pond/Landfill

3H.3.1 Waste Inventory at Active Disposal Site _____ ft^3

3H.3.2 Waste Inventory at Inactive Disposal Sites _____ ft^3

3H.3.3 Remaining Capacity of Active Site _____ ft^3

3H.3.4 Remaining Capacity of Active Site _____ years

3H.3.5 Planned New Capacity (Year _____) _____ ft^3

3H.3.6 Pond Effluent Recycled to Plant (Yes or No) _____

3H.3.7 Number of Groundwater Monitoring Wells _____

_____

_____

_____

3H.4 Disposal Pond/Landfill Liner (Check as Appropriate)

3H.4.1 None _____

3H.4.2 Clay _____

3H.4.3 Membrane _____

3H.4.4 Other _____

3H.4.5 Describe Liner System _____

_____

_____

3H.4.6 Depth to Groundwater _____ ft

3H.4.7 Depth to Bedrock _____ ft

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3H
CURRENT (1980) WASTE DISPOSAL PRACTICES
(Continued)

3H.4.8 Existing soils/groundwater characteristics

3H.4.8.1 State/County Health Department percolation tests for vicinity (obtain).

3H.4.8.2 State Highway Department soil testing in area (new state roads constructed within last 20 or so years) (obtain) *1.

3H.4.8.3 County extension service SCS office soils experience (and mapping) for area (obtain if available).

3H.4.8.4 State Water Resources Division - Wetlands/ Floodplains (obtain).

3H.4.8.5 State Geologic Society (most likely associated with University of [state]) often will have mappings of

1. Geologic (rock) formations
2. Soil overburden depths and soil types - geologist will often be able to estimate relative "order-of-magnitude" permeabilities of major soil types present in area. It may be helpful to take a copy of SCS soil survey (county scale surface soils) and potential permeability mapping and discuss the origin of these materials and the potential location of clay deposits.
3. Ground water quality
4. Ground water quantity
5. Areas where rock formations and/or overburden would be most likely suitable for waste disposal and industrial waste disposal (studies often done in conjunction with Health Department).
6. Faults.
7. 7 1/2 minute series, quadrangle maps of area surrounding and including power plant and waste disposal areas.

3H.4.8.6 County (or City) Planning and Zoning - Zoning and Land Use Maps (obtain).

Notes:

1. This item necessary only if limited soils information is available for potential disposal areas from the utility (ie. if plant does not have soil borings available.

DATA SOURCE _____ PLANT ID NO._____

SECTION 3H
CURRENT (1980) WASTE DISPOSAL PRACTICES
(Continued)

3H.5 Coal Pile and Transfer Area (unloading/crusher) Runoff

3H.5.1 Contained (Yes or No)_____

3H.5.2 Area_____ft^2

3H.5.3 Storage Pile_____days

3H.5.4 Describe Liner _____

_____

3H.5.5 Annual Runoff_____gallons

3H.5.6 Describe Treatment_____

_____

3H.6 Is There Adequate Waste Transportation Available?

Yes_____ No_____ Truck Haul Cost_____$/ton/mile

Yes_____ No_____ Rail Haul Cost_____$/ton/mile

Yes_____ No_____ Barge Haul Cost_____$/ton/mile

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3I
DESIGN DATA FOR CURRENT DISPOSAL FACILITIES

3I.1 Location of Current Disposal Facilities

3I.1.1 Distance from Plant _____

3I.1.2 Above a Sole Source Aquifer (Yes or No) _____

3I.1.3 Within an Active Fault Zone (Yes or No) _____

3I.1.4 Within 100-yr Floodplain (Yes or No) _____

3I.1.5 Within Designated Wetland (Yes or No) _____

3I.1.6 Critical Habitat of Endangered Species (Yes or No) _____

3I.1.7 Coastal High Hazard Area (Yes or No) _____

3I.1.8 National and State Parks, Forests, Historical Monuments (Yes or No) _____

3I.1.9 Comments Regarding Location _____

3I.2 Geophysical Characteristics of Current Disposal Site

3I.2.1 Average Annual Precipitation _____ in/yr

3I.2.2 Average Annual Evaporation _____ in/yr

3I.2.3 Percolation Test Available _____ Yes _____ No

3I.2.4 Depth of Groundwater _____ ft

3I.2.5 Depth to Bedrock _____ ft

3I.2.6 Clay Availability/cost

3I.2.6.1 On Site (Yes or No) _____

3I.2.6.2 Permeability of On-site Clay Deposits _____ cm/sec

3I.2.6.3 Depth to On-site Clay Deposits _____ ft

3I.2.6.4 Average Thickness of On-Site Clay Deposit _____ ft

3I.2.6.5 Distance to Nearest Off-Site Clay Deposit _____ miles

3I.2.6.6 Permeability of Nearest Off-Site Clay Deposit _____ cm/sec

3I.2.6.7 Cost of Nearest Off-site Clay _____ ($/ton) ($/yd^3)

3I.2.6.8 Cost of Clay Delivered to Disposal Site _____ ($/ton) ($/yd^3)

3I.2.7 Cost of Sand Delivered to Disposal Site _____ ($/ton) ($/yd^3)

3I.2.8 Cost of Suitable Topsoil Delivered to Disposal Site _____ ($/ton) ($/yd^3)

3I.2.9 Comments Regarding Geophysical Site Characteristics _____

3I.3 Aesthetic/Architectural Requirements _____

3I.4 Availability of Construction Contractors (if yes, include avg. labor rates) _____

DATA SOURCE _____

PLANT ID NO. _____

SECTION 3I
DESIGN DATA FOR CURRENT DISPOSAL FACILITIES
(Continued)

3I.5 Have or anticipate Liability Insurance _____Yes _____No

3I.6 Anticipated Cost_____$/yr

3I.7 Physiographic Location_____

_____

3I.8 Other_____

_____

_____

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3J
DESIGN DATA FOR FUTURE DISPOSAL FACILITIES

3I.1 Location of Proposed Disposal Facilities

3I.1.1 Distance from Plant _____

3I.1.2 Average Land Cost for Proposed Site _____/Acre

3I.1.3 Above a Sole Source Aquifer (Yes or No) _____

3I.1.4 Within an Active Fault Zone (Yes or No) _____

3I.1.5 Within 100-yr Floodplain (Yes or No) _____

3I.1.6 Within Designated Wetland (Yes or No) _____

3I.1.7 Critical Habitat of Endangered Species (Yes or No) _____

3I.1.8 Coastal High Hazard Area (Yes or No) _____

3I.1.9 National and State Parks, Forests, Historical Monuments (Yes or No) _____

3I.1.10 Comments Regarding Location _____

_____

_____

3I.2 Geophysical Characteristics of Proposed Disposal Site

3I.2.1 Average Annual Precipitation _____ in/yr

3I.2.2 Average Annual Evaporation _____ in/yr

3I.2.3 Percolation Test Available _____ Yes _____ No

3I.2.4 Depth of Groundwater _____ ft

3I.2.5 Depth to Bedrock _____ ft

3I.2.6 Clay Availability/cost

3I.2.6.1 On Site (Yes or No) _____

3I.2.6.2 Permeability of On-site Clay Deposits _____ cm/sec

3I.2.6.3 Depth to On-site Clay Deposits _____ ft

3I.2.6.4 Average Thickness of On-Site Clay Deposit _____ ft

3I.2.6.5 Distance to Nearest Off-Site Clay Depqsit _____ miles

3I.2.6.6 Permeability of Nearest Off-Site Clay Deposit _____ cm/sec

3I.2.6.7 Cost of Nearest Off-site Clay _____ ($/ton) ($/yd^3)

3I.2.6.8 Cost of Clay Delivered to Disposal Site _____ ($/ton) ($/yd^3)

3I.2.7 Cost of Sand Delivered to Disposal Site _____ ($/ton) ($/yd^3)

3I.2.8 Cost of Suitable Topsoil Delivered to Disposal Site _____ ($/ton) ($/yd^3)

3I.2.9 Comments Regarding Geophysical Site Characteristics _____

_____

_____

_____

3I.3 Modifications to Existing Power Plant to Provide Dry Disposal

3I.3.1 Requirements _____

_____

_____

_____

_____

3I.3.2 Estimated Capital Costs of Modifications $ _____

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3J

DESIGN DATA FOR FUTURE DISPOSAL FACILITIES

(Continued)

3I.4 Utility Availability at Proposed Disposal Site

3I.4.1 Water _____

3I.4.2 Electricity _____

3I.4.3 Sewer _____

3I.5 Aesthetic/Architectural Requirements _____

3I.6 Availability of Construction Contractors (if yes, include avg. labor rates) _____

3I.7 Have or anticipate Liability Insurance _____ Yes _____ No

3I.3 Anticipated Cost _____ $/yr

3I.9 Physiographic Location _____

3I.10 Other _____

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3K
IMPACTS OF OTHER REGULATIONS ON WASTE DISPOSAL

3J.1 Clean Water Act

3J.1.1 Does State have NPDES Authority _____Yes _____No

3J.1.2 Name of State Permit _____

3J.1.3 Expiration Dates of Permits _____

3J.1.4 IS River Water Quality Limited _____Yes _____No

3J.1.5 Does Station have Draft of New NPDES Permit _____Yes _____No

3J.1.6 Draft Attached _____Yes _____No

3J.1.7 Effluent Discharge Requirements

		(Monthly Averages)	
3J.1.7.1	Suspended Solids	_____mg/l	_____lbs/day
3J.1.7.2	BOD_5	_____mg/l	_____lbs/day
3J.1.7.3	COD	_____mg/l	_____lbs/day
3J.1.7.4	Fe	_____mg/l	_____lbs/day
3J.1.7.5	Cu	_____mg/l	_____lbs/day
3J.1.7.6	pH	_____	_____pH Units
3J.1.7.7	TDS	_____mg/l	_____lbs/day
3J.1.7.8	Other	_____	_____
3J.1.7.9	Other	_____	_____

3J.1.8 Comments _____

3J.2 TSCA

3J.2.1 Do you have Transformers/Capacitors with PCB On-Site _____Yes _____No

3J.2.2 Quantity _____gallons

3J.2.3 Disposal Practice _____

3J.2.4 Comments _____

3J.3 Clean Air Act

		Stack 1	Stack 2	Stack 3	Stack 4	Stack 5	Stack 6
3J.3.1	Emission Sources						
3J.3.2	Identify the most stringent air quality regulation under which the site is operating. (indicate Federal, State, Local)	_____	_____	_____	_____	_____	_____
3J.3.3	Enter maximum air emissions allowable	_____	_____	_____	_____	_____	_____
3J.3.4	Particulates (lbs/MMBtu)	_____	_____	_____	_____	_____	_____
3J.3.5	SO_2 (ppm or lbs SO_2/MMBtu)	_____	_____	_____	_____	_____	_____
3J.3.6	NO_2 (tons/year)	_____	_____	_____	_____	_____	_____
3J.3.7	CO (ppm)	_____	_____	_____	_____	_____	_____
3J.3.8	Other (specify)	_____	_____	_____	_____	_____	_____
3J.3.9	Expiration Date	_____	_____	_____	_____	_____	_____

3J.3.10 Does State Issue PSD Permits _____Yes _____No

3J.3.11 Are Any Construction Permits Issued for Station _____Yes _____No

3J.3.12 Explain _____

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3K
IMPACTS OF OTHER REGULATIONS ON WASTE DISPOSAL
(Continued)

3J.4 Surface Mining Control and Reclamation Act (SMCRA)

3J.4.1 Is Facility Considered a Mine Mouth operation _____Yes _____No

3J.4.2 Coal Source - Surface_____ Below Ground_____

3J.4.3 Have You Filed or Do You Have a Permit _____Yes _____No

3J.4.4 Are Reclamation Efforts Being Specified to Ash Disposal Areas _____Yes _____No

3J.4.5 Describe Reclamation Procedures of Ash Areas_____

3J.5 Consolidated Permit Program

3J.5.1 Has Station Recently Filed Under the Consolidated Permit Program _____Yes _____No

3J.5.2 Are you Planing any future Underground Injection or Disposal in Abandoned Surface or Subsurface Mines _____Yes _____No

3J.5.3 Explain Procedure for Disposal_____

3J.6 CERCLA (Superfund)_____

3J.6.1 Have Previous Waste Disposal Sites Been Identified:_____

3J.6.2 Location_____

3J.6.3 Size, Acres_____

3J.6.4 Depth_____

3J.6.5 Construction_____

3J.6.6 Have There Been Previous Dike Failures On Ash Ponds:_____

3J.6.7 When:_____

3J.6.8 Where:_____

3J.7 Power Plant and Industrial Fuel Use Act 1978

Status with Regard to Fuel Use Conversion

Financially Feasible?_____

Effect on Rated Capacity?_____

3J.8 Others_____

DATA SOURCE _____ PLANT ID NO. _____

SECTION 3L
JURISDICTIONS/GEO-POLITICAL CONSTRAINTS

3K.1 List of Recent Projects Requiring Public Hearing:

_____

_____

_____

3K.2 Describe tone of Public Hearing Including Time Spent with Public Interest Groups:

_____

_____

_____

3K.3 Describe Impact of Local Reaction on Project Timing:

_____

_____

_____

3K.4 Names of Active Organizations:

_____

_____

_____

3K.5 Local Zoning:

Plant Site: _____

Surrounding Area: _____

County Jurisdiction - Plant _____

- Surrounding Area _____

3K.6 Land Use Plan:

_____

_____

_____

DATA SOURCE _____

PLANT ID NO. _____

SECTION 3M
CHECKLIST OF SUPPLEMENTAL CASE STUDY INFORMATION

	REQUIREMENTS	SOURCE(S)	RECEIVED
3L.1	Power Plant Location Map		
3L.2	Power Plant Schematic Flow Diagram		
3L.3	Mass Balance of Coal Feed and Wastes		
3L.4	Current Waste Disposal Facilities (Plans, Schematics, etc.)		
3L.5	Flow Diagram of Wastewater Treatment Facilities (including Unit Sizes)		
3L.6	Topo Map of Proposed Disposal Site		
3L.7	Boring Logs for Proposed Disposal Site		
3L.8	Composition of Typical Ash Sample		
3L.9	Air Emission Permits		
	3L.9.1 Federal		
	3L.9.2 State		
	3L.9.3 Local		
3L.10	Wastewater Discharge Permit		
3L.11	Percolation Test Results for Proposed Disposal Site		
3L.12	Other _____		
3L.13	Other _____		
3L.14	Other _____		
3L.15	Other _____		

3L.16 Comments _____

Appendix D

Summary of DOE RCRA Utility Advisory
Task Force Meeting Report

SUMMARY OF DOE RCRA UTILITY ADVISORY TASK FORCE MEETING REPORT

Contract Title and Number: RCRA UTILITY IMPACT STUDY
DE-AC-01-79ET13543

Contractor Name: Engineering-Science, Inc.
57 Executive Park South
Atlanta, Georgia 30329

Meeting Date: February 5, 1982

Location: Sheraton Inn - Atlanta Airport, Atlanta, Georgia

Participants: See Attachment 1 - List of Attendees

Author: Chuck Mangan

Subjects Discussed:

This report provides a summary of activities and a list of items resolved by the Task Force during the meeting. Please contact the author within one week of the receipt of this Task Force Report if you have any questions or comments. Attachment 2 is a copy of the Agenda used for the meeting. Copies of visual aids used during the presentation are included as Attachment 3. The following is a summary of information discussed and keyed into the visual aids (Attachment 3) and the meeting Agenda (Attachment 2).

DISCUSSION

Introduction - An introduction was presented by Val Weaver, the DOE Program Manager, who explained the importance of the program, the purpose of the meeting, and the continuing critical role which the Utility Task Force participants will play in providing input to the project in the areas of current practice, non-hazardous and hazardous engineering designs.

Project Overview - Dave Burstein, the ES Project Manager, reviewed the overall scope of the project and the major interfacing between the project's three phases (See Attachments 3.2 through 3.6). Emphasis was placed on explaining the factors taken into consideration by members at previous Task Force meetings in making the selection of the case study sites including the significance of the geographic distribution. The project's three waste disposal scenarios (current practice, non-hazardous and hazardous) were reviewed in conjunction with the ES proposed cost estimating procedure.

Waste Disposal Model - This section of the report has been deleted since it is not pertinent to the design assumptions and major revisions have been made subsequently to the model with the issuance by EPA of revised regulations on June 26, 1982.

Current Design Practice - Chuck Mangan, the ES Deputy Project Manager, used Attachments 3.20 through 3.32 to explore site engineering design questions with the Task Force members. Under ES contract with DOE, ES has the responsibility, among others, of estimating the cost range of implementing RCRA's hazardous and non-hazardous regulations in relation to the industry's current practice disposal costs (See Attachment 3.20). As indicated in this attachment, ES and DOE are interested more in the incremental cost than in the absolute cost; therefore, it is critical that costs be assigned properly to each of these design cases.

To define current practice disposal cost, ES explored the possibility of utilizing utility data to determine this baseline situation. Because of the diversity of ownership within the utilities, and the variability between accounting practices as required by various public utility commissions, it became obvious that the utilization of industry cost data was not possible. Therefore, it became necessary for ES to develop a "current practice baseline" as shown in Attachment 3.20.

To illustrate the problem in quantifying current practice costs, ES presented information on three plants which seemed to be representative of a broad spectrum of the industry:

Item	Plant A	Plant B	Plant C
Units	5	5	4
Rating - MW	1100	200	1050
Total Ash Generation (10^3 cu yd/yr)	265	30	250
Year Constructed	1957-61	1937-61	1958-80
Ash Handling	wet	wet	wet
Ash Pond Capacity Remaining	16 yrs	2 yrs	30 yrs

After examining data on the above information, the Task Force discussed the fact that it was a difficult problem to compare current disposal costs from these plants because of diverse disposal and accounting procedures. It became evident to the Task Force that a common design basis would be required to compare any current practice costs.

Attachment 3.21 presented four possible options of a design life (design basis) which would allow comparison of costs from individual utility sites. They were:

- Existing facilities - develop costs for all existing ash handling facilities currently in use or which have been utilized in the past.

- Average capacity (10 years) - assume the average ash disposal site capacity remaining nationally is an average of approximately 10 years.

- Average site design life of 35 years from 1980.

- Average site design life of 35 years from last boiler installation.

The utilization of existing facility costs as a current practice baseline was recently done by Michael Baker in their evaluation for EPRI on the impacts of RCRA. The advantages to this procedure are that it allows for ready documentation of costs; however, they are not on the same design basis for all plants.

The last design methodology, namely, looking at a 35 year design life from the last boiler installation was considered too complicated and would not allow for ready comparison of the information. For this reason, specific emphasis was placed on using 10 and 35 year design periods. To explore the option of a 35 year design period, ES examined three site development alternatives (See Attachments 3.22, 3.24, 3.25, and 3.26) for Plant A. This plant was selected and assumed for the purpose of discussion and examination of effects to be representative for the industry (wet codisposal in a pond having a remaining capacity of 16 years). These three alternatives were shown on Attachment 3.26 and are as follows:

No.	Alternative
1	Dry ash handling off-site. Bottom ash to existing pond.
2	Excavated ash to on-site structural fill.
3	Dry ash handling to on-site structural fill.

ES explained that it was not obvious which would be the most economical; therefore, it was necessary to examine all three alternatives. For discussion purposes, ES mentioned that Alternative No. 3 was the most cost effective. For those alternatives requiring "dry" fly ash handling, ES included a capital and operating cost for conversion from wet to dry (See Attachment 3.23).

ES also evaluated the case of developing capital and operating costs for Plant A with an average design life of ten years. No major capital expenditures would be required for either land or equipment. O & M costs were included for replacement of equipment parts and associated labor for operating the facilities. These costs were appreciably lower than the previous methodology which employed a 35 year design life.

At this point in the meeting, the whole concept of "current practice" was opened for detailed discussion with the Task Force members. The fact that current environmental legislation allows for the grandfathering of existing plants encourages many utilities to invest money in maintenance and renovation, rather than build a new plant. Members tended to agree that a 35 year design life was reasonable, considering the current emphasis of environmental regulations. The other concept which was explored was the fact that plants will utilize the cheapest disposal alternative first, namely, property adjacent to the plant and with time, more distant sites will be developed, thereby increasing

their disposal cost. This argument tends to negate using the existing facilities as a design basis and would foster a longer term design period.

CONCLUSION: It was the consensus of the Advisory Task Force members that the methodology which employed a design life of 35 years will be used for the current practice design basis. In addition, the conversion of wet ash handling to dry handling should also be including in the current practice design if it is shown to be cost effective.

The concept of "sunk costs" was explored with the Utility Task Force members. Most of the members present agreed that from an accounting standpoint, the utilities' rate structures have been set to pay for all "sunk costs", i.e., equipment and land which has been previously purchased by the utility. Therefore, in evaluating the current practice cost estimate for this project, it would not be correct to include "sunk costs" in the current practice estimate since the rate structure already reflects recovery of these costs.

CONCLUSION: "Sunk costs", including existing capital equipment and existing land, will not be included in any cost estimates of current practice.

To maximize the benefit of the report to the utility members, ES sought guidance in two areas; namely, units (weight-volume) to be utilized as well as the economic procedure to be utilized for the life cycle costing. A spirited discussion was held with regard to the reporting of ash quantities and unit disposal costs in terms of either tons or cubic yards. It was pointed out that the utility industry in general utilizes tons since coal is purchased and inventoried on that basis. However from a landfill design basis, the volume in cubic yards is a critical factor.

CONCLUSION: It was proposed by the Task Force members that ES will report results in both cubic yards and tons for the 24 sites which were visited and for regional and national analyses appearing in the report. Tons will be utilized in the main body of the report with cubic yards being utilized in the report appendices.

A brief discussion was held with regard to which life cycle cost procedure would be most meaningful to the industry. The feeling was that individual utilities have their own cost accounting procedures; however, levelized revenue is well known throughout the industry.

CONCLUSION: The Task Force members recommended that for consistency ES utilize a levelizing procedure for all economic analyses for this project.

Hazardous Design - To address any potential implementation of RCRA hazardous waste regulations and to quantify landfilling disposal costs at a particular plant site, ES examined two broad considerations; site characteristics and areas of designer preference (See Attachment 3.27). For the purposes of the Advisory Task Force, site characteristics were only briefly mentioned; the majority of the members' time was spent

discussing designer preferences including cell life, construction sequence, and cell configuration. Cell life (size) has a number of factors which must be considered in determining optimum sizing:

- o Cost Effective Capital Construction Cost
- o Vegetation control
- o Surface runoff control
- o Leachate quantity

Since a landfill for hazardous waste disposal will be lined, all precipitation on the site must be handled by the leachate collection system. It was discussed by the members that there are mechanisms to divert uncontaminated surface runoff and to discharge this off-site while surface runoff coming in contact with any hazardous material in a landfill will have to be collected and treated. Vegetation control is another consideration as the cell life increases. Vegetation rooting could penetrate the clay layer and possibly lead to deterioration.

To assist in the discussion with the Advisory Task Force, a relationship of disposal cost per cubic yard vs. cell size was developed (See Attachment 3.29). The overall disposal cost in Attachment 3.29 indicates, as would be expected, that the cost decreases the larger the individual cell size. However, in this case, it does seem to reach an asymptote in the 15 to 20 year range. Integral to any discussion of an optimum cell life is the overall availability of funding and the ease in obtaining these funds.

CONCLUSION: The Task Force recommended that the cell life for hazardous and non-hazardous landfills should be five years. ES was instructed to sequence the construction so that five years of cell life was always available to the utility. The only exception would be if a five-year cell would not fit on the individual site. The major rationale for the five year recommendation was that this point was located far enough down on the unit cost curve (See Attachment 3.29) to take advantage of reduced disposal costs while not incurring all of the major problems associated with a cell having a much larger size.

Recent proposed RCRA regulations were discussed (see Federal Register, Vol. 46, No. 25, Pg. 11148); they propose that a hazardous landfill would have to be operated dry. Therefore, for the case study (Plant A), the Task Force believed that the hydroveyer (See Attachment 3.23) would have to be replaced with a low pressure blower (See Attachment 3.30) and the bottom ash system would have to be modified to include a recirculation system (See Attachment 3.31). The Task Force also felt that all of the capital and operating costs associated with any inplant equipment replacement such as the above examples should be included in the hazardous design cost estimate in order to be truly reflective of the impacts of RCRA upon a utility site.

The need for a leachate treatment facility was examined and explained by ES, and critiqued by the Task Force members (See Attachment 3.32).

CONCLUSION: It was the conclusion of the Task Force members that the leachate treatment scheme as shown on Attachment 3.32 is acceptable. The relationship between cell size and the size of the leachate treatment facilities was also discussed. As the cell size increases, the relative amount of leachate also increases. Steps will be taken to construct small earthen berms to separate "clean" surface runoff from water contaminated with the landfill cell contents.

Since a hazardous landfill may have to be operated dry, a number of liquid wastes currently generated at the utility site may have to be handled utilizing a different disposal scheme. Miscellaneous wastes such as coal pile runoff and boiler cleaning wastes, which under current practice are handled in disposal ponds, under the hazardous scenario would probably have to be disposed of differently. ES asked the Task Force members to identify the current industry practice with regard to the disposal of these wastes.

CONCLUSION: The Task Force felt that miscellaneous wastes such as coal pile runoff and boiler cleaning wastes should be used for ash conditioning, bottom ash makeup water, or other uses at the utility site in order to reduce clean water usage. The remaining waste would have to be treated in either an on-site treatment facility, or combined with leachate from the hazardous landfill and then treated.

Under the hazardous design scenario, the Task Force members discussed the possible ramifications of disposal sites which had been closed previously on the utility property, and how they would eventually be handled under RCRA. Also discussed was the renovation of existing facilities.

CONCLUSION: The Task Force felt that baseline hazardous disposal costs will assume no renovation required for previously closed disposal sites. Renovation for existing facilities will be handled as an additional incremental cost.

Non-Hazardous Design - Under the Subtitle D proposed non-hazardous RCRA design guideline, it is possible that the "current practice design" may be very similar to the "non-hazardous design", especially if dry handling is utilized for current practice. The Task Force members discussed that miscellaneous wastes would be handled under the non-hazardous waste scenario. The general consensus was that under no circumstances should the liquid waste handling jeopardize the non-hazardous classification of the flyash and bottom ash under this scenario.

CONCLUSION: It was the consensus of the Task Force members that for the non-hazardous waste scenario, ES should combine miscellaneous wastes, such as boiler cleaning wastes with ash before disposal, provided this does not jeopardize the ash classification by having the ash then fall under a hazardous classification because of the mixture.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS OF THE DOE RCRA UTILITY ADVISORY TASK FORCE

The following conclusions and recommendations were agreed upon as the consensus of the Utility Advisory Task Force:

Recommendations 1 through 3 were deleted as they were not pertinent to the design assumptions.

4. Sunk costs including existing capital equipment and existing land will not be included in the cost estimates.

5. A plant design life of 35 years will be used for the ES design basis.

6. Conversion of wet ash handling to dry handling should be included in the "current practice design", if it is the most cost effective method of ash disposal.

7. ES will report results in both cubic yards and tons for the 24 sites visited and for regional/national analyses. Tons will be used in the main body of the report and cubic yards in the Report Appendix.

8. An annual levelized revenue procedure will be used for all economic analyses.

9. Cell life for hazardous and non-hazardous landfills will be five years. Sequence construction is always to have five years of cell life available. The only exception would be if a five year cell would not fit on the site.

10. The leachate treatment scheme as shown in Attachment 3.32 is acceptable.

11. Miscellaneous wastes such as coal pile runoff, and boiler cleaning waste, will be used for ash conditioning, bottom ash makeup water or other uses whenever practical. Remaining wastes will be treated in either an on-site treatment facility or combined with leachate from the hazardous landfill and then treated.

12. Baseline hazardous disposal costs will assume no renovation required for previously closed disposal sites. Renovation for existing facilities will be handled as an incremental cost.

13. For the non-hazardous waste scenario, ES will combine miscellaneous wastes, such as boiler cleaning wastes with ash before disposal provided this does not jeopardize the ash classification by having the ash fall under a hazardous classification.

ATTACHMENT 1
LIST OF ATTENDEES

NAME	COMPANY	PHONE
John B. Howard	Alabama Electric Corp.	205/222-2571
Mike Noel	Alabama Electric Corp.	205/222-2571
Jerry Heavilon	Heavilon & Assoc.	404/971-5010
Bill Pearse	TVA	615/632-2702
Dotson Luton	TVA	615/751-2815
James Crowe	TVA	615/751-5651
A.C. Schroeder	TVA	205/386-2814
Doye Cox	TVA	615/751-7340
H.P. (Trey) Harbert	Central & South West System/USWAG	214/745-3761
Dave Burstein	Engineering-Science	404/325-0770
Roger Mayfield	Engineering-Science	404/325-0770
Macon Sheppard	Engineering-Science	404/325-0770
Tom Sargent	Engineering-Science	404/325-0770
Don Fry	Engineering-Science	404/325-0770
Chuck Mangan	Engineering-Science	404/325-0770
Lester Allen	Indianapolis Power & Light	317/261-8261
Vernon Huckleberry	Oklahoma Gas & Electric Co.	405/272-3205
Wayne R. Johnson	Kansas City Power & Light Co.	816/556-2910
Art Jung	Versar, Inc.	703/750-3000
Eric Juergens	Versar, Inc.	703/750-3000
Chris M. Hobson	Georgia Power Company	404/526-6526
Mark Cochran	Central Illinois Public Service	217/523-3600
Tom Benge	Iowa-Illinois Gas & Electric	319/326-7386
Larry Jackson	DOE/LETC	307/721-2255
Val Weaver	DOE - H.Q. (FE/OCUE)	301/353-2843
John Maulbetsch	EPRI	415/855-2438
Bill Webster	Webster & Assoc.	215/584-1444
Arnold Gnilka	Duke Power Company	704/373-4011
Bob Beck	Edison Electric Institute	202/828-7623
Jim Davis	USWAG/General Counsel	202/828-1384

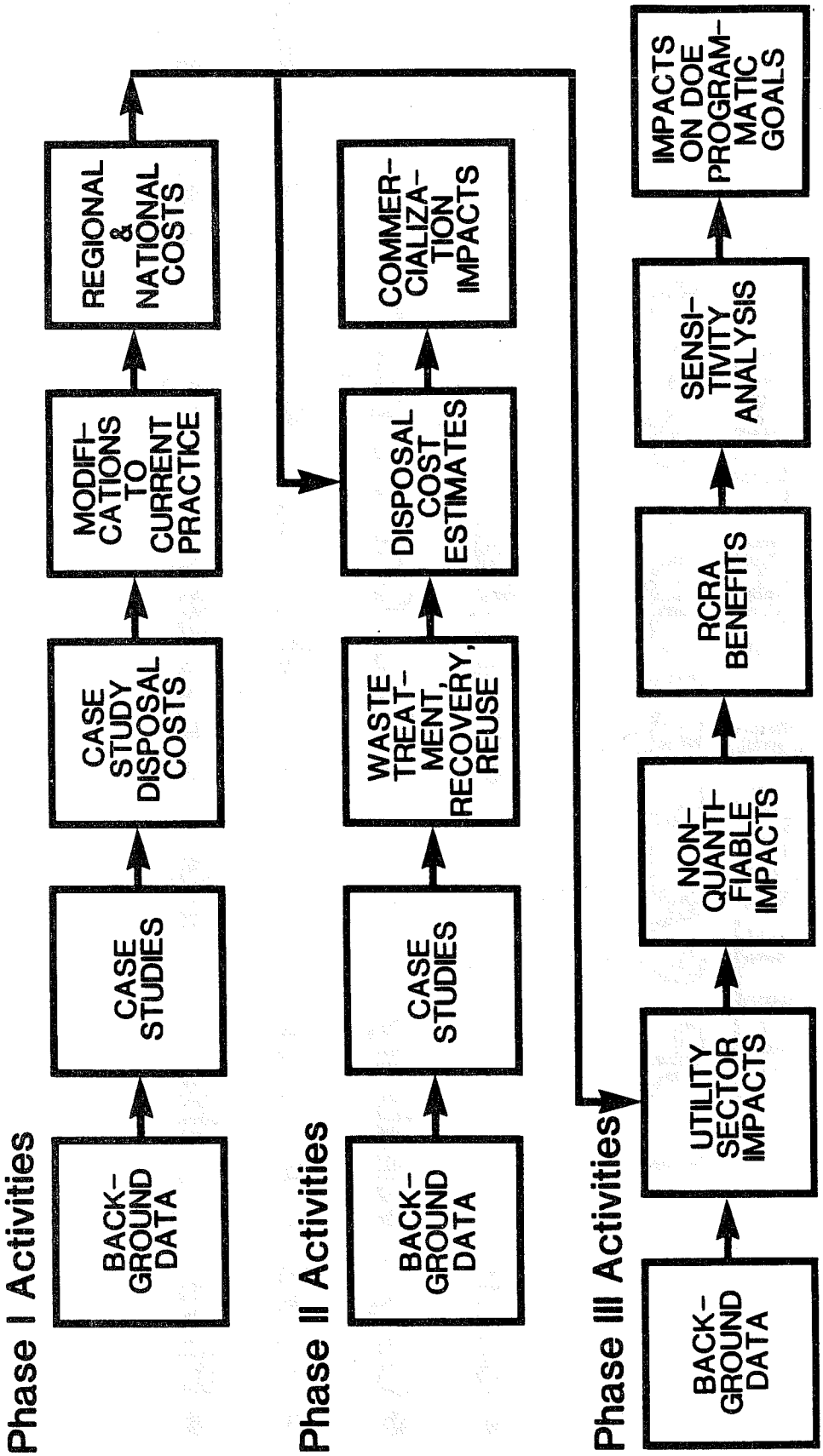
RCRA Review Meeting Agenda
February 5, 1982

Individual	Topic	Time
	Coffee	9:30 - 10:15 A.M.
Val Weaver	Introduction	10:15 - 10:30 A.M.
Dave Burstein	Project Overview	10:30 - 10:45 A.M.
Roger Mayfield	Waste Disposal Model	10:45 - 11:45 A.M.
	Questions and Answers	11:45 - 12:00
	Lunch	12:00 - 12:45 P.M.
Chuck Mangan	Current Design Practice	1:00 - 2:30 P.M.
Chuck Mangan	Hazardous Design	2:30 - 3:30 P.M.
Chuck Mangan	Non-Hazardous Design	3:45 - 4:15 P.M.
Dave Burstein	Summary	4:15 - 4:30 P.M.

WHY IS PROGRAM DOE SPONSORED?

- Coal Utilization
- OMB Directive
- Environmental Impacts Effecting Future R&D Activities

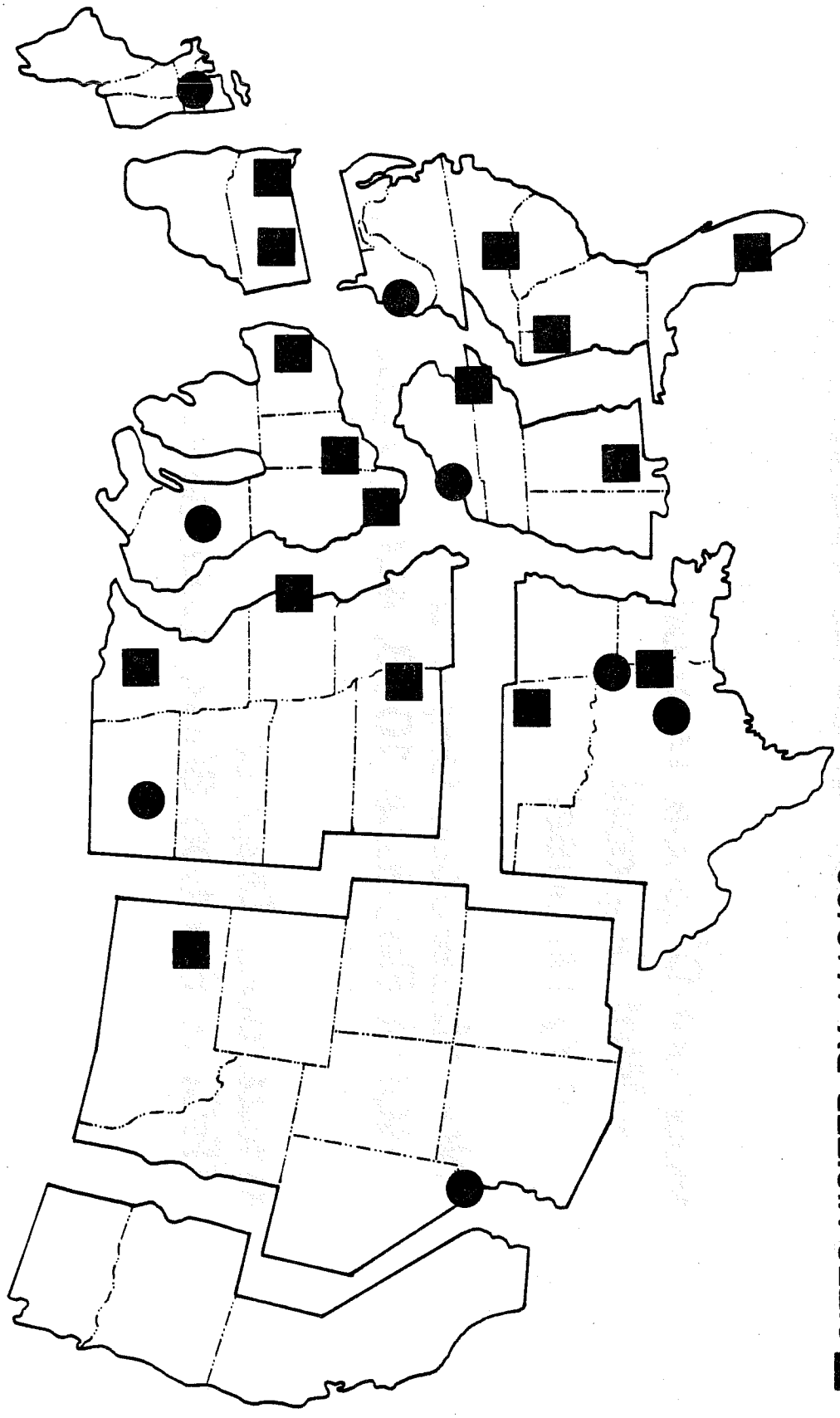
ENGINEERING-SCIENCE PROJECT



SELECTION CRITERIA FOR CASE STUDY SITES

- State
- Clay Availability
- Population Density
- Physiographic Location
- Plant Size
- Coal Characteristics
- Environmentally Sensitive Areas
- Existence of SO_2 Scrubbers

UTILITY CASE STUDIES



■ SITES VISITED BY 1/18/82

● SITES TO BE VISITED

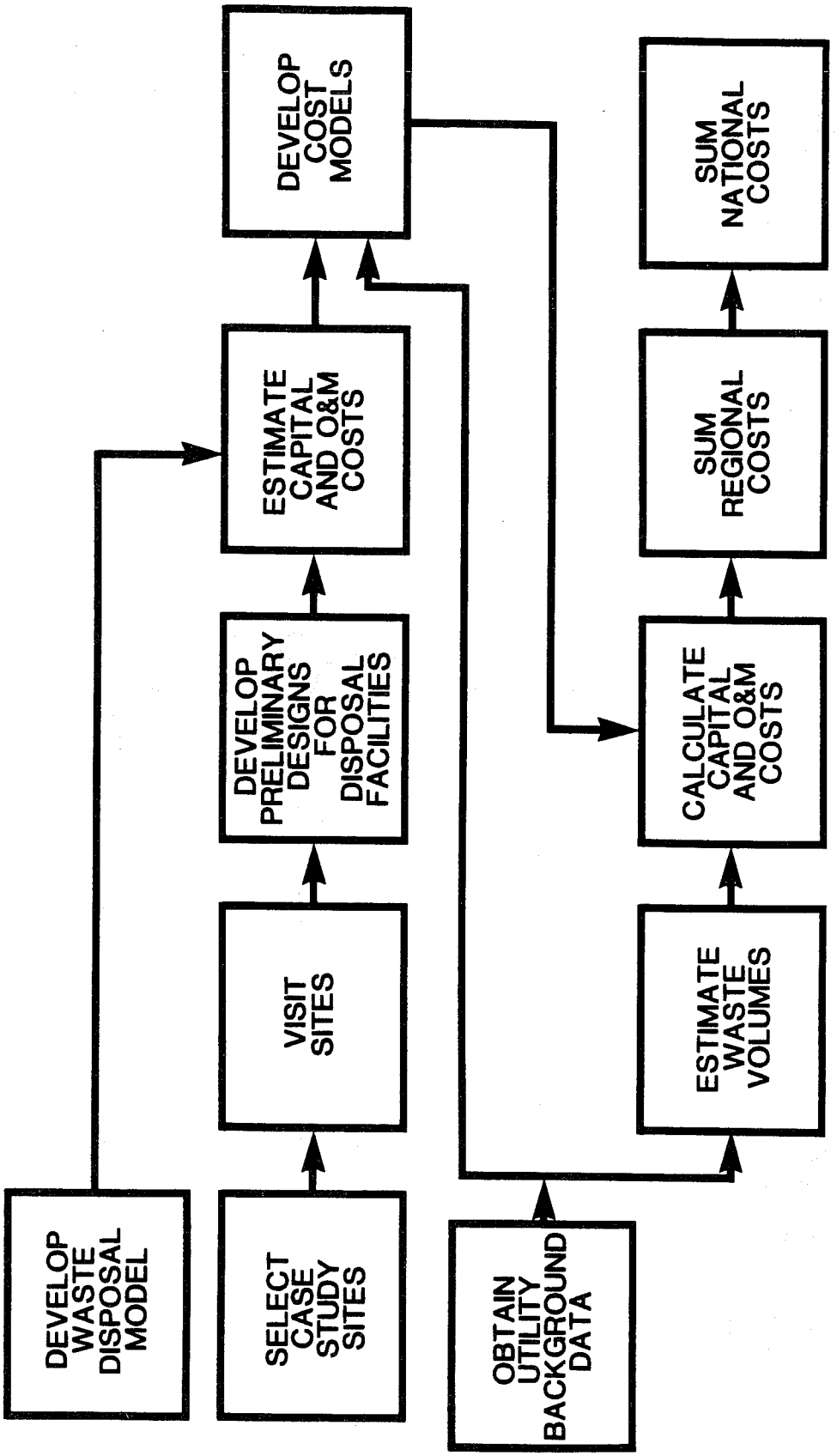
WASTE DISPOSAL SCENARIOS

- Current Disposal Methods
  - Wet Disposal
  - Dry Disposal

- Non-Hazardous Disposal
  (RCRA Sections 1008, 4004; Subtitle D)

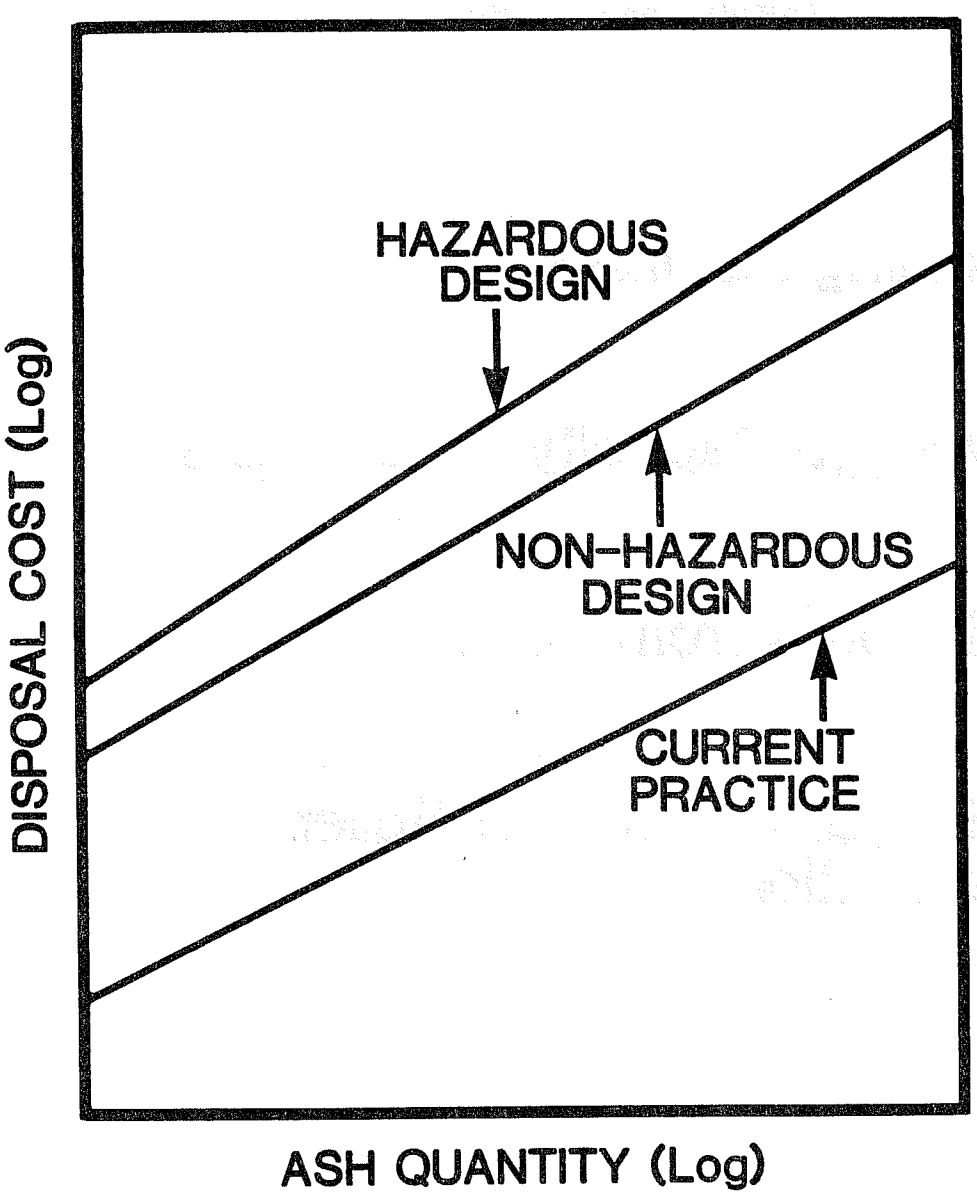
- Hazardous Disposal
  (RCRA Section 3004; Subtitle C)

COST ESTIMATING PROCEDURE



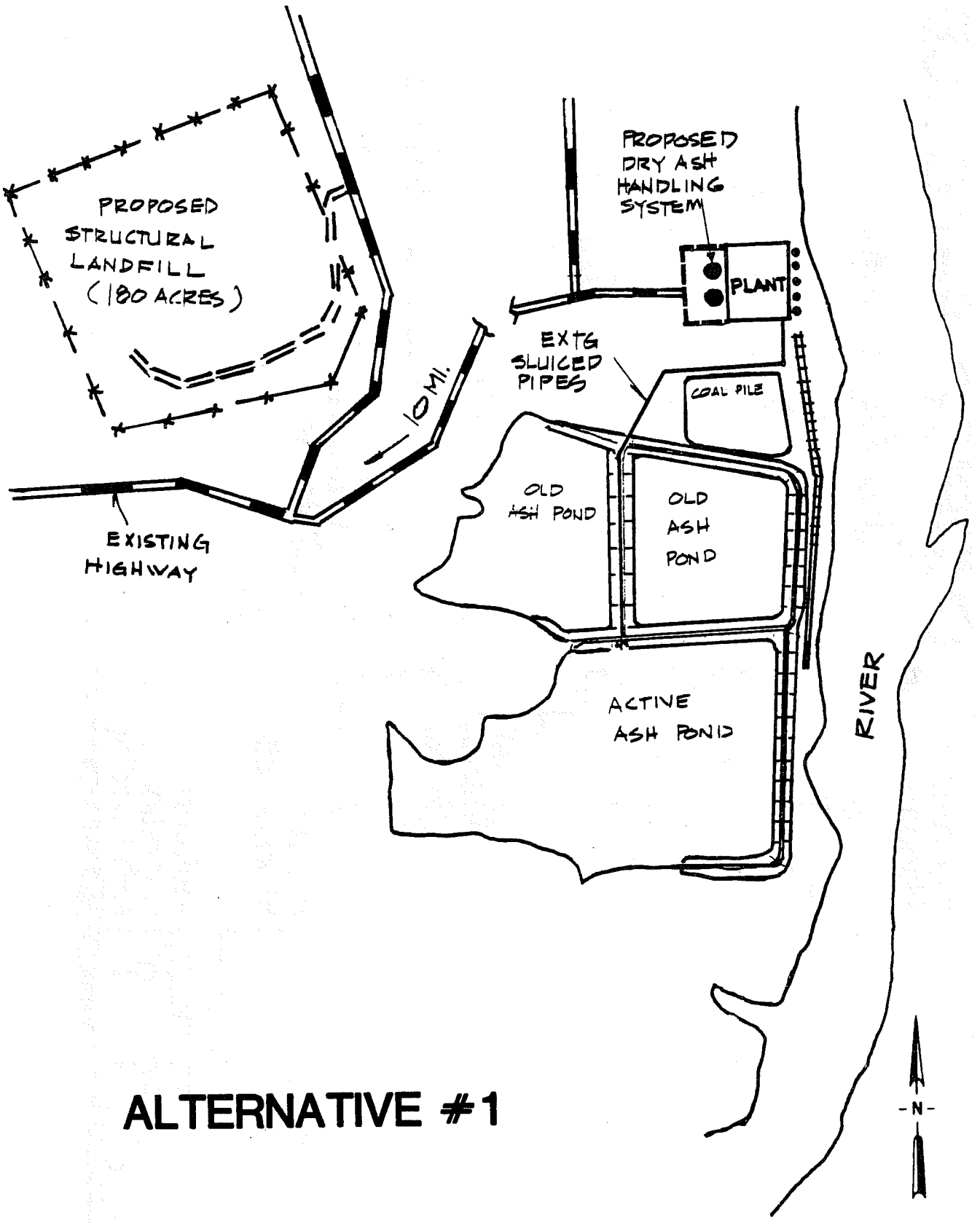
ATTACHMENTS 3.7 THROUGH 3.19 WERE DELETED SINCE THEY ARE NOT PERTINENT TO THE DESIGN ASSUMPTIONS.

RCRA ECONOMIC IMPACT



CURRENT PRACTICE
DESIGN LIFE

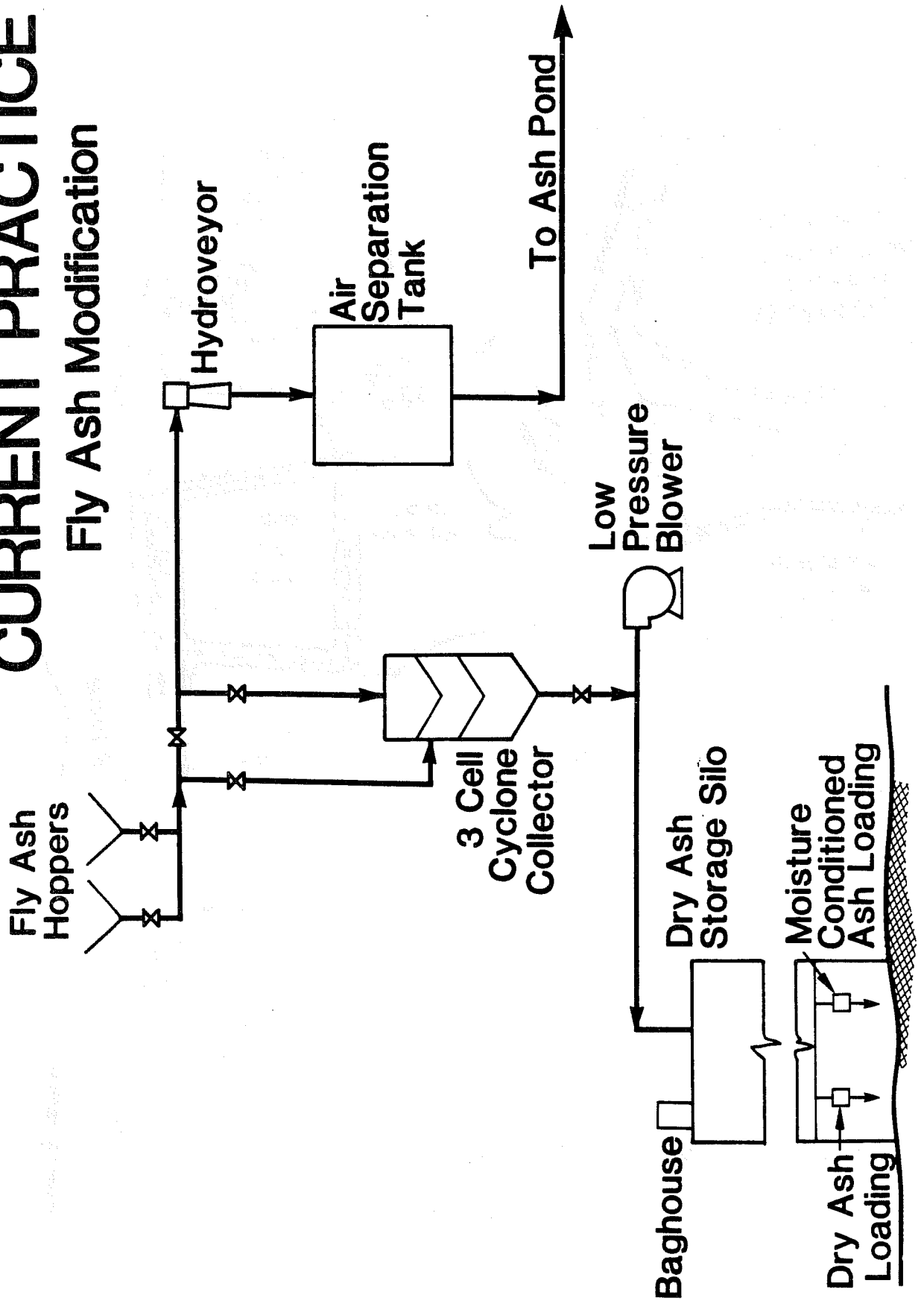
- Existing Facilities
- Average Capacity – 10 Years
- 35 Years from 1980
- 35 Years from Last Boiler Installation



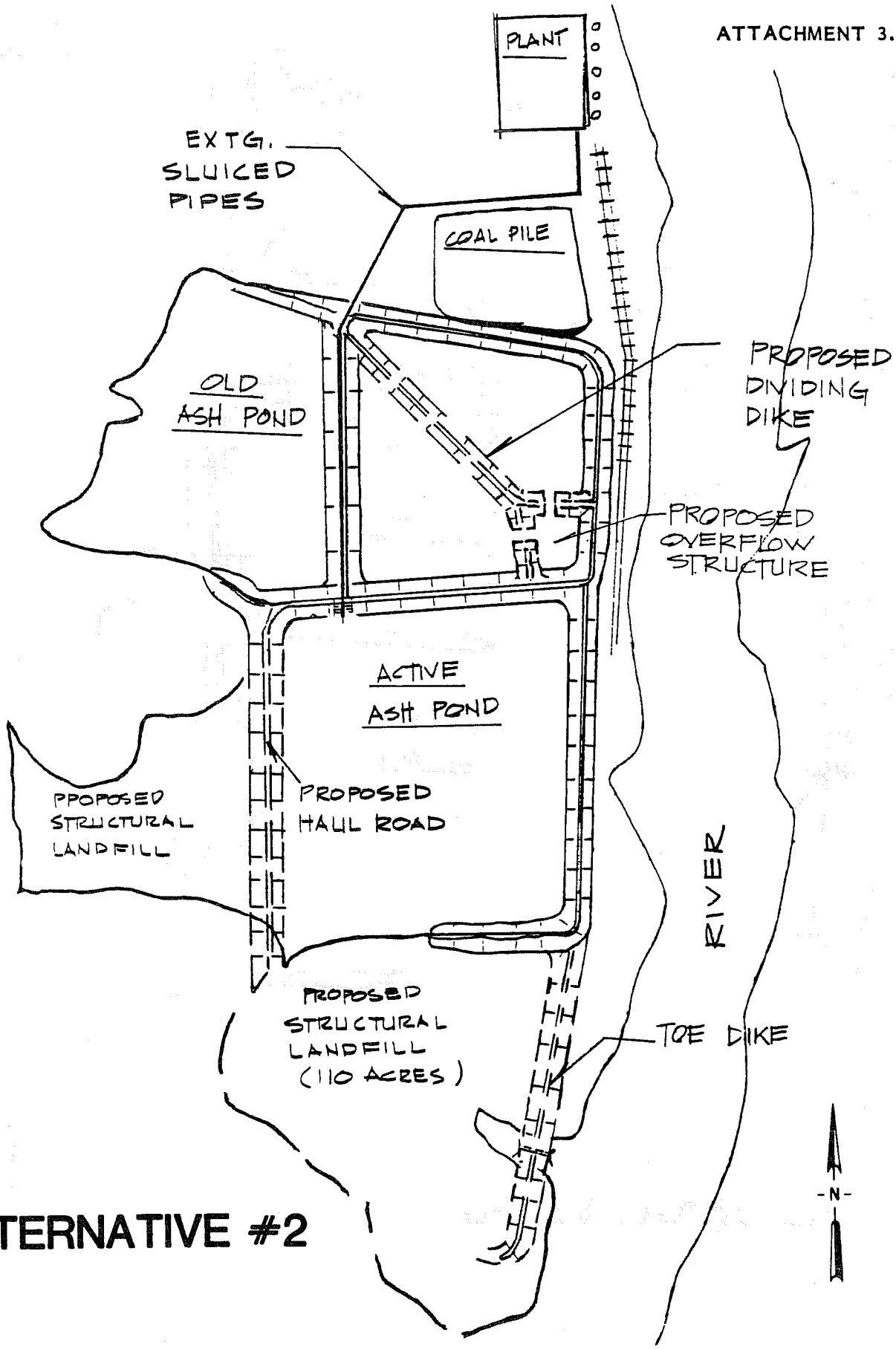
ALTERNATIVE #1

CURRENT PRACTICE

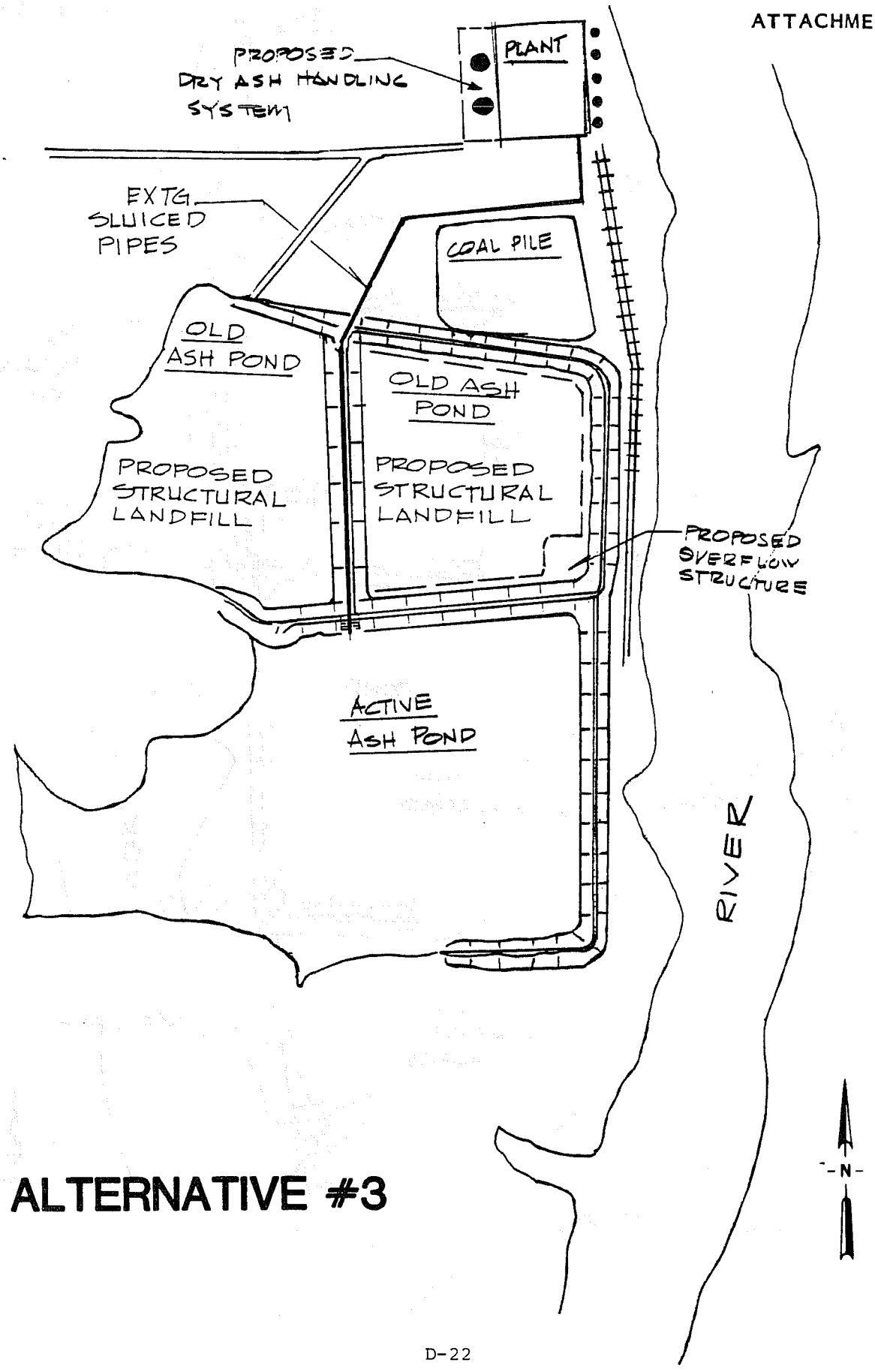
Fly Ash Modification



ATTACHMENT 3.24



ALTERNATIVE #2



ALTERNATIVE #3

CURRENT PRACTICE ALTERNATIVES
PLANT A

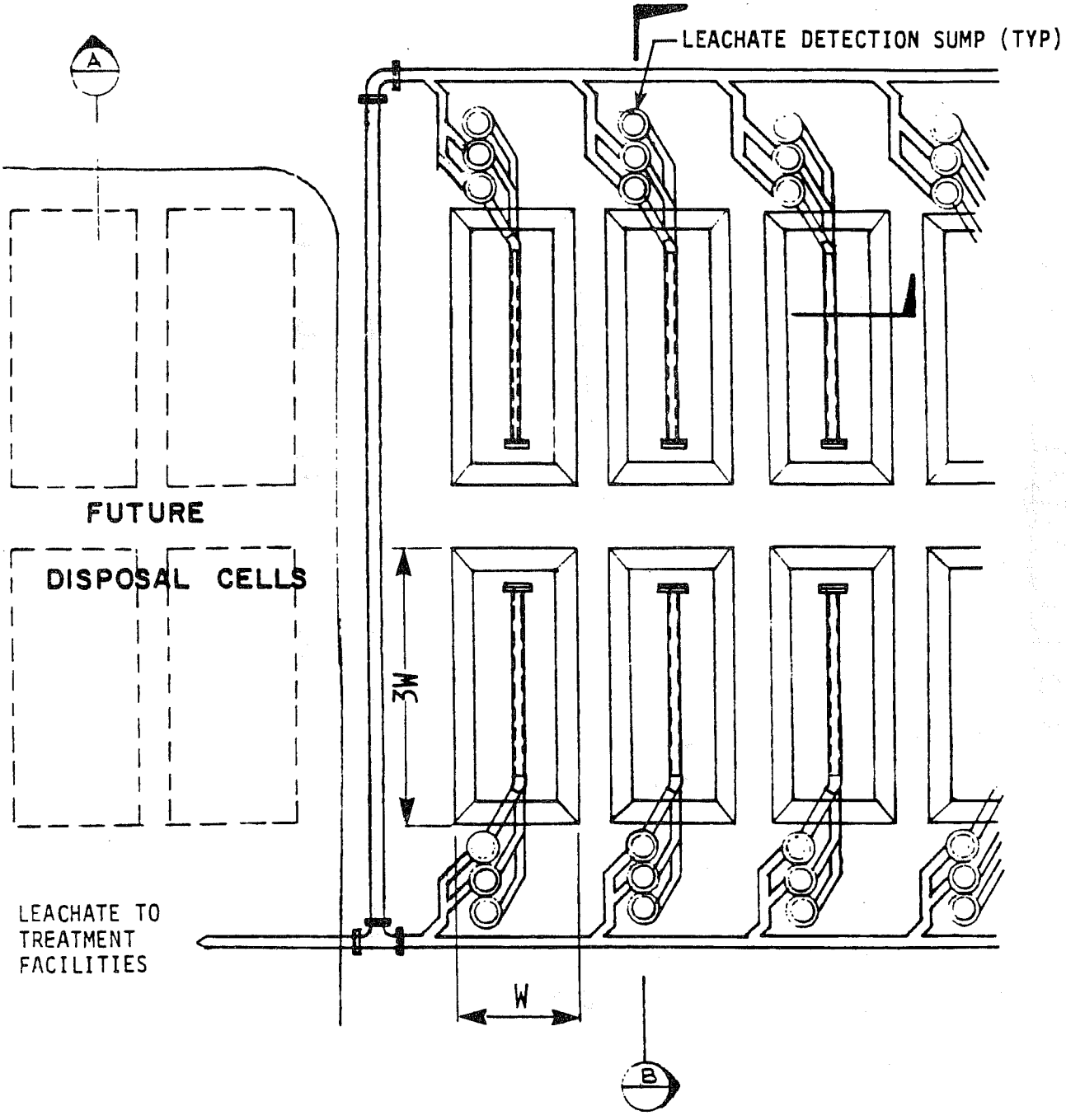
NO.	ALTERNATIVE
1	Dry Ash Handling Off-Site
	Bottom Ash To Pond
2	Excavated Ash To On-Site Structural Fill
3	Dry Ash Handling To On-Site Structural Fill

HAZARDOUS DESIGN

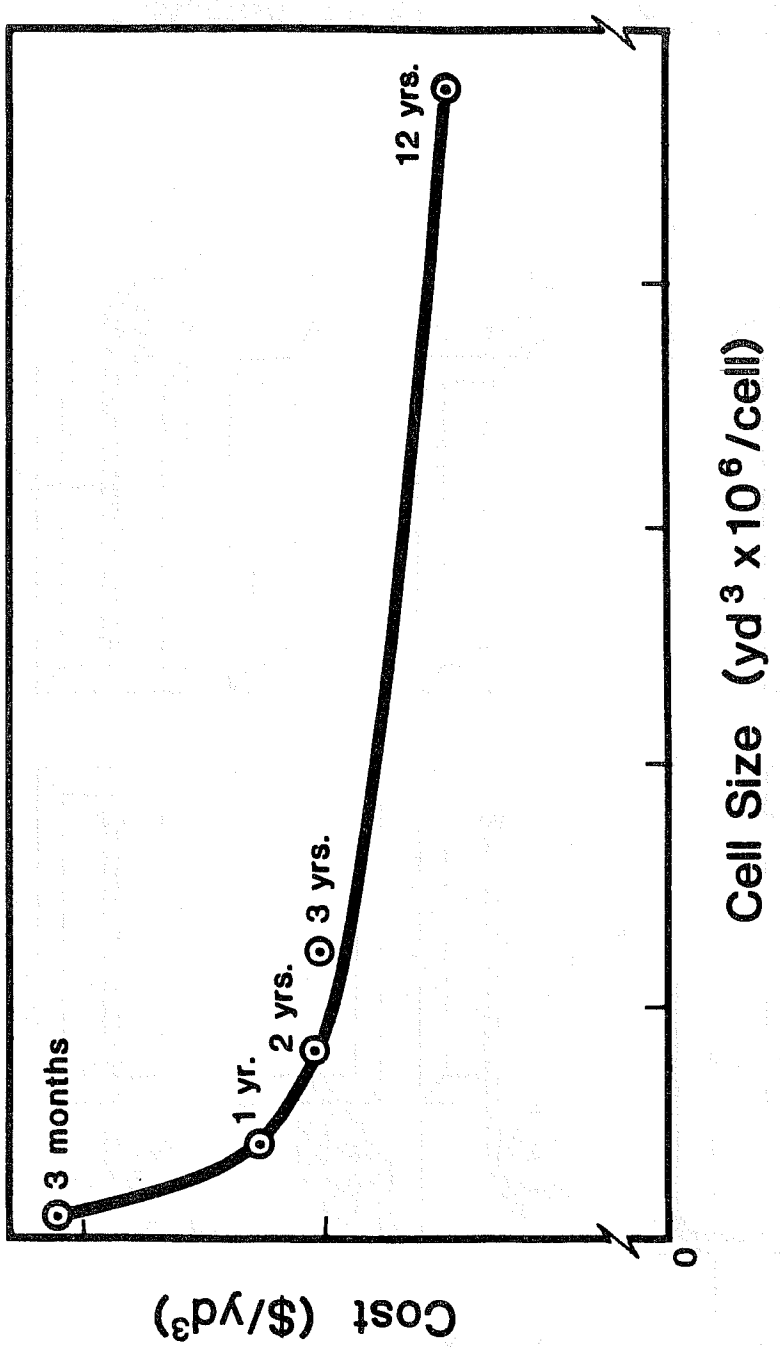
- Site Characteristics
  - — Ground-Water Depth
  - — Soil Bearing Pressure
  - — Soil Permeability

- Designer Preference
  - — Cell Life
  - — Construction Sequence
  - — Cell Configuration

TYPICAL SITE LAYOUT FOR HAZARDOUS (RCRA 3004) DISPOSAL

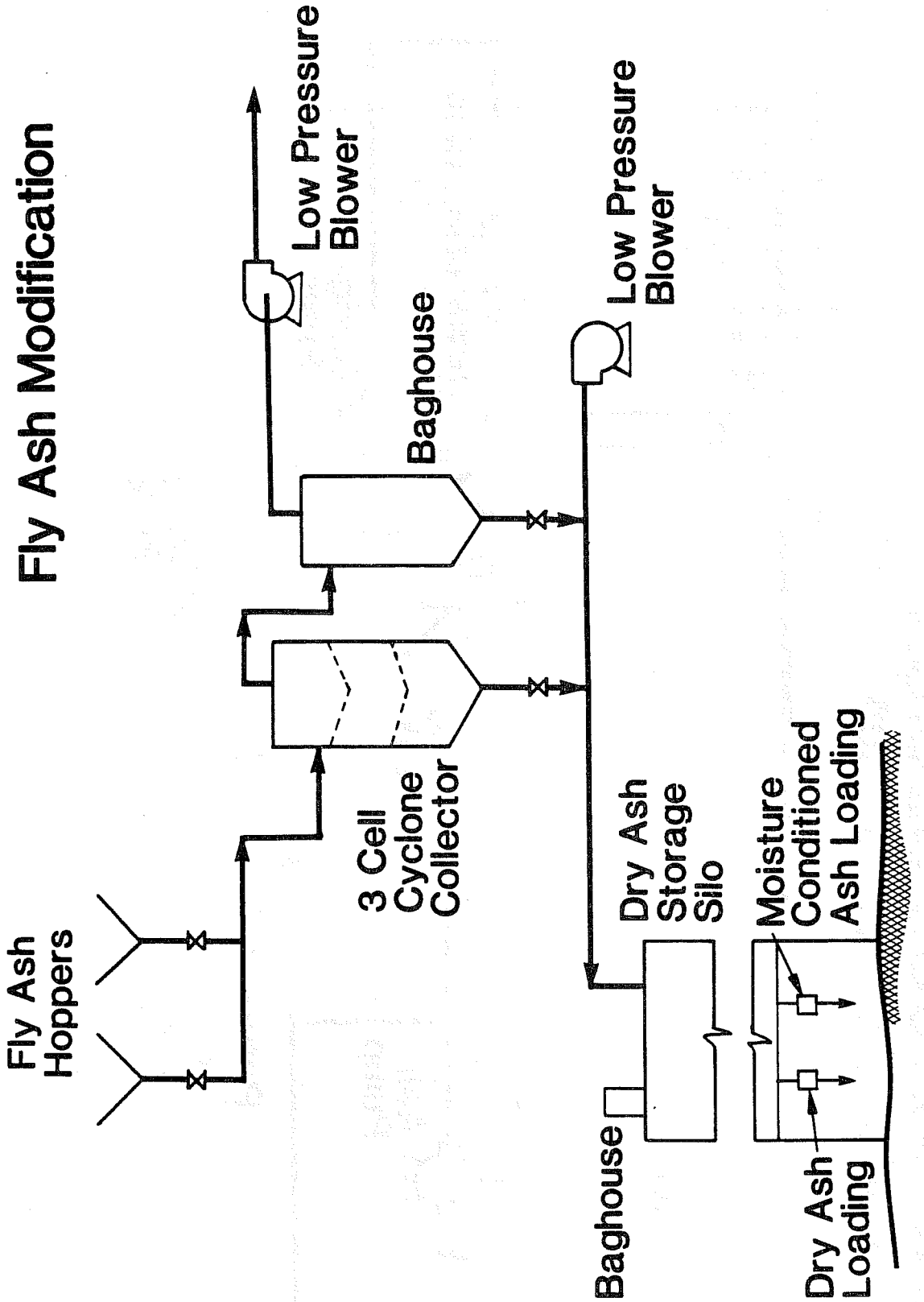


CELL SIZE vs COST

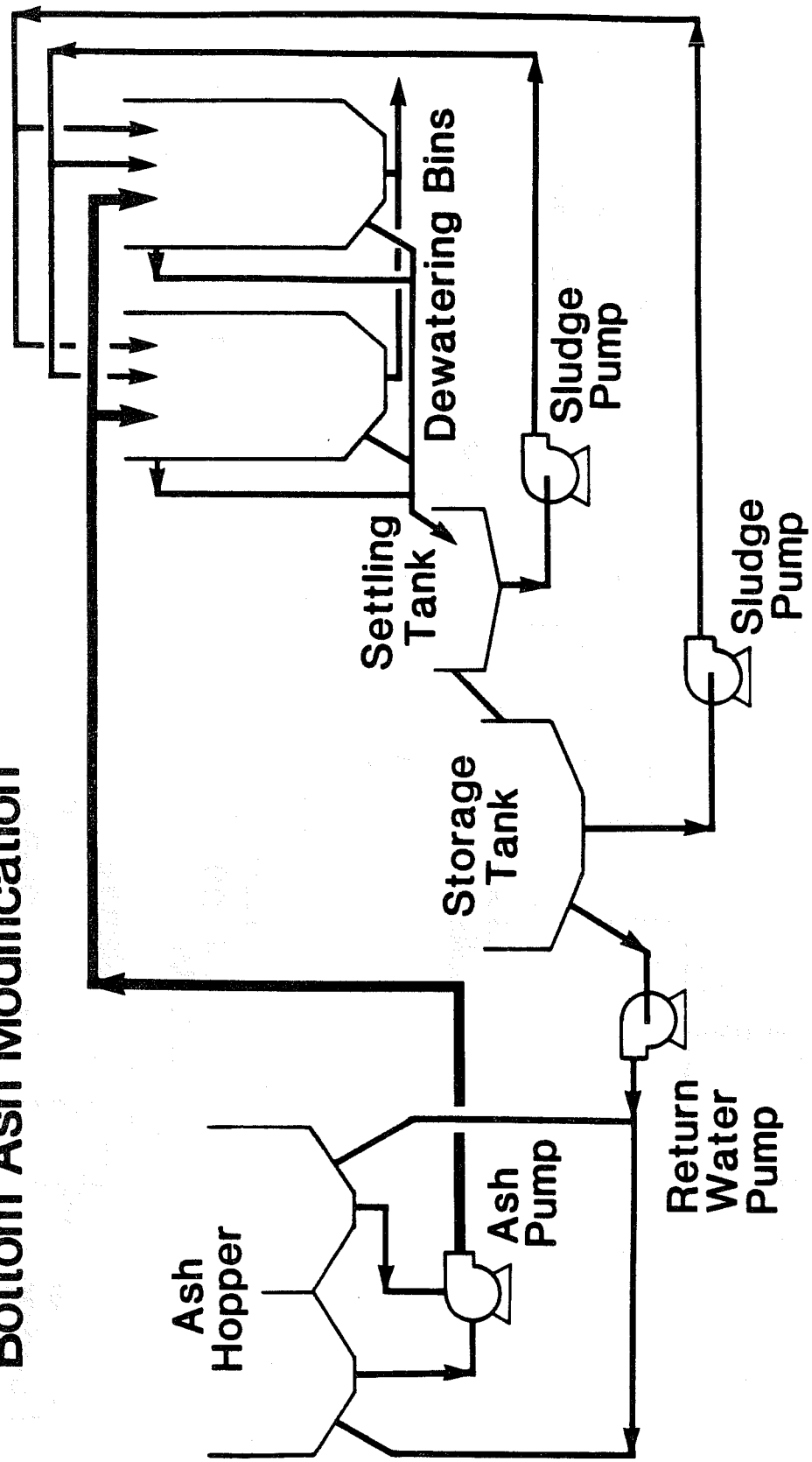


HAZARDOUS DESIGN

Fly Ash Modification



HAZARDOUS DESIGN
Bottom Ash Modification



Appendix E

LFDESIGN Model Description

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	3.2	Calculation of Construction and Capital Costs	E-43
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SECTION	4.0	ECONOMIC CALCULATIONS/LEVELIZATION PROCEDURE	E-44
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1.0 INTRODUCTION

LFDESIGN is a system of related computer programs which were developed to generate preliminary designs and cost estimates for a variety of coal-fired utility waste disposal scenarios. The disposal scenarios addressed are:

- Hazardous Maximum Cost - Maximum probable disposal cost which would be incurred under the RCRA hazardous waste regulations if coal-fired utility wastes were to be given a hazardous classification (40 CFR 264, Federal Register, July 26, 1982),
- Hazardous Minimum Cost - Minimum probable disposal cost which would be incurred under the RCRA hazardous waste regulations if coal-fired utility wastes were to be given a hazardous classification (40 CFR 264, Federal Register, July 26, 1982),
- Non-Hazardous Cost - Probable disposal cost which would be incurred due to implementation of RCRA-related non-hazardous waste regulations (40 CFR 241 and 257, Federal Register, March 26, 1979 and September 13, 1979),
- Current Practice Cost - Probable cost for disposal based on site specific design assumptions generally conforming to existing disposal practices (i.e., unregulated by RCRA).

This Appendix describes the logic, methods and assumptions incorporated within the LFDESIGN program system and includes complete output runs for two disposal scenarios. From a program procedure point of view, the two hazardous waste scenarios are similar to one another and are discussed concurrently in Section 2.0 with differences noted. The procedures used for the non-hazardous and current practice scenarios are also similar, and are be addressed together in Section 3.0.

In order to produce meaningful and easily comparable costs for the waste disposal scenarios, the expenditures over the design life have been "levelized" or converted into constant annual estimates of revenue requirements. Section 4.0 of this Appendix discusses the basic levelization procedure and outlines cost assumptions. EPRI's Technical Assistance Guide (EPRI, 1982) describes in detail the methodology used.

Section 5.0 includes the output runs for the Hazardous Minimum and Current Practice scenarios. The runs have been annotated with references to descriptive portions of Sections 2.0, 3.0, and 4.0.

2.0 HAZARDOUS MINIMUM AND MAXIMUM DESIGNS

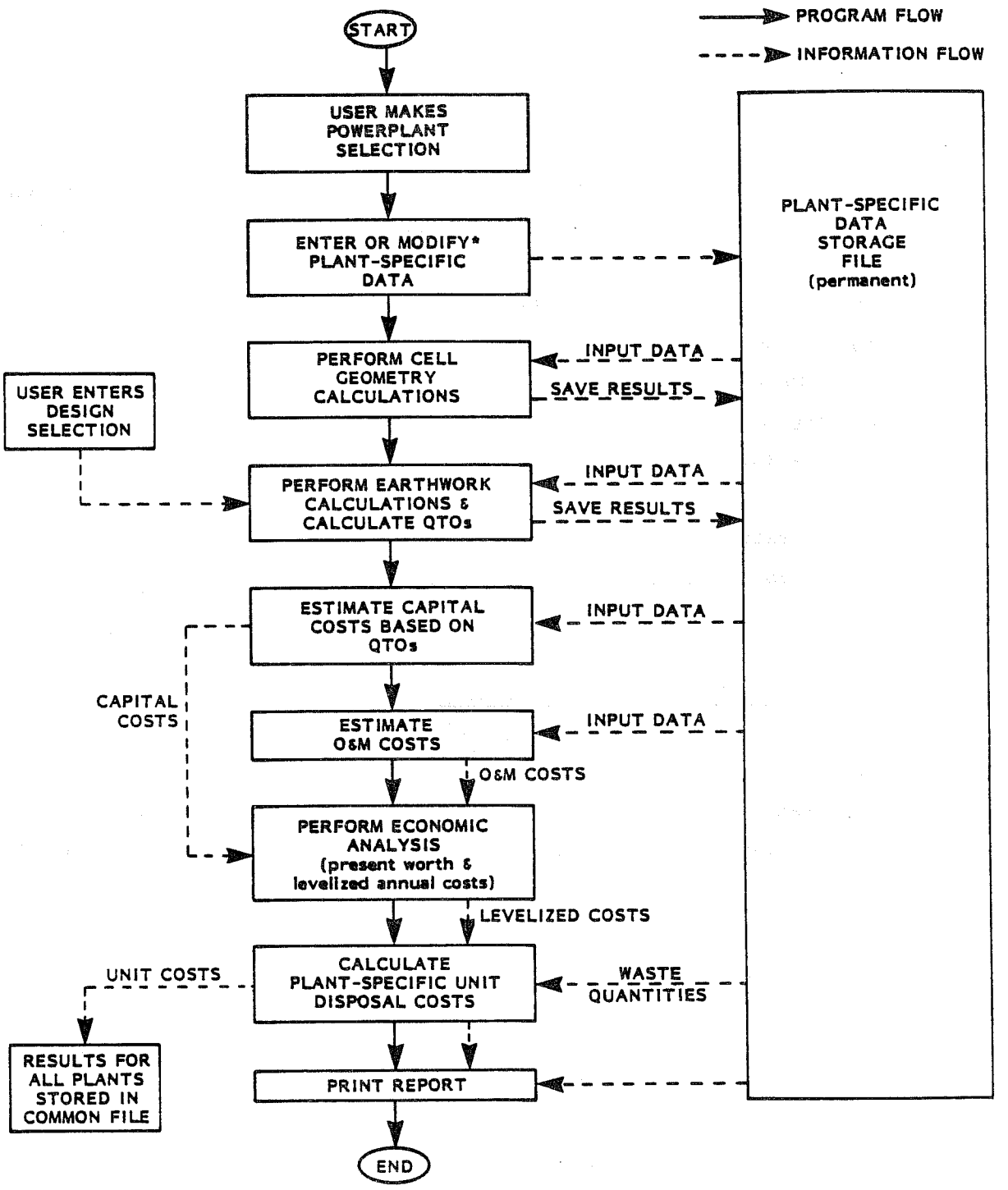
Designs and cost estimates for the hazardous minimum and maximum scenarios are generated using a common mode of the LFDESIGN program. This program mode performs the following general functions:

- Assists users in specifying liner and cover system designs,
- Assists users in establishing disposal cell geometry and site lay-out,
- Performs an earthwork balance to identify the most economical relationship between on-site cut, fill and soil borrow for construction of the facility,
- Calculates quantity take-offs (QTOs) for earthwork and other materials required to construct the disposal facility,
- Estimates construction capital costs based on QTOs and appropriate unit costs,
- Estimates annual operation and maintenance (O&M) costs for operation of the disposal facility and post-closure activities.
- Performs economic calculations to generate equivalent levelized annual costs for capital and O&M,
- Calculates unit disposal costs ($/ton, $/cu yd) based on waste generation rates and levelized capital and O&M costs.

Figure E.1 presents a logic diagram for the LFDESIGN hazardous waste mode. The diagram illustrates the general sequence of program execution as well as data and information flow. The logic incorporated into the various program functions listed above are discussed in the following sections.

FIGURE E.1

LFDESIGN Flow Diagram - Hazardous Waste Design



*On first run with each plant, all site data must be entered into permanent storage. On subsequent runs, user may modify stored data as desired.

2.1 Cell Geometry Calculations

LFDESIGN includes a subroutine which performs a series of calculations to aid the user in establishing the disposal cell geometry. Cell geometry refers to the volume, length, width, thickness and shape of the body of waste in the disposal cell.

The cell geometry subroutine is used interactively with the user specifying certain components of the cell geometry and the computer calculating the unspecified parameters. Table E.1 lists the four calculation options that are available. The option selected is a matter of user preference and available data· all options result in a cell geometry which contains sufficient waste disposal volume for the facility's design life. Typically, the user will run through the cell geometry subroutine several times until a suitable geometry is defined which will allow a practical disposal facility lay-out that meets site-specific constraints, e.g. topography and cell life. During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force (see Appendix A), the following criteria were designated to be incorporated into the engineering analyses:

- The designs should be based on a 35 year life,
- Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.

2.2 Earthwork Balance and Quantity Calculations

The earthwork subroutine within the hazardous waste design mode is utilized to :

- balance, if possible, construction cut and fill volumes to define the most economical depth of excavation for the disposal cells,
- calculate earthwork quantities required for waste disposal facility construction.

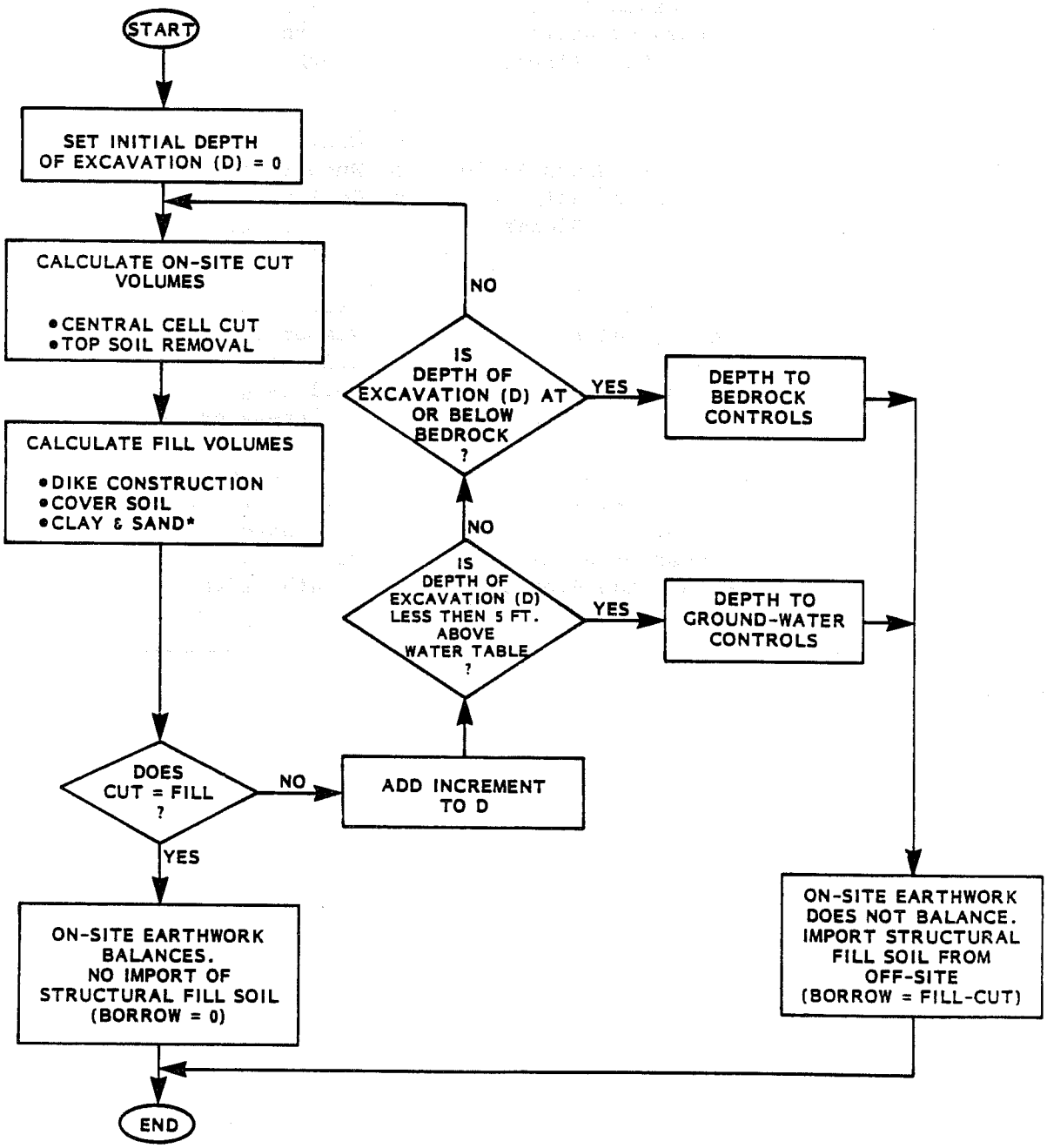
Figure E.2 presents a logic flow diagram for the earthwork balance subroutine. The sketches shown on Figure E.3 illustrate the conceptual model used for the iterative calculations. Initially, the cell is assumed to be built above grade (Sketch 1 on Figure E.3) and the quantity of earthwork required for cover and structural fill (dikes) is calculated

TABLE E.1
CELL GEOMETRY CALCULATION OPTIONS

CELL GEOMETRY CALCULATION OPTION	USER INPUTS	PROGRAM CALCULATIONS
1	o Cell Volume or Number of Cells o Length/Width Ratio o Thickness of Waste o Interior Side Slopes of Cell	o Cell Volume or Number of Cells* o Cell life o Length o Width
2	o Cell Width o Cell Length/Width Ratio o Thickness of Waste o Interior Side Slopes of Cell	o Cell Volume o Number of Cells o Cell Life o Cell Length
3	o Cell Volume or Number of Cells o Cell Width o Cell Length/Width Ratio o Interior Side Slopes	o Cell Volume or Number of Cells* o Cell Life o Cell Length o Thickness of Waste
4	o Cell Volume or Number of Cells o Cell Width o Thickness of Waste o Interior Side Slopes of Cell	o Cell Volume or Number of Cells* o Cell Life o Cell Length o Length/Width Ratio

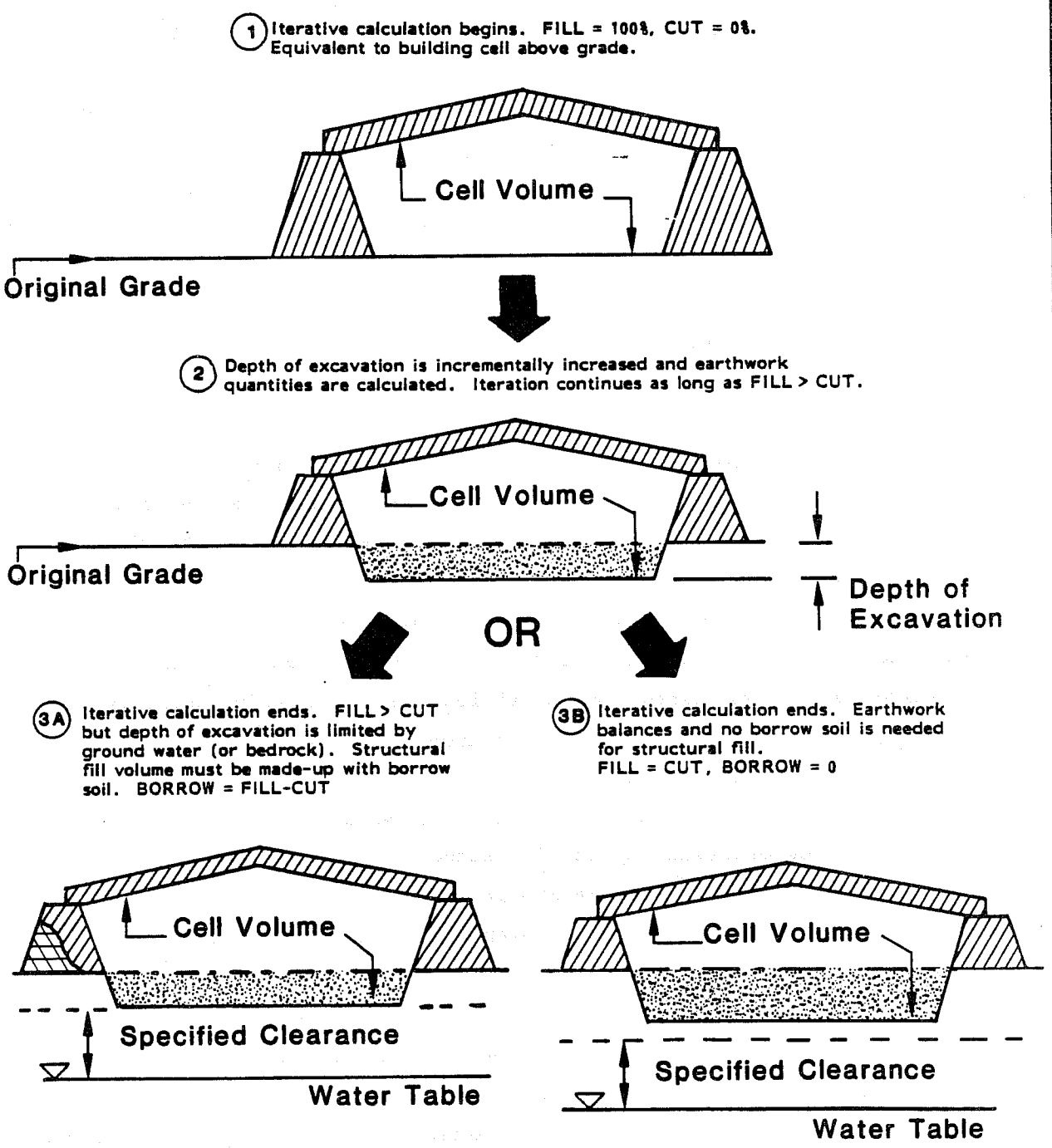
* Calculates the value which is not input.

Algorithm for Earthwork Balance and Calculation of Import Soil Requirement



*Only included if to be obtained on-site from central cell cut.

CONCEPTUAL REPRESENTATION OF EARTHWORK BALANCE CALCULATIONS



along with clay liner and sand leachate collection volumes (if clay and sand are available from on-site excavation). At the initial condition, FILL is 100% of the total earthwork and CUT is 0%. The iterative calculation proceeds as the depth of excavation (D) is incrementally increased as long as the FILL > CUT condition is true (Sketch 2 on Figure E.3). The calculation loop is exited when an earthwork balance is achieved, i.e., CUT = FILL (Sketch 3B on Figure E.3). This, in general, represents the most economical depth of excavation since it minimizes the total volume of soil which must be excavated, placed, graded and compacted.

For sites which have high groundwater or bedrock conditions, a balanced earthwork condition may not be possible. The earthwork balance iteration is automatically exited if the depth of excavation reaches one of the following points:

- 5 ft. above the local water table,
- the local bedrock surface.

This situation is represented for a groundwater table limitation in Sketch 3A of Figure E.3. When a balance between the central cell excavation and required structural fill is not achieved, the difference between the available cut volume and required fill volume is obtained as borrow soil. This represents the most economical situation obtainable given the excavation constraints.

At the point when the earthwork iteration is complete due to a balanced condition or exited due to a depth of excavation limitation, the existing values for earthwork quantities are retained as quantity take-offs for the construction cost calculations. These include:

- Cut and non-compacted fill
- On-site structural cut and fill to be used in dike construction
- Borrow material import (if needed)
- Topsoil removal and stockpile
- Sand collection zone placement (if sand is obtained from on-site cut)
- Clay liner/cap placement (if clay is obtained from on-site cut).

If clay and sand are not available from on-site excavation, their quantities are calculated directly as import volumes and costs for purchasing, loading, and hauling these materials are included in the construction cost estimate.

2.3 Liner and Cover System Designs

The hazardous mode of LFDESIGN is designed such that the user may specify any desired configuration for the disposal cell cover/cap and liner/leachate collection systems. The potential components include:

- o Cover/cap system
  - surface vegetation
  - cover soil
  - one or more sand drainage layers
  - one or more synthetic membranes
  - one or more compacted clay layers
- o Liner/leachate collection system
  - leachate collection zone
  - primary liner (synthetic membrane or compacted clay)
  - leachate detection zone
  - secondary liner (synthetic membrane or compacted clay)
  - additional leachate detection zones and liners if desired.

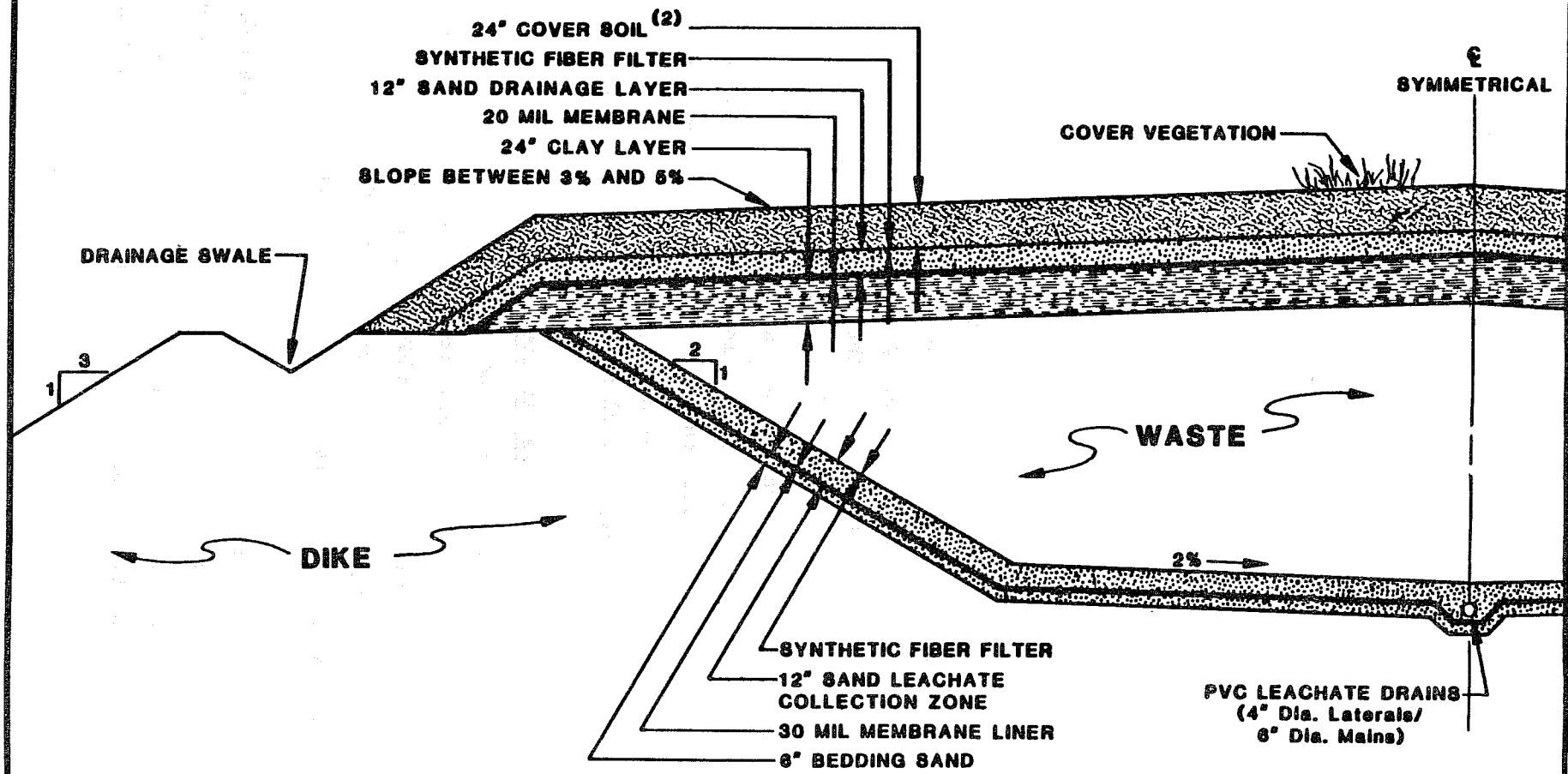
The design configurations being utilized for the DOE RCRA evaluation project are shown on Figures E.4 through E.7 with design specifications given in Tables E.2 through E.6. The specific design configuration selected is dependent upon whether hazardous minimum or maximum is being evaluated and whether wet or dry disposal is being assumed. The cover and liner designs are based on U.S. EPA design recommendations which have been published (in draft) to accompany the current RCRA land disposal regulations (40 CFR 264, Federal Register, July 26, 1982).

2.4 Other Quantity Take-Off Items

There are a variety of items, other than the earthwork quantities previously discussed, necessary for construction of hazardous waste disposal facilities. The LFDESIGN program has built-in calculation procedures for many of these quantity take-off (QTO) items. The other QTO cost items, their units and basis of calculation are described in Table E.7.

Since conditions at a specific site can dictate the need for special construction provisions, the LFDESIGN system has been structured to allow users to directly input quantities for certain construction items which have been manually calculated. An example would be a site where a

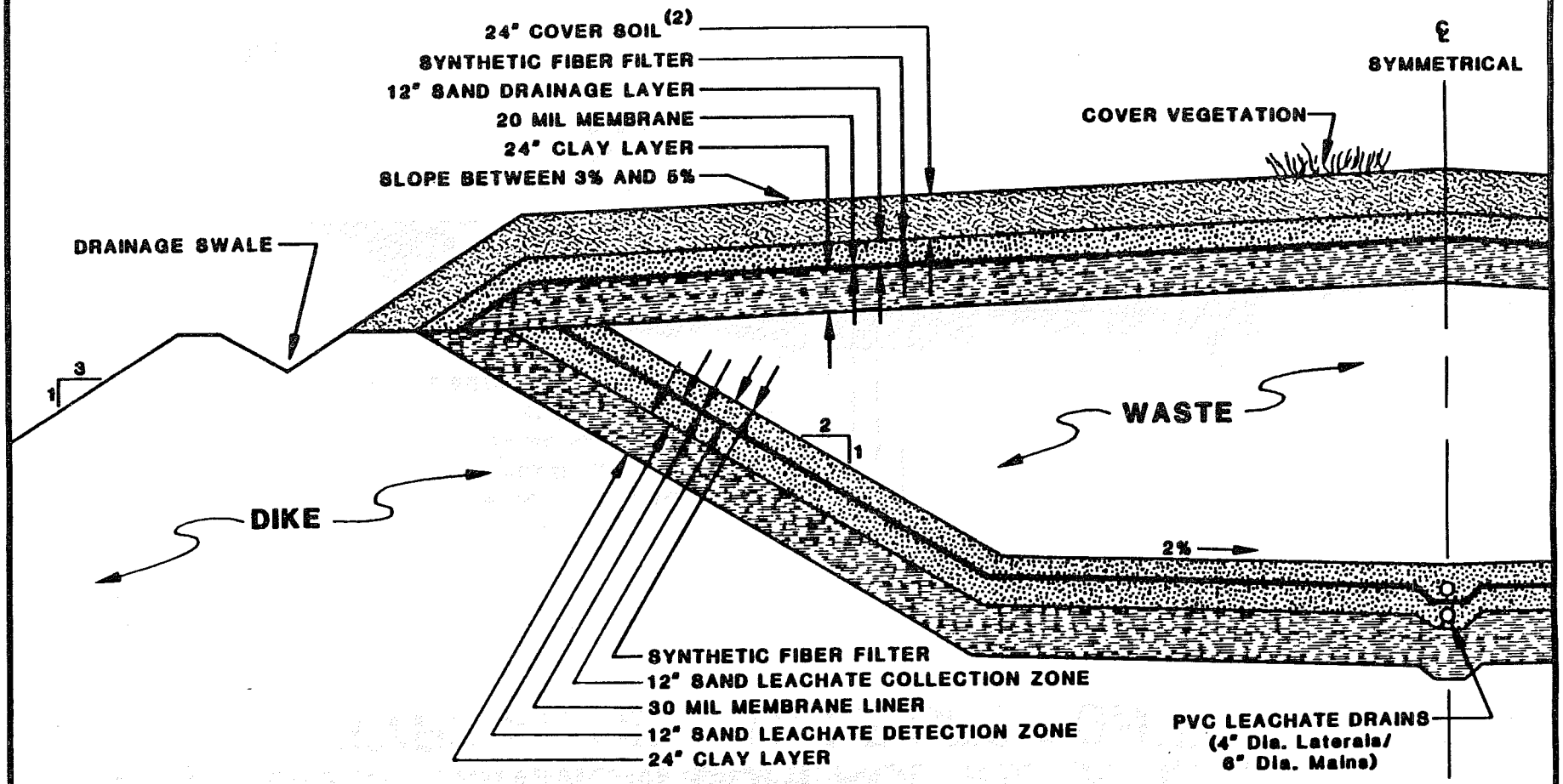
HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION (1)



NOTE:
*24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE E.4

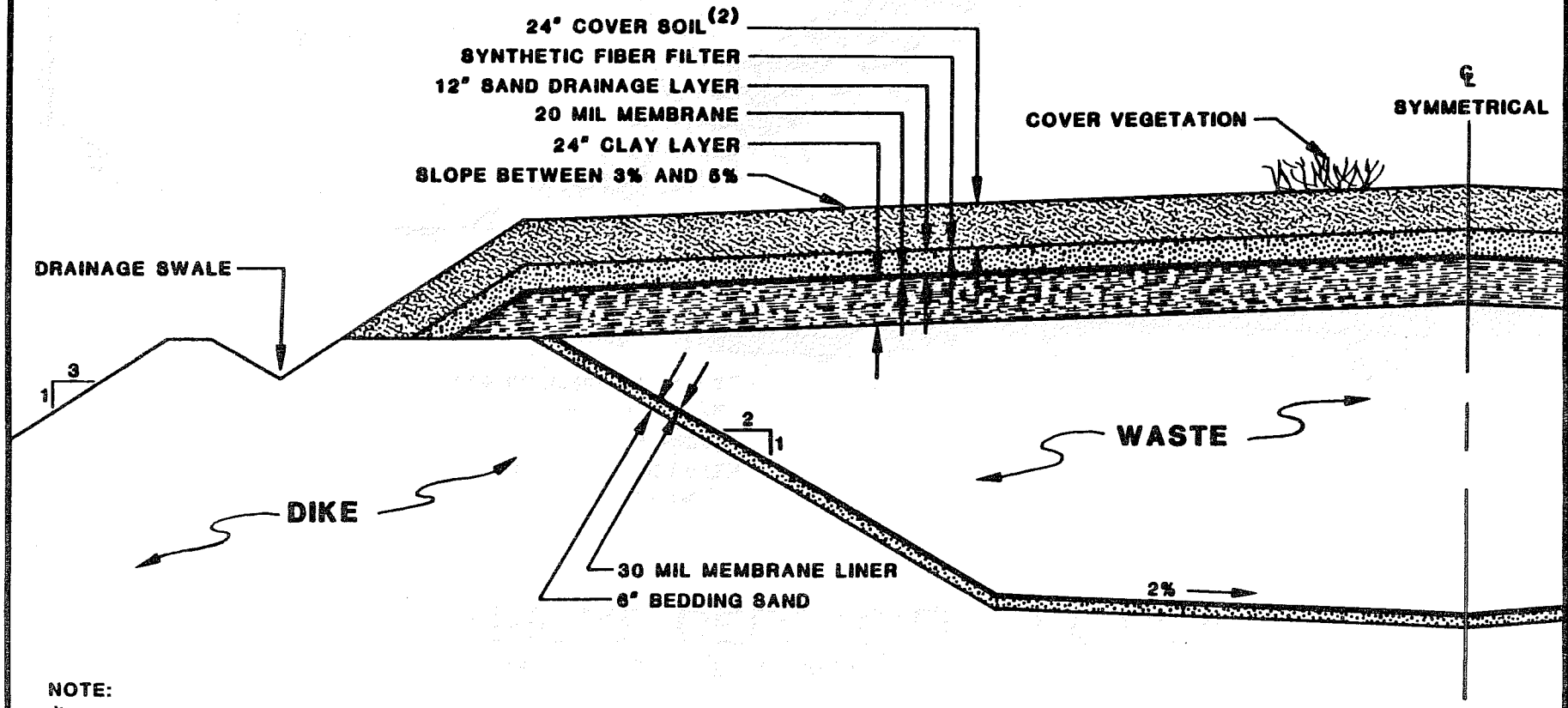
HAZARDOUS MAXIMUM LANDFILL – TYPICAL CELL HALF SECTION[1]



NOTE:
*24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE E.5

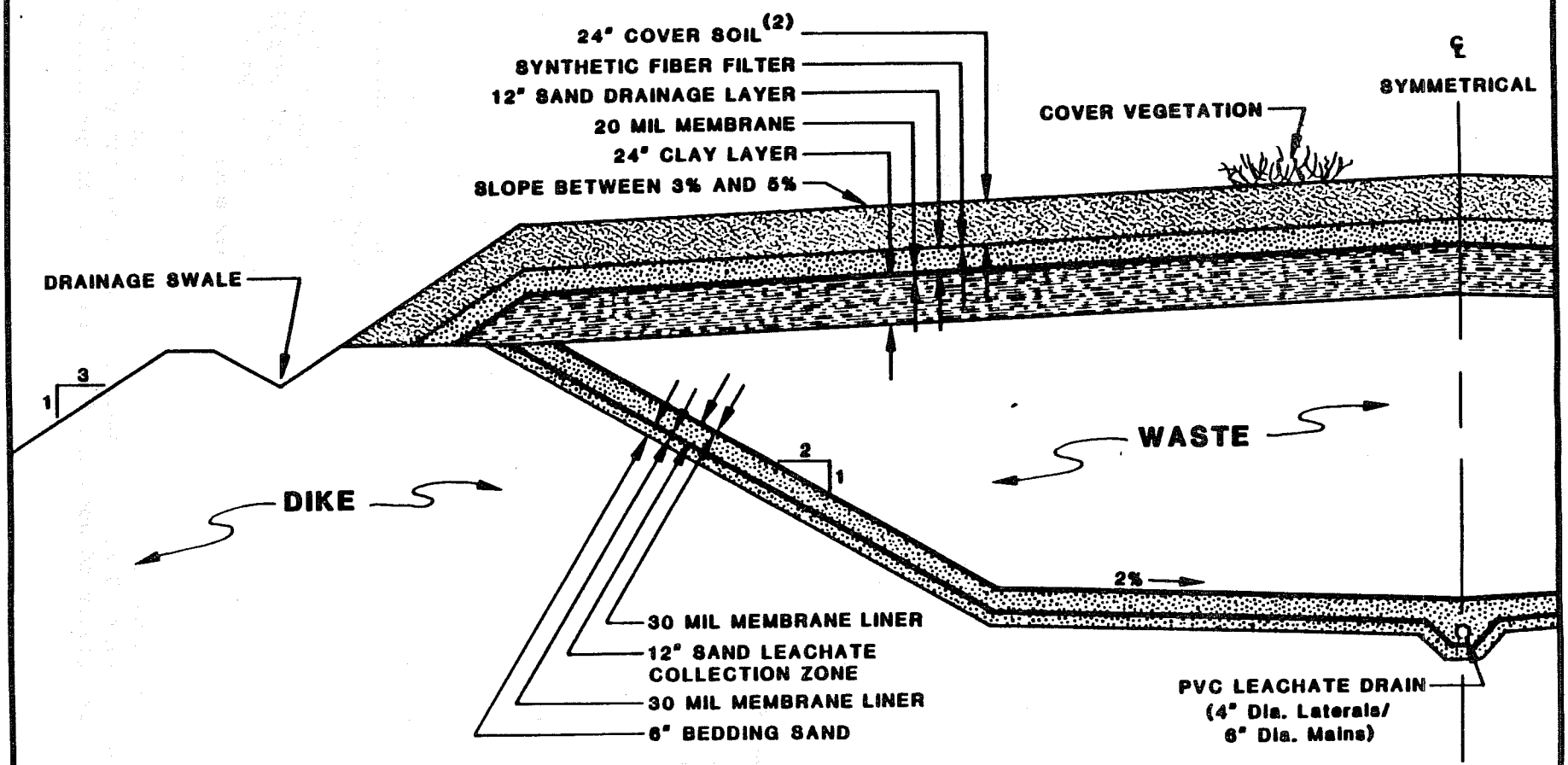
HAZARDOUS MINIMUM SURFACE IMPOUNDMENT – TYPICAL CELL HALF SECTION[1]



NOTE:
*24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE E.6

HAZARDOUS MAXIMUM SURFACE IMPOUNDMENT – TYPICAL CELL HALF SECTION[1]



NOTE:
*24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE E.7

TABLE E.2
GENERAL SPECIFICATIONS FOR COVER/CAP SYSTEM

(Used for wet and dry disposal, minimum and maximum design)

COMPONENTS (in order from top to bottom)	GENERAL SPECIFICATIONS[1]
VEGETATION	o Does not need continuing man-provided water and fertilizer after establishment o Root system not capable of penetrating synthetic membrane o Capable of stabilizing cover and minimizing erosion
COVER SOIL	o 2-ft minimum thickness o Thickness should be increased if needed to protect synthetic membrane from freeze/thaw (cover soil and sand drainage layer $\geq$maximum frost penetration depth) o Final top slope within the range of 3% to 5% o Capable of supporting vegetation
FILTER LAYER	o Graded granular or synthetic fiber filter o If graded granular filter is used, it should meet grain-size specifications (see referenced document) o Capable of preventing clogging of sand drainage layer
SAND DRAINAGE LAYER	o 1-ft minimum thickness o Permeability $\geq 10^{-3}$ cm/sec o 2% minimum slope o no drainage tiles
SYNTHETIC MEMBRANE	o 20-mil minimum thickness o Chemically resistant to site soil conditions
CLAY LAYER	o 2-ft minimum thickness o Compacted permeability $\leq 10^{-7}$ cm/sec o Placed and compacted in 6-in lifts (maximum)

[1] Based on "RCRA Guidance Document, Landfill Design, Liner Systems and Final Cover", Draft, U.S. Environmental Protection Agency, July 1982.

NOTE: See referenced document for more detail on specifications.

TABLE E.3

GENERAL SPECIFICATIONS FOR LANDFILL SINGLE LINER SYSTEM

(Used for dry disposal, minimum hazardous design)

COMPONENTS (in order from top to bottom)	GENERAL SPECIFICATIONS[1]
FILTER LAYER	o Graded granular or synthetic fiber filter
	o If graded granular filter is used, it should meet grain-size specifications (see referenced document)
	o Capable of preventing clogging of leachate collection layer
LEACHATE COLLECTION/REMOVAL LAYER (sand)	o 1-ft minimum thickness
	o Permeability $\geq 10^{-3}$ cm/sec
	o 2% minimum slope
	o Drainage tile system - 4-in minimum diameter - 50 to 200-ft centers - sump with pump capable of removing leachate
SYNTHETIC MEMBRANE LINER	o 30-mil minimum thickness
	o Chemically resistant to waste and leachate
BEDDING SOIL LAYER	o 6-in minimum thickness
	o No coarser than sand (SP-USCS)
	o No sharp objects (e.g., rocks)

1 Based on "RCRA Guidance Document Landfill Design, Liner Systems and Final Cover," Draft, U.S. Environmental Protection Agency, July 1982.

NOTE: See referenced document for more detail on specifications.

TABLE E.4
GENERAL SPECIFICATIONS FOR LANDFILL DOUBLE LINER SYSTEM

(Used for dry disposal, maximum hazardous design)

COMPONENTS (in order from top to bottom)	GENERAL SPECIFICATIONS[1]
FILTER LAYER	o Graded granular or synthetic fiber filter o If graded granular filter is used, it should meet grain-size specifications (see referenced document) o Capable of preventing clogging of leachate collection layer
PRIMARY LEACHATE COLLECTION/ REMOVAL LAYER (sand)	o 1-ft minimum thickness o Permeability $\geq 10^{-3}$ cm/sec o 2% minimum slope o Drainage tile system - 4-in minimum diameter - 50 to 200-ft centers - sump with pump capable of removing leachate
SYNTHETIC MEMBRANE PRIMARY LINER	o 30-mil minimum thickness o Chemically resistant to waste and leachate
SECONDARY LEACHATE COLLECTION/ DETECTION/REMOVAL LAYER (sand)	o 1-ft minimum thickenss o Permeability $\geq 10^{-3}$ cm/sec o 2% minimum slope o Drainage tile system - 4-in minimum diameter - 50 to 200-ft centers - sump with pump capable of removing leachate
SECONDARY CLAY LINER	o 2-ft minimum thickness o Compacted permeability $\leq 10^{-7}$ cm/sec o Placed and compacted in 6-in lifts (maximum)

[1] Based on "RCRA Guidance Document, Landfill Design, Liner Systems and Final Cover," Draft, U.S. Environmental Protection Agency, July 1982.

NOTE: See referenced document for more detail on specifications.

TABLE E.5
GENERAL SPECIFICATIONS FOR DISPOSAL,
IMPOUNDMENT SINGLE LINER SYSTEM

(Used for wet disposal, minimum hazardous design)

COMPONENTS (in order from top to bottom)	GENERAL SPECIFICATIONS[1]
PROTECTIVE SOIL LAYER	o 18-in minimum where vehicles are to be driven
	o 6-in minimum where exposed to sunlight
	o Exclusion of protective soil layer is acceptable where vehicles are not to be driven and membrane is not exposed to sunlight
	o No sharp objects (e.g. rocks)
SYNTHETIC MEMBRANE LINER	o 30-mil minimum thickness
	o Chemically resistant to waste and leachate
BEDDING SOIL	o 6-in minimum thickness
	o No coarser than sand (SP-USCS)
	o No sharp objects (e.g., rocks)

1 Based on "RCRA Guidance Document, Surface Impoundment, Liner Systems, Final Cover and Freeboard Control," Draft, U.S. Environmental Protection Agency, July 1982.

NOTE: See referenced document for more detail on specifications.

TABLE E.6
GENERAL SPECIFICATIONS FOR DISPOSAL,
IMPOUNDMENT DOUBLE LINER SYSTEM

(Used for wet disposal, maximum hazardous design)

COMPONENTS (in order from top to bottom)	GENERAL SPECIFICATIONS[1]
PROTECTIVE SOIL LAYER	o 18-in minimum where vehicles are to be driven o 6-in minimum where exposed to sunlight o Exclusion of protective soil layer is acceptable where vehicles are not to be driven and membrane is not exposed to sunlight o No sharp objects (e.g. rocks)
SYNTHETIC MEMBRANE PRIMARY LINER	o 30-mil minimum thickness o Chemically resistant to waste and leachate
LEACHATE COLLECTION/DETECTION/ REMOVAL LAYER (sand)	o 1-ft minimum thickness o Permeability $\geq 10^{-3}$ cm/sec o 2% minimum slope o Drainage tile system - 4-in minimum diameter - 50 to 200-ft centers - sump with pump capable of removing leachate
SYNTHETIC MEMBRANE SECONDARY LINER	o 30-mil minimum thickness o Chemically resistant to waste and leachate
BEDDING SOIL	o 6-in minimum thickness o No coarser than sand (SP-USCS) o No sharp objects (e.g., rocks)

1 Based on "RCRA Guidance Document, Surface Impoundment Cover and Freeboard Control," Draft, U.S. Environmental Protection Agency, July 1982.

NOTE: See referenced document for more detail on specifications.

TABLE E.7
OTHER QUANTITY TAKE-OFF ITEMS

COST ITEM	UNITS	BASIS OF CALCULATION
Real Estate Purchase	acre	Site area if new site is purchased.
Clear and Grub	acre	All of site except 300-ft buffer area around perimeter.
Heavy Stump Removal	acre	Portion of clear and grub area that is heavily wooded.
Light Stump Removal	acre	Portion of clear and grub area that is lightly wooded.
Final Grading	acre	Portion of site developed.
Synthetic Membrane	sq ft	Area as required based on cell dimensions and specific cap and liner design.
Seeding and Mulching	sq yd	Portion of site developed.
Synthetic Fiber Filter	sq yd	Area as required based on cell dimensions and specific cap and liner design.
Heavy Duty Bituminous Road	ft	Distance from public road to disposal area.
Light Duty Bituminous Road	ft	On top of about 1/2 of the dikes for access to cells. From landfill to leachate treatment plant.
Fencing	ft	Around site perimeter.

TABLE E.7 (Continued)
OTHER QUANTITY TAKE-OFF ITEMS

COST ITEM	UNITS	BASIS OF CALCULATION
Leachate Collection Mains (6-in PVC)	ft	Double mains down length of cell. Pair in both primary and secondary collection zones for double liner system.
Leachate Collection Materials (4-in PVC)	ft	Extending from mains to edge of cell bottom at 125-ft centers. Primary and secondary collection zones for double liner system.
Leachate Collection Sumps	ft	About one every 400 ft down length of cell.
Investigative Soil Borings	ft	1 boring per 2 acres developed. 20 ft below water table or to bedrock surface; whichever is less.
Ground Water Monitoring Wells	ft	One every 500 ft around perimeter of fill. 10 ft below water table.
Direct-input QTOs (e.g. rip-rap, gravel stabilization)	varies	Quantities calculated manually based on site-specific requirements. Entered as input data.

natural drainage swale must be re-routed to avoid the disposal area. The rip-rap quantity to line the swale is input directly. The direct input quantities are included along with the calculated QTOs in the construction cost calculations. Items for which quantities may be directly entered are:

- Gravel stabilization (sq yd),
- Gravel roadways (ft),
- Rip-rap (hand-placed, machine-placed, grouted; sq yd),
- Corrugated metal drainage pipe (48-in dia, ft),
- Reinforced concrete drainage pipe (48-in dia, ft),
- Fiberglass reinforced plastic pipe (8-in dia, ft),
- Ceramcore/basalt pipe (12-in dia, ft),
- Steel pipe (12-in dia, ft),
- Miscellaneous steel (tons),
- Jacking and boring (36-in casing, ft).

If site-specific conditions require construction items which are not covered by either the computer-calculated QTOs or the direct-input quantities, there are provisions for the user to directly input lump sum costs which have been manually calculated. These lump sum costs are included along with the costs calculated from the QTOs in the construction cost estimate.

2.5 Construction Cost Estimates

The disposal facility construction costs are estimated based on the computer-calculated QTOs, direct input QTOs and direct input lump sum costs previously discussed. The basic method of cost calculation is to multiply each quantity by an appropriate unit cost. The result of this computation is referred to as the extension. The unit cost takes into account the direct costs for material and/or installation as applicable.

For the purpose of this project, the various unit costs are based on 1980 national average values which are adjusted for each study plant using regional cost adjustment factors. The national average costs utilized are listed in Table E.8. These costs are based on information from published cost construction manuals, direct inquiries of vendors and contractors and in-house ES cost estimates. The cost adjustment factors used for the 24 power plant sites under study are tabulated in Table E.9.

Table E.8
1980 NATIONAL AVERAGE UNIT COSTS

ITEM	UNIT	$/UNIT[1]
Real Estate	acres	3000
Clear and grub	acres	1315
Heavy stump removal	acres	900
Light stump removal	acres	540
Final grading	acres	545
Cut & fill non-compacted	cu yd	1.52
On-site structural cut & fill	cu yd	2.39
Off-site borrow soil	cu yd	7.40
Topsoil placement and grading	cu yd	1.69
Topsoil removal and stockpile	cu yd	1.52
Sand collection zone placement	cu yd	8.81
Sand import	cu yd	6.35
Clay liner placement	cu yd	4.70
Clay import	cu yd	5.00
Synthetic membrane	sq ft	0.56
Seeding and mulching-grass	sq yd	0.42
Gravel stabilization	sq yd	0.70
Synthetic fiber filter	sq yd	0.72
Gravel roadways - 20 feet wide	ft	3.02
Light duty bituminous road	ft	12.68
Heavy duty bituminous road	ft	16.64
Perimeter fencing	ft	12.00
Riprap, hand placed	sq yd	17.28
Riprap, machine placed	sq yd	9.11
Riprap, grouted	sq yd	76.68
Drainage cmp-48'	ft	47.45
Drainage rccp-48''	ft	60.45
Plastic pipe, pvc-4''	ft	9.95
Plastic pipe, pvc-6''	ft	14.33
Fibercast pipe 8''	ft	36.60
Ceramcore/basalt pipe - 12''	ft	74.50
Steel pipe - 12''	ft	46.00
Leachate collection sumps	ft	94.00
Miscellaneous structures		(2)
Miscellaneous concrete		(2)
Miscellaneous steel	tons	2302
Jacking and boring 36'' casing	ft	295
Miscellaneous drainage structures		(2)
Soil borings	ft	15.00
Groundwater monitoring wells	ft	12.00

(1) Costs include material and/or installation as applicable.
(2) Costs are calculated manually and input as lump sum amounts.

TABLE E.9
SITE COST ADJUSTMENT FACTORS

Plant Code Number	Cost Adjustment Factor	Plant Code Number	Cost Adjustment Factor
1	0.956	14	0.916
2	1.136	16	0.887
3	1.205	18	1.100
4	1.019	20	0.965
5	1.033	22	1.084
6	0.933	23	1.076
8	1.091	24	0.983
9	1.022	28	0.955
10	0.987	39	1.084
11	0.987	50	1.103
12	1.017	51	0.867
13	0.990	52	0.891

NOTES: 1. Site-Specific Cost = National Average Cost multiplied by Site Cost Adjustment Factor

2. Based on City Cost Indexes for Total Site Work (Means Building Construction Cost Data, 38th Edition, 1980)

2.6 Other Capital Items

Major capital cost items which are not covered by the site development and construction cost estimates discussed above include:

- o leachate treatment plant costs
- o wet-to-dry conversion costs for handling fly ash, bottom ash or FGD sludge
- o closure costs for existing disposal facilities

2.6.1 Leachate Treatment Plant Costs

Costs f r leachate treatment plant (LTP) construction are included when dry landfill disposal is specified for the hazardous minimum or maximum scenarios. The LTP cost model is based on a design to treat landfill leachate and contaminated surface runoff. The approach for development of the cost model was as follows:

1. identify possible waste constituents in the leachate and runoff
2. identify LTP effluent requirements
3. identify treatment processes to achieve desired removals
4. select a standard LTP unit process configuration
5. develop LTP construction and O&M cost estimates for a variety of flow rates using the standard unit processes
6. develop curves for calculation of LTP costs based on design flow.

A number of sources were investigated for establishing possible leachate and runoff waste characteristics. Data on fly ash leachate, ash pond leachate, scrubber sludge leachate, fly ash sluicing water, bottom ash sluicing water and FGD sludge liquors and elutriates were used to estimate the influent to the LTP. As a worst case condition, it was assumed that leachate and contaminated surface runoff would have the same waste characteristics.

There are presently no established effluent criteria for leachate treatment plants. The U.S. EPA effluent requirements for the metal waste producing industries vary widely:

- o Chrome 0.2 to 4.0 mg/l,
- o Copper 0.15 to 2.7 mg/l,
- o Iron 0.5 to 3.0 mg/l,
- o Zinc 0.5 to 5.0 mg/l,

- Arsenic 0.5 to 10.0 mg/l,
- Cadmium 0.05 to 0.7 mg/l.

Considering these broad ranges and lacking specific guidelines, the general effluent requirements for the "Steam Electric Power Generating Industry" were selected as LTP effluent limits:

- pH 6 to 9,
- Total suspended solids 30 mg/l,
- Chrome 0.2 mg/l,
- Copper 1.0 mg/l,
- Zinc 1.0 mg/l.

A number of treatment technologies were evaluated to meet these effluent requirements before selecting hydroxide precipitation followed by clarification and filtration. A flow chart of the LTP is shown on Figure E.8. The equalization basin in Figure E.8 is sized based on the cell dimensions and a 10-year 24-hour rainfall event. The design flow to the LTP from the equalization basin was based on the cell dimensions and the average annual rainfall.

Table E.10 presents the LTP construction costs which were calculated and serve as a basis for the LTP cost model. The LTP construction cost estimates are calculated within the program using a second-order equation developed from a statistical curve fit for these data.

2.6.2 Wet To Dry Conversion Costs

A wet to dry conversion was specified when it was necessary to locate a suitable hazardous waste disposal site some distance from the immediate property of the power plant. Wet to dry handling conversion costs are not calculated for plants which already practice dry disposal. This is considered a sunk cost and therefore not included.

Wet to dry conversion construction cost models were developed for fly ash, bottom ash and FGD scrubber sludge. Individual cost estimates for a variety of facility capacities were developed from published data and used to generate construction cost curve equations. These equations are used within the LFDESIGN program. The cost estimates used as a basis for the fly and bottom ash conversion cost models are tabulated in Table E.11. The basis for the FGD conversion cost model is given in Table E.12. Conversion costs for fly ash and bottom ash are calculated as a

FIGURE E.8

Leachate Treatment Plant

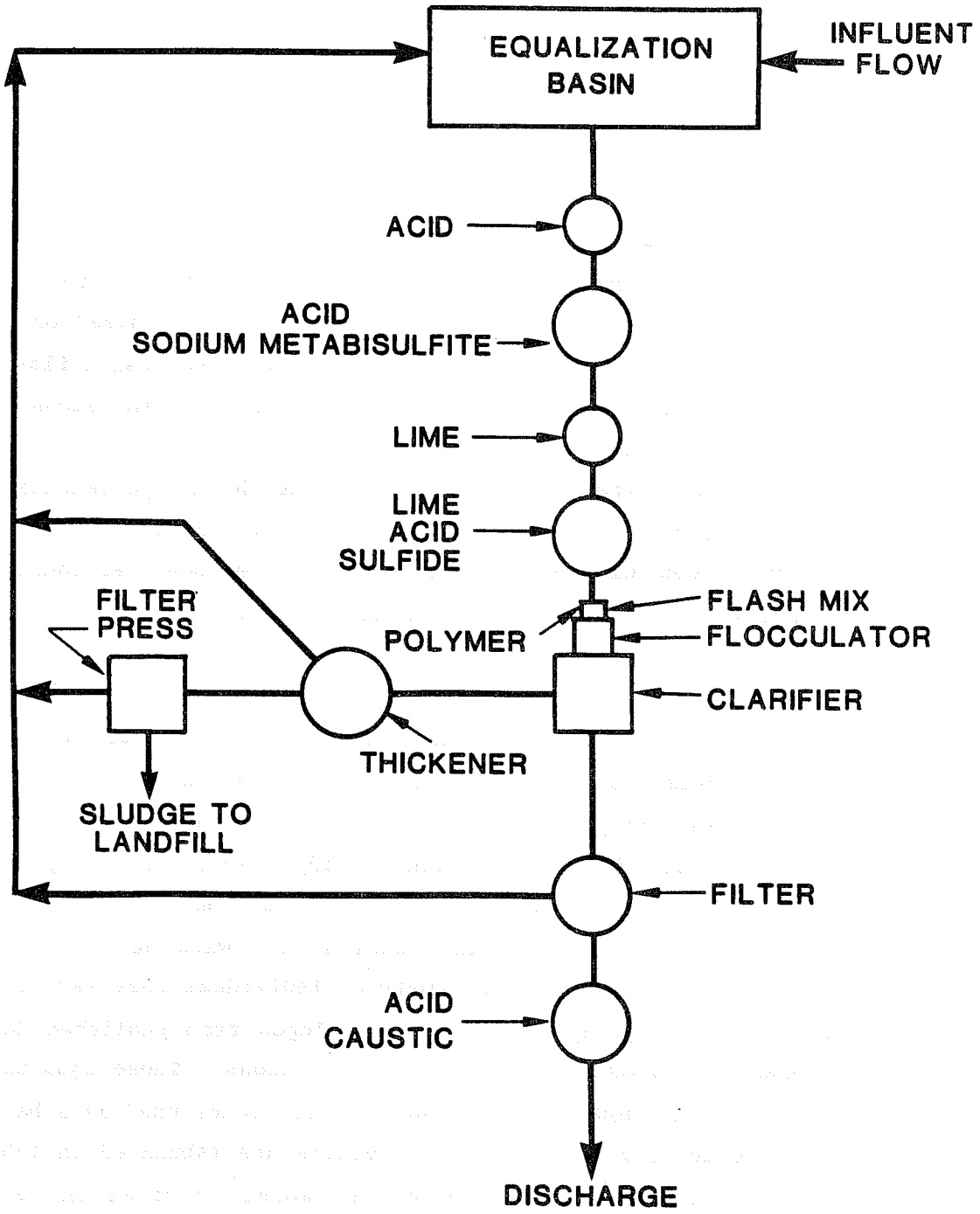


TABLE E.10

BASIS OF LEACHATE TREATMENT PLANT CONSTRUCTION AND O&M COST ESTIMATES

Leachate Treatment Plant Flow (gpd)	Operating Schedule	Construction Cost ($1980)	OPERATION AND MAINTENANCE				
			Labor (man/m/yr)	Power (kw-hr/yr)	Misc. Material ($1980/yr)	Chemicals ($1980/yr)	Analytical ($1980/yr)
1,440	8 hr/day	1,110,000	3,800	26,600	3,900	1,300	25,000
7,200	24 hr/day	1,240,000	8,400	95,800	9,600	3,000	25,000
14,400	24 hr/day	1,390,000	8,600	106,000	10,800	5,900	25,000
72,000	24 hr/day	2,150,000	9,300	167,000	12,800	29,700	25,000
144,000	24 hr/day	2,770,000	10,400	212,000	13,700	59,400	25,000
288,000	24/ hr/day	3,860,000	11,500	343,000	16,600	119,000	25,000
432,000	24 hr/day	4,720,000	13,400	404,000	17,400	178,000	25,000

NOTE: Estimates developed by Engineering-Science based on literature research and contacts with equipment vendors. Costs for equalization basin are not included (calculated separately at $0.45/cu ft volume).

TABLE E.11

BASIS FOR FLY ASH AND BOTTOM ASH WET-TO-DRY CONVERSION COSTS

Plant Size (MW)	Wet-to-Dry Conversion Construction Cost ($1980)		
	Fly Ash Conversion Only	Bottom Ash Conversion Only	Conversion For Both Fly Ash and Bottom Ash
300	990,000	820,000	1,800,000
600	1,500,000	1,300,000	2,800,000
900	2,300,000	1,900,000	4,200,000
1,300	3,000,000	2,500,000	5,500,000
2,600	6,900,000	5,700,000	13,000,000

NOTES:

1. Cost estimates based on information contained in "Economic Analysis of Wet Versus Dry Ash Disposal Systems", U.S. Environmental Protection Agency, Tennessee Valley Authority, EPA-600/7-81-013, TVA/OP/EDT-81/30, January 1981.

2. Costs are for equipment purchase and installation only. Contingency engineering, contractor O&P and legal are not included.

TABLE E.12

FGD WET-TO-DRY CONVERSION AND O&M COSTS

FGD Generation Rate (dry ton/yr)	Conversion Construction Cost ($1980)		O&M Cost ($1980)	
	Total Cost	Unit ($/dry tpy)	Total Annual Cost	Unit ($/dry ton)
88,000	4,000,000	45.5	1,100,000	12.5
210,000	5,600,000	26.7	1,600,000	7.6
640,000	11,800,000	18.4	3,300,000	5.2

NOTES: 1. Cost estimates based on information contained in "Economics of Disposal of Lime/Limestone Scrubbing Wastes: Sludge/Fly Ash Blending and Gypsum Systems", U.S. Environmental Protection Agency, Tennessee Valley Authority, EPA 600/7-79-069, TVA Bulletin Y-140, February 1979.

2. Costs are for equipment purchase and installation only. Contingency, engineering, contractor O&P and legal are not included.

function of plant capacity (megawatts) while FGD conversion costs are calculated as a function of annual dry tonnage of scrubber sludge generated.

2.6.3 Closure of Existing Facilities

According to the RCRA regulations, hazardous waste disposal facilities in operation on the effective date of the regulations, though not orginally designed according to RCRA standards, must be closed according to RCRA standards. For this reason it was necessary to include costs for secure closure of the existing power plant disposal facilities. Due to the wide variety of situations represented by the existing disposal sites for the study plants, it was decided that the most practical approach was to calculate these costs manually and enter them as lump sum construction costs. The existing facility's closure costs are assumed to occur in the base study year of 1980.

Though the existing facility's closure plans vary between the study plants, the following general guidelines were followed as closely as possible:

- o Closure of existing disposal sites for Hazardous Minimum Scenario,
  - 12-in compacted clay cap
  - adequate cover soil for freeze/thaw protection (2-ft minimum)
  - groundwater monitoring system,
- o Closure of existing disposal sites for Hazardous Maximum Scenario,
  - cover/cap system as specified in Table E.2
  - groundwater monitoring system.

2.7 Calculation of Capital Costs

The construction costs discussed in the above sections for the disposal facility, LTP, wet to dry conversion and existing facility closure are calculated within LFDESIGN on a basis of direct material, equipment and labor cost i.e., the direct costs that a contractor would incur. The following percent add-ons are applied to the construction costs to estimate the capital cost for the disposal scenario:

Contractor Overhead	15%
Contractor Profit	10%
Engineering and Legal Costs	10%
Contingency	15%
Total Add-on Percentage	50%

In addition to these construction percent add-ons, permitting cost estimates are included. Based on ES' experience with environmental permitting situations, permitting costs of $250,000 for the hazardous minimum scenario and $500,000 for the hazardous maximum scenario are reasonable expected ranges.

2.8 Calculation of O&M Costs

One of the key functions of LFDESIGN is to estimate O&M costs for the two hazardous waste disposal scenarios. Estimates are calculated for the following types of O&M costs:

- Non-administrative O&M,
- Administrative O&M,
- Post-closure costs
  - existing facilities (closed in 1980)
  - new facilities (those constructed in 1980 to achieve RCRA standards).

2.8.1 Non-Administrative O&M Costs

The non-administrative O&M cost items estimated by LFDESIGN include (where applicable):

- Waste handling costs,
- Excavation from interim storage ponds,
- Waste transportation,
- Landfill operation,
- Leachate treatment plant operation.

In general, handling costs cover transporting the waste from its point of generation to the vehicle loading facility in the case of dry handling and disposal. Wet disposal handling costs cover pumping of

waste slurries to an on-site disposal facility. Waste transportation costs are included when dry disposal is specified and these costs cover truck or rail haul to the landfill disposal facility. Landfill operation costs cover labor and equipment for placement and compaction of the wastes at the disposal site.

The LFDESIGN non-administrative O&M cost calculations are based on the information summarized in Table E.13 and Figures E.9 through E.11. The O&M unit costs were developed by ES based on estimates of labor and equipment requirements.

2.8.2 Administrative O&M Costs

The administrative O&M cost items estimated by the LFDESIGN program system are as follows:

- Manifesting,
- Groundwater monitoring,
- Facility inspection,
- Personnel training,
- Non-sudden occurrence insurance,
- General administration.

The methods and basis for the administrative O&M cost calculations are summarized in Table E.14.

2.8.3 Post-Closure O&M Costs

LFDESIGN accounts for the following post-closure costs:

- Existing disposal site,
  - closed in 1980
  - 30-yr post-closure period beginning in 1980
- New RCRA disposal site,
  - closed in 2015
  - 30-yr post-closure period beginning in 2015.

The items included in the post-closure O&M cost estimates and the basis of calculation are summarized in Table E.15. The method utilized to account for post-closure costs within the disposal cost estimates is described along with the economic calculations in Section 4.0 of this Appendix.

TABLE E.13
NON-ADMINISTRATIVE OPERATION AND MAINTENANCE COSTS

O&M ITEM	UNIT COST
Waste Handling	
Wet Handling (all wastes)	$2.50/dry ton
Dry Handling	
Fly Ash and Bottom Ash	$3.50/dry ton
FGD Sludge	Unit cost estimated based on waste generation rate (See Table E.12)
Excavation From Interim Storage Pond	
Pond Active	$1.54/cu yd
Pond Inactive	$0.76/cu yd
Waste Transportation	
Closed Truck	See Figure E.9
Open Truck	
On-Road (16-cu yd)	See Figure E.10
Off-Road (30-cu yd)	See Figure E.11
Rail	Site-Specific Unit Cost
Landfill Operation	$1.07/cu yd
Leachate Treatment Plant Operation	Annual cost calculated based on design flow (See Table E.10)

NOTES:
1. All costs are based on $1980
2. Site cost adjustment factors (Table E.9) are applied to O&M costs within program.
3. Dry disposal handling costs include all costs for transport of the wastes from their point of generation through loading on the transport vehicle.
4. Wet disposal handling costs include costs for transferring waste slurries to an on-site disposal impoundment. Pumping costs as well as pump and pipe replacement are included.

FIGURE E.9

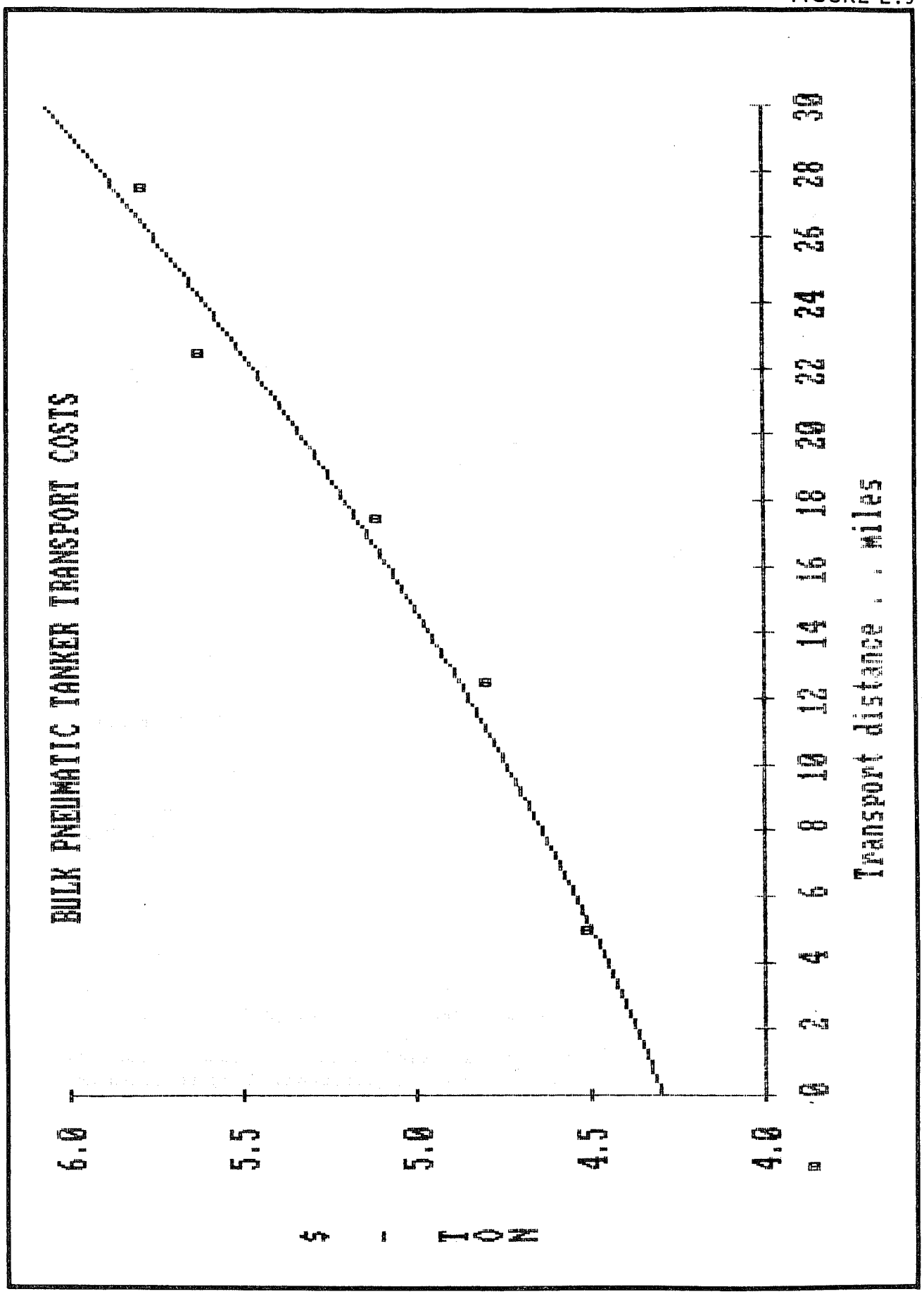

BULK PNEUMATIC TANKER TRANSPORT COSTS
6.0
5.5
5.0
4.5
4.0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Transport distance , miles

FIGURE E.10

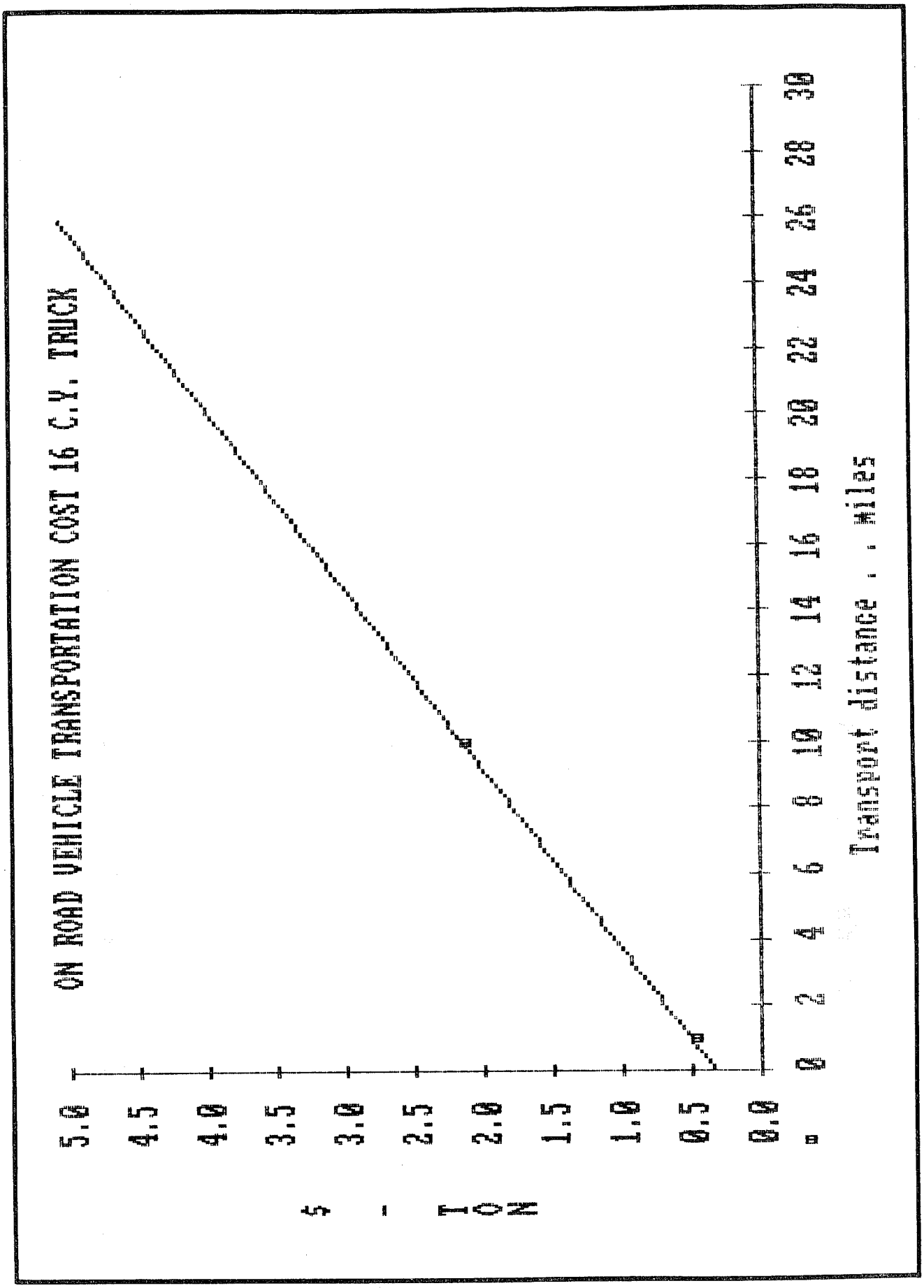

ON ROAD VEHICLE TRANSPORTATION COST 16 C.Y. TRUCK
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Transport distance , , miles

FIGURE E.11

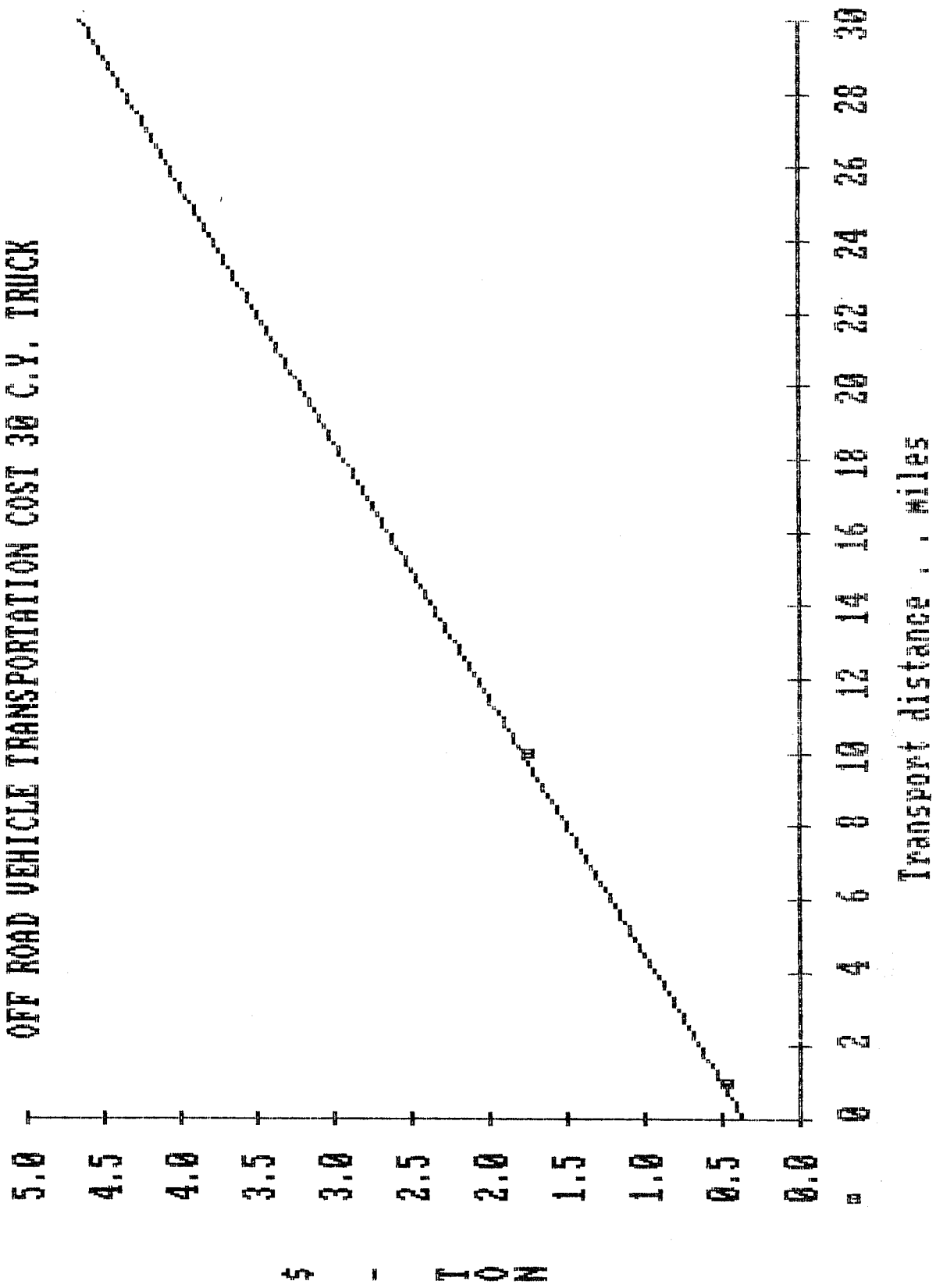

OFF ROAD VEHICLE TRANSPORTATION COST 30 C.Y. TRUCK
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Transport distance . . miles

TABLE E.14

ADMINISTRATIVE O&M COSTS

ITEM	COST CALCULATION	BASIS
Manifesting	$7,400/yr + $0 027/dry ton	Assume 1/4 man-yr for smallest plant evaluated, 1-1/2 man-yr for largest plant evaluated.
Ground-Water Monitoring	$945/yr per well	$1890/yr per well. Assume average of 1/2 of total wells monitored during active life of facility.
Facility Inspection	$12.10/yr per acre	$24.2/yr per acre. Assume average of 1/2 of site inspected during active life of the facility.
Personnel Training	$1 200/yr	Assume 2 man wk/yr.
Non-Sudden Occurrence Insurance	$18,500/yr + $0.0429/dry ton	Assume $20,000/yr for first million cu ft, $1,500/yr for each additional million cu ft.
General Administration	$35,800/yr + $0.059/dry ton	Assume 1/2 professional man-yr plus 1/2 support man-yr for smallest plant, 2 professional man-yr plus 1 support man-yr for largest plant.

NOTES: 1. Site cost adjustment factors (Table C.9) are applied for administrative O&M costs within program.
2. Reference for non-sudden occurence insurance costs is "Report and Technical Studies on the Disposal and Utilization of Fossil Fuel Combustion By-Products," Draft, Volume III, Utility Solid Waste Activities Group, Edison Electric Institute, National Rural Electric Cooperative Association, October 1982.

TABLE E.15
POST-CLOSURE COSTS

ITEM	COST CALCULATION
Groundwater Monitoring	$1890/yr per well
Inspection	$24.2/yr per acre*
Maintenance:	
Mowing	$19.7/yr per acre*
Erosion Repair	$8.11/yr per acre*
Fence	$0.43/yr per ft*
Fertilizing	$35.8/yr per acre*
Groundwater Monitor Wells	$0.13/yr per ft
Leachate Disposal	$27.6/yr er acre*
Erosion Repair	$7.0/yr per acre*
Cover Vegetation Replanting	$3.47/yr per acre*
Administrative Services	$5,600/yr*

NOTES: 1. Site cost adjustment factors (Table E.9) are applied to post-closure costs within program.

2. Costs indicated with asterisk (*) are based on information from "Draft Guidance for Subpart H of the Interim Status Standards for Owners and Operators of Hazardous Waste Treatment Storage and Disposal Facilities," U.S. Environmental Protection Agency, EPA Contract 68-01-5794, August 1980. Others are based on ES cost estimates.

2.9 Calculation of Unit Disposal Costs

The capital and O&M cost estimates previously discussed are used to calculate equivalent annual levelized costs over the 35-year design period in accordance with the methods described in Section 4.0 of this Appendix. Unit disposal costs are then calculated using the following procedure:

- Total Levelized Disposal Cost ($/yr) =
  Levelized Capital Cost ($/yr) + Levelized O&M Cost ($/yr)
- Unit Disposal Cost ($/ton) =

$$\frac{\text{Total Levelized Disposal Cost (\$/yr)}}{\text{35-yr Average Waste Production Rate (ton/yr)}}$$

- Unit Disposal Cost ($/cu yd) =

$$\frac{\text{Total Levelized Disposal Cost (\$/yr)}}{\text{35-yr Average Waste Production Rate (cu yd/yr)}}$$

The volumetric unit disposal cost is based on an as-disposed (in the landfill) density.

3.0 NON-HAZARDOUS AND CURRENT PRACTICE DESIGNS (NH/CP)

As previously discussed, the non-hazardous and current practice scenarios are handled similarly within LFDESIGN. The functions performed by LFDESIGN in the non-hazardous/current practice (NH/CP) mode are as follows:

- Estimation of construction capital costs based on QTOs (directly input by user) and appropriate unit costs,
- Estimation of annual O&M costs for operation of the disposal facility,
- Performance of economic calculations to generate equivalent levelized annual costs for capital and O&M,
- Calculations of unit disposal costs ($/ton, $/cu yd) based on waste generation rates and levelized capital and O&M costs.

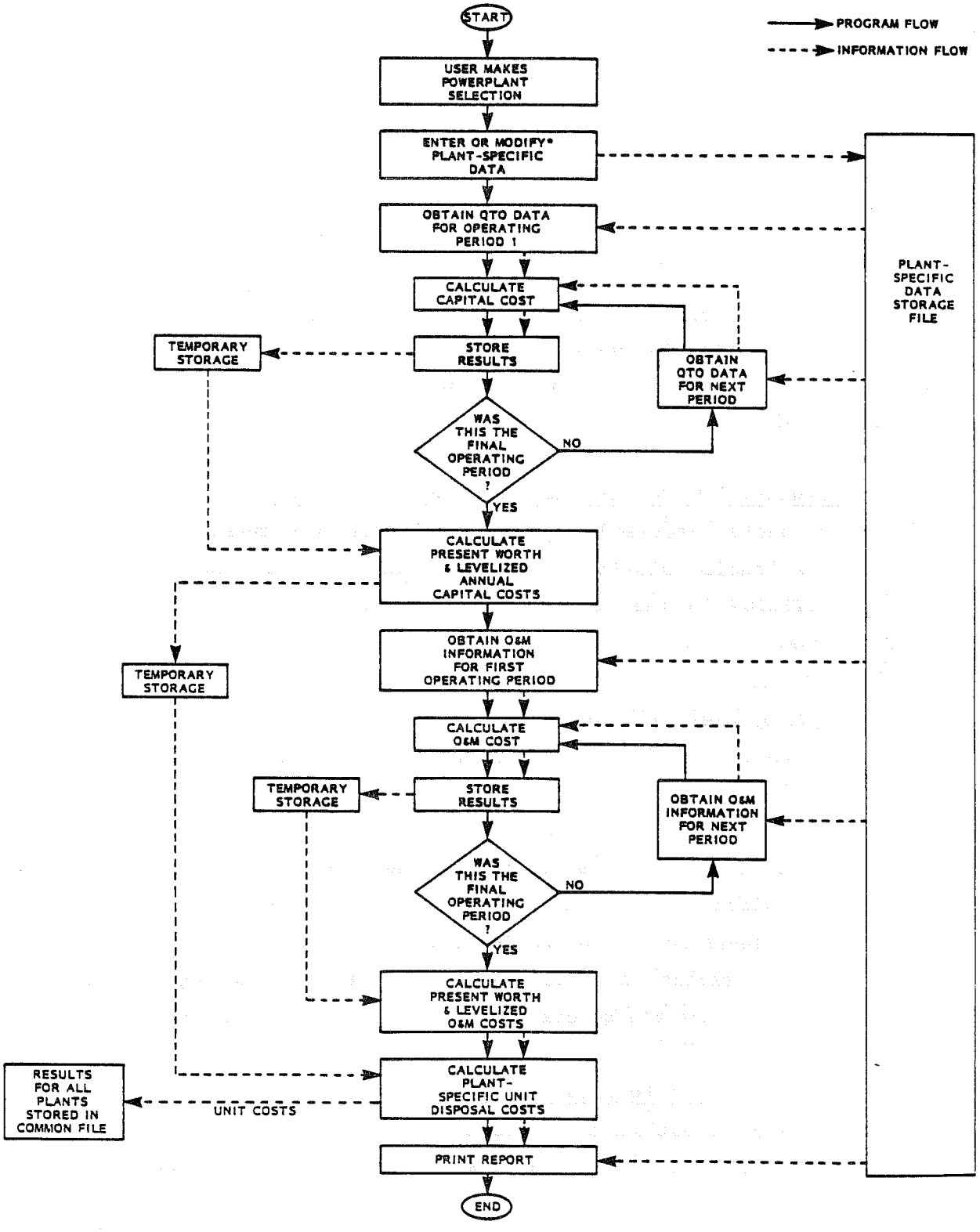
Figure E.12 presents a logic diagram for the LFDESIGN NH/CP mode. The diagram illustrates the general order of procedure and data flow.

3.1 Development of Designs and QTOs

The NH/CP cost estimates, unlike the RCRA hazardous scenarios previously discussed, do not assume closure of existing facilities in

FIGURE E.12

LFDESIGN Flow Diagram – Current Practice & Non-Hazardous Waste Disposal



*On first run with each plant, all site data must be entered into permanent storage. On subsequent runs, user may modify stored data as desired.

1980. The life of the existing facilities are estimated based on site-specific waste generation rates and it is assumed that they are utilized through that time.

Many of the power plants being studied in the DOE RCRA evaluation project do not have sufficient capacity in existing disposal facilities to last for the 35-yr period which is being used as the basis of the study. For these sites, it was necessary to plan a second or, in some cases, a third disposal facility to provide the 35-yr disposal capacity.

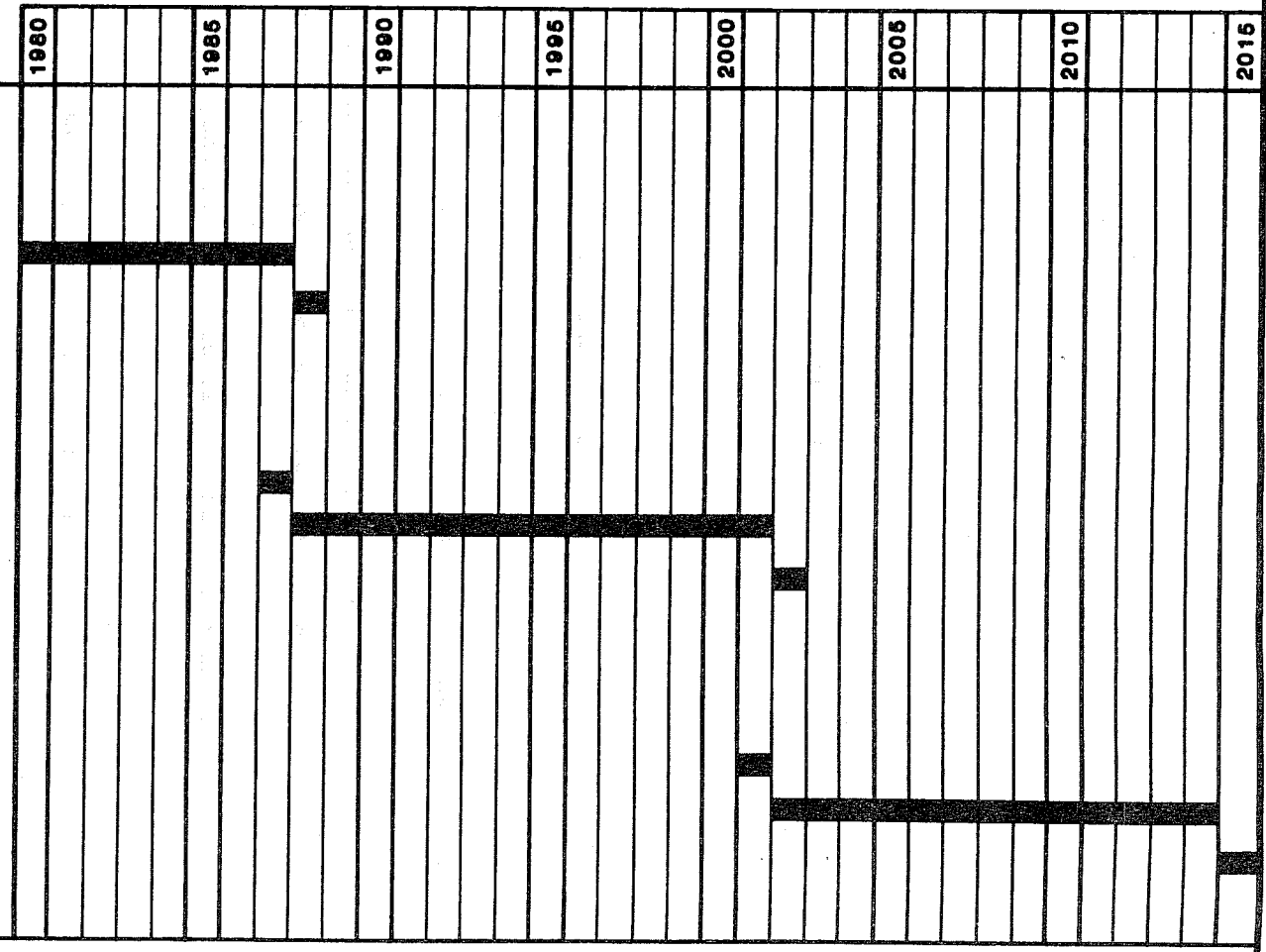
A typical NH/CP operating schedule is illustrated by the bar chart presented in Figure E.13. The operating times for the three disposal sites are referred to as periods. Period 1, continuation of the existing disposal site, extends from 1980 through 1987. Closure of the Period 1 site is assumed to occur in 1988, the year following its final year of operation. Since operation of the Period 2 site begins in 1988, its construction is assumed to occur in the year prior to its start-up, 1987. The schedule continues in similar fashion through the end of the 35-yr evaluation period with construction for each site occurring the year before operation start-up and closure occurring in the year following the end of its use.

The construction requirements for the various NH/CP designs were developed individually for each disposal site. Due to the wide variety of conditions represented by the study plants, it was determined that the most practical approach was to perform the designs and to calculate the QTOs manually.

The current practice designs were developed using specific design assumptions generally conforming to existing disposal practices. The non-hazardous designs are similar to the current practice designs. However, more extensive environmental protection measures have been included to account for more stringent non-hazardous waste disposal regulations. Though there are some variations due to site-specific conditions, the following general guidelines were followed in development of the non-hazardous designs:

- Closure of existing and future disposal sites with a 1-ft compacted clay cap,
- Cover soil above the clay cap sufficient to protect it from freeze/thaw (2-ft minimum),

Typical Current Practice/ Non-Hazardous Operating Schedule



*First period is a continuation of present disposal practice. No construction costs.

FIGURE E.13

Inclusion of ground-water monitoring at existing disposal sites by 1985,

- Groundwater monitoring systems at all new disposal sites,
- Construction of new disposal facilities with 1-ft compacted clay liners (no leachate collection).

3.2 Calculation of Construction and Capital Costs

As previously discussed, all QTOs for the NH/CP designs are developed manually and entered as input to LFDESIGN. The program calculates the NH/CP construction costs based on these QTOs as discussed in Section 2.5 of this Appendix. The national average unit costs listed in Table E.8 and the site cost adjustment factors listed in Table E.9 are used in the calculations.

Wet-to-dry conversion costs are included for future disposal periods where the assumed 35-yr design requires a change from wet to dry handling. The costs are calculated manually and input as lump sum amounts. The same cost data listed in Tables E.11 and E.12 are used for these manual calculations.

The percent add-ons presented in Section 2.7 are used to estimate total capital costs based on calculated construction costs for the NH/CP mode.

3.3 Calculation of O&M Costs

The specific operation conditions for the various NH/CP designs are specified as input data for the individual operating periods. LFDESIGN calculates non-administrative O&M costs for each period based on the specified operating conditions. The unit costs described in Table E.13 are used for calculation of the O&M costs.

Administrative O&M costs are not included for the current practice disposal scenario. This is due to the fact that activities such as manifesting and ground-water monitoring are not required. Groundwater monitoring costs are included as administrative O&M costs under the non-hazardous waste disposal scenario.

3.4 Calculation of Unit Disposal Costs

Levelized annual NH/CP capital and O&M costs are calculated as described in Section 4.0. The same procedure is used for calculation of unit disposal costs as described for the hazardous mode (Section 2.9).

4.0 ECONOMIC CALCULATIONS/LEVELIZATION PROCEDURE

Hazardous, non-hazardous, and current practice capital charges and O&M costs are calculated on a levelized basis. Levelization is a standard electric utility industry financial analysis technique used to calculate the annual revenue requirements associated with investment alternatives. The levelized cost associated with a stream of actual costs is that constant value which, if expended every year over the period of analysis, yields the same present value as the series of actual costs. A levelized cost is what financial analysts term an annuity.

There are two types of annuities, real annuities and nominal annuities. Real annuities are constant in real (constant dollar) terms and increase at the rate of inflation in nominal (current dollar) terms. Nominal annuities are constant in nominal terms and decrease with inflation in real terms.

The levelized cost value of a cost stream may be calculated by dividing the present value of the cost stream by the sum of the discount factors used for the present value calculation. For this project, a real annuity is desired, and as such the sum of the real discount factors must be used.

Each of the waste control alternatives considered involves both capital investments and O&M costs. Procedures to calculate annuity (or levelized) costs for each differ according to the nature of the costs.

4.1 Capital Charges

Utility revenue requirements for capital investments are determined by the return of and on capital. It is the return of and on capital that is levelized, not the actual capital expenditures. The return of capital is book depreciation. The return on capital depends upon the basis for analysis. This basis may be either return on total invested capital or return on equity. The return on capital may be calculated on either a pre- or post-tax basis.

This analysis is consistent with standard utility practice for comparing investment alternatives, which considers return on a real, post-tax, total invested capital basis. The return on capital on this basis consists of:

- interest on debt,
- dividends on preferred stock,
- post-tax earnings on common stock,
- property tax and insurance, and
- state and federal income tax.

The real discount rate is the deflated after-tax weighted average cost of capital. Using the utility capital structure recommended in the Electric Power Research Institute Technical Assessment Guide, (P-2410-SR, May 1982) and current corporate income tax policies, a real total return of 2.3 percent is calculated as is shown in Table E.14.

Table E.15 calculates both real and nominal capital charge rates (also known as levelization factors). A capital charge rate is a number, which when multiplied by the present value of the capital investment, yields an annuity or levelized value for the annual capital charges. In Table E.15, an initial investment with a present value of $100.00 is assumed along with the capital structure and other financial assumptions of Table E.14. When normalized by dividing by the initial asset base, the resultant capital charge rate can be applied to the present value of any initial net asset base. A real levelization factor of 0.074 is calculated (see Table E.15).

To verify our previous assumptions, Table E.16 was prepared showing a comparison of discounted capital charges using both actual and levelized costs. As can be seen, the present values calculated using each procedure are equivalent. Graphical presentations of the capital cost levelizing procedure are shown on time-line diagrams in Figures E.14 and E.15.

4.1 O&M Costs

The calculation of the real levelized O&M costs is accomplished by dividing the present value of the real O&M costs by the sum of the real discount factors, which is 24.515 (see Table E.15). To verify our assumptions regarding O&M cost levelization, Table E.17 was prepared to compare actual and levelized O&M cost calculations. As can be seen, both methodologies are equivalent.

Graphical presentations of the O&M cost levelizing procedure are shown on time-line diagrams in Figures E.16 and E.17.

TABLE E.14
ASSUMED CAPITAL STRUCTURE

Type of Security	Percent	Pre-Tax Cost	Post-Tax Weighted Cost	Post-Tax Weighted Return
Debt	50.0	8.0	4.8(a)	2.4
Preferred Stock	15.0	8.5	8.5	1.3
Common Stock	35.0	13.5	13.5	4.7
Total Return (Nominal)				8.4
Inflation Rate				6.0
Total Return (Real) (b)				2.3

Financial Assumptions		Value
Property Tax & Insurance (Percent of Initial Investment)		2.0
Marginal Tax Rate (Percent) (c)		
Federal	36.0	
State	6.0	
Total		39.8
Investment Tax Credit (Percent)		0.0
Financial Life (Years)		35
Incentive Depreciation System Schedule		10
Basis for Deflating/Discounting (1=Beginning of Year, 0=End of Year)		1

NOTES:

(a) Post-Tax Debt Cost = 8.0(1 - .398) = 4.8

(b) Total Return (Real) = (1.084/1.06) - 1 = .023

(c) The Total Marginal Tax Rate is slightly less than the sum of Federal and State rates because state taxes are deductible on Federal Income Taxes.
Total = Federal x (1-State) + State
= .36(1-.06)+.06 = .398

TABLE E.15
CAPITAL CHARGE RATE ESTIMATE

Year	Net Asset Base	Nominal Capital Charges: Book Depreciation	Interest Payment	Preferred Dividends	Common Earnings	Property Tax & Inc.	Fed & State Income Tax	Total Charges: Nominal	Real	Discount Factors: Nominal	Real	Present Value
1	100.0	2.9	4.0	1.3	4.7	2.0	4.0	18.8	18.8	1.000	1.000	18.83
2	97.1	2.9	3.9	1.2	4.6	2.0	3.9	18.4	17.4	0.922	0.978	17.00
3	94.3	2.9	3.8	1.2	4.5	2.0	3.7	18.0	16.0	0.851	0.956	15.34
4	91.4	2.9	3.7	1.2	4.3	2.0	3.6	17.6	14.8	0.785	0.935	13.84
5	88.6	2.9	3.5	1.1	4.2	2.0	3.5	17.2	13.7	0.724	0.914	12.48
6	85.7	2.9	3.4	1.1	4.0	2.0	3.4	16.8	12.6	0.668	0.894	11.24
7	82.9	2.9	3.3	1.1	3.9	2.0	3.3	16.4	11.6	0.616	0.874	10.13
8	80.0	2.9	3.2	1.0	3.8	2.0	3.2	16.0	10.7	0.568	0.855	9.11
9	77.1	2.9	3.1	1.0	3.6	2.0	3.1	15.6	9.8	0.524	0.836	8.20
10	74.3	2.9	3.0	0.9	3.5	2.0	3.0	15.2	9.0	0.484	0.817	7.37
11	71.4	2.9	2.9	0.9	3.4	2.0	2.8	14.8	8.3	0.446	0.799	6.62
12	68.6	2.9	2.7	0.9	3.2	2.0	2.7	14.4	7.6	0.412	0.781	5.94
13	65.7	2.9	2.6	0.8	3.1	2.0	2.6	14.0	7.0	0.380	0.764	5.33
14	62.9	2.9	2.5	0.8	3.0	2.0	2.5	13.6	6.4	0.350	0.747	4.78
15	60.0	2.9	2.4	0.8	2.8	2.0	2.4	13.2	5.9	0.323	0.730	4.28
16	57.1	2.9	2.3	0.7	2.7	2.0	2.3	12.8	5.4	0.298	0.714	3.83
17	54.3	2.9	2.2	0.7	2.6	2.0	2.2	12.4	4.9	0.275	0.698	3.42
18	51.4	2.9	2.1	0.7	2.4	2.0	2.0	12.0	4.5	0.254	0.683	3.05
19	48.6	2.9	1.9	0.6	2.3	2.0	1.9	11.6	4.1	0.234	0.668	2.72
20	45.7	2.9	1.8	0.6	2.2	2.0	1.8	11.2	3.7	0.216	0.653	2.43
21	42.9	2.9	1.7	0.5	2.0	2.0	1.7	10.8	3.4	0.199	0.638	2.16
22	40.0	2.9	1.6	0.5	1.9	2.0	1.6	10.4	3.1	0.184	0.624	1.92
23	37.1	2.9	1.5	0.5	1.8	2.0	1.5	10.0	2.8	0.169	0.610	1.70
24	34.3	2.9	1.4	0.4	1.6	2.0	1.4	9.6	2.5	0.156	0.597	1.51
25	31.4	2.9	1.3	0.4	1.5	2.0	1.2	9.2	2.3	0.144	0.583	1.33
26	28.6	2.9	1.1	0.4	1.3	2.0	1.1	8.8	2.1	0.133	0.571	1.18
27	25.7	2.9	1.0	0.3	1.2	2.0	1.0	8.5	1.9	0.123	0.558	1.04
28	22.9	2.9	0.9	0.3	1.1	2.0	0.9	8.1	1.7	0.113	0.545	0.91
29	20.0	2.9	0.8	0.3	0.9	2.0	0.8	7.7	1.5	0.104	0.533	0.80
30	17.1	2.9	0.7	0.2	0.8	2.0	0.7	7.3	1.3	0.096	0.522	0.70
31	14.3	2.9	0.6	0.2	0.7	2.0	0.6	6.9	1.2	0.089	0.510	0.61
32	11.4	2.9	0.5	0.1	0.5	2.0	0.5	6.5	1.1	0.082	0.499	0.53
33	8.6	2.9	0.3	0.1	0.4	2.0	0.3	6.1	0.9	0.076	0.488	0.46
34	5.7	2.9	0.2	0.1	0.3	2.0	0.2	5.7	0.8	0.070	0.477	0.39
35	2.9	2.9	0.1	.0	0.1	2.0	0.1	5.3	0.7	0.064	0.466	0.34
Sum		100.00	72.0	22.9	85.0	70.0	71.5	421.5	219.2	12.131	24.515	181.51

Capital Charge Rate (Levelization Factor)

Nominal (Present Value Sum/Nominal Discount Factors Sum) 14.96

Normalized (Divided by Initial Asset Base) 0.1496

Real (Present Value Sum/Real Discount Factors Sum) 7.40

Normalized (Divided by Initial Asset Base) 0.0740

26-10115

TABLE E.16
CHECK OF EQUALITY OF PRESENT VALUES
(Constant Dollars)

Year	Discount Factors	Capital Charges		Discounted Capital Charges	
		Actual	Levelized	Actual	Levelized
1	1.000	18.8	7.4	18.8	7.4
2	0.978	17.4	7.4	17.0	7.2
3	0.956	16.0	7.4	15.3	7.1
4	0.935	14.8	7.4	13.8	6.9
5	0.914	13.7	7.4	12.5	6.8
6	0.894	12.6	7.4	11.2	6.6
7	0.874	11.6	7.4	10.1	6.5
8	0.855	10.7	7.4	9.1	6.3
9	0.836	9.8	7.4	8.2	6.2
10	0.817	9.0	7.4	7.4	6.0
11	0.799	8.3	7.4	6.6	5.9
12	0.781	7.6	7.4	5.9	5.8
13	0.764	7.0	7.4	5.3	5.7
14	0.747	6.4	7.4	4.8	5.5
15	0.730	5.9	7.4	4.3	5.4
16	0.714	5.4	7.4	3.8	5.3
17	0.698	4.9	7.4	3.4	5.2
18	0.683	4.5	7.4	3.1	5.1
19	0.668	4.1	7.4	2.7	4.9
20	0.653	3.7	7.4	2.4	4.8
21	0.638	3.4	7.4	2.2	4.7
22	0.624	3.1	7.4	1.9	4.6
23	0.610	2.8	7.4	1.7	4.5
24	0.597	2.5	7.4	1.5	4.4
25	0.583	2.3	7.4	1.3	4.3
26	0.571	2.1	7.4	1.2	4.2
27	0.558	1.9	7.4	1.0	4.1
28	0.545	1.7	7.4	0.9	4.0
29	0.533	1.5	7.4	0.8	3.9
30	0.522	1.3	7.4	0.7	3.9
31	0.510	1.2	7.4	0.6	3.8
32	0.499	1.1	7.4	0.5	3.7
33	0.488	0.9	7.4	0.5	3.6
34	0.477	0.8	7.4	0.4	3.5
35	0.466	0.7	7.4	0.3	3.5
Present Value				181.5	181.5

TABLE E.17
EXAMPLE O&M COST LEVELIZATION CALCULATION
(1000 Constant Dollars)

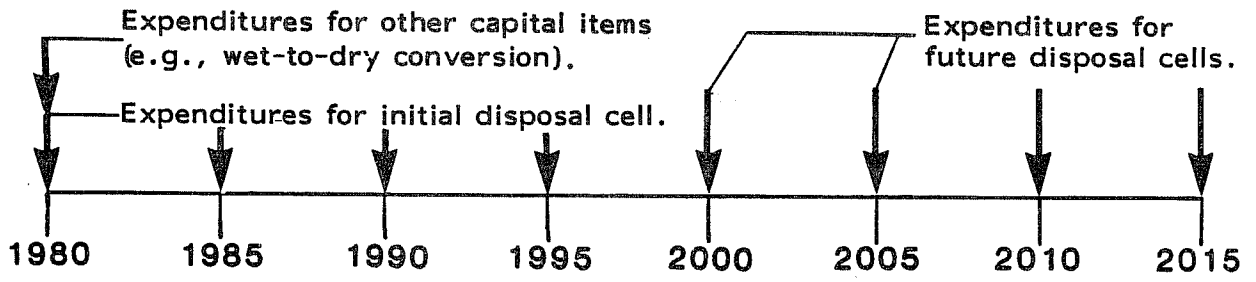
Year	Discount Factors	Actual O&M Costs	Actual Discounted	Levelized O&M Costs	Levelized Discounted
1	1.000	1,021.5	1,021.5	1,425.9	1,425.9
2	0.978	1,021.5	998.8	1,425.9	1,394.3
3	0.956	3,378.9	3,230.6	1,425.9	1,363.3
4	0.935	1,021.5	955.0	1,425.9	1,333.1
5	0.914	1,021.5	933.8	1,425.9	1,303.5
6	0.894	1,021.5	913.0	1,425.9	1,274.5
7	0.874	1,021.5	892.8	1,425.9	1,246.2
8	0.855	1,021.5	873.0	1,425.9	1,218.6
9	0.836	3,378.9	2,823.5	1,425.9	1,191.5
10	0.817	1,021.5	834.6	1,425.9	1,165.1
11	0.799	1,021.5	816.1	1,425.9	1,139.2
12	0.781	1,021.5	798.3	1,425.9	1,113.9
13	0.764	1,021.5	780.3	1,425.9	1,089.2
14	0.747	1,021.5	763.0	1,425.9	1,065.0
15	0.730	3,378.9	2,467.7	1,425.9	1,041.4
16	0.714	1,021.5	729.5	1,425.9	1,018.3
17	0.698	1,021.5	713.3	1,425.9	995.7
18	0.683	1,021.5	697.4	1,425.9	973.6
19	0.668	1,021.5	682.0	1,425.9	951.9
20	0.653	1,021.5	666.8	1,425.9	930.8
21	0.638	3,378.9	2,156.7	1,425.9	910.2
22	0.624	1,021.5	637.5	1,425.9	890.0
23	0.610	1,021.5	623.4	1,425.9	870.2
24	0.597	1,021.5	606.9	1,425.9	850.9
25	0.583	1,021.5	596.0	1,425.9	832.0
26	0.571	1,021.5	582.8	1,425.9	813.5
27	0.558	3,378.9	1,885.0	1,425.9	795.5
28	0.545	1,021.5	557.2	1,425.9	777.8
29	0.533	1,021.5	544.8	1,425.9	760.5
30	0.522	1,021.5	532.7	1,425.9	743.7
31	0.510	1,021.5	520.9	1,425.9	727.2
32	0.499	1,021.5	509.4	1,425.9	711.0
33	0.488	3,378.9	1,647.4	1,425.9	695.2
34	0.477	1,021.5	487.0	1,425.9	679.8
35	0.466	1,021.5	476.2	1,425.9	664.7
Sum	24.515		34,957.1		34,957.1

$$\text{Levelized O\&M} = \frac{34,957.1}{24.515} = 1,425.9$$

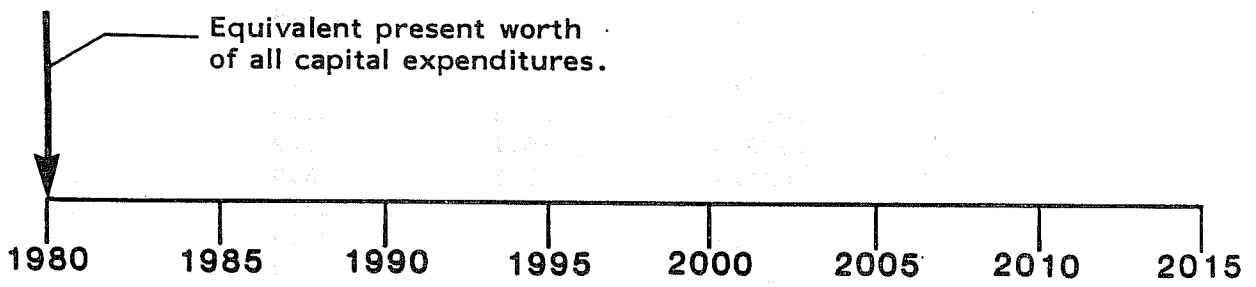
FIGURE E.14

Capital Cost Levelizing for Hazardous Waste Disposal

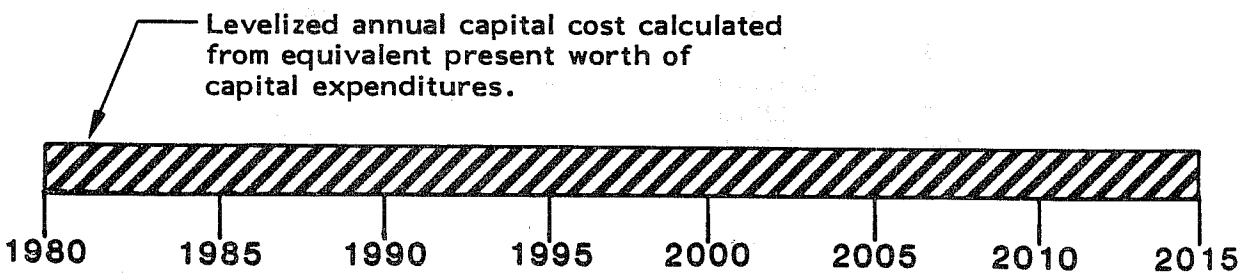
ACTUAL EXPENDITURES



PRESENT WORTH CONVERSION



COST LEVELIZATION



LEGEND

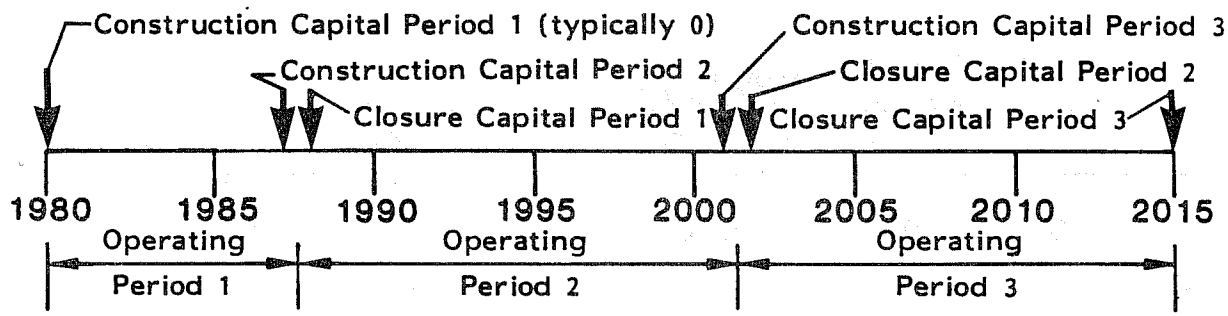
Capital Expenditure (e.g., construction expenditure)

Annual Expenditure (e.g., O&M cost)

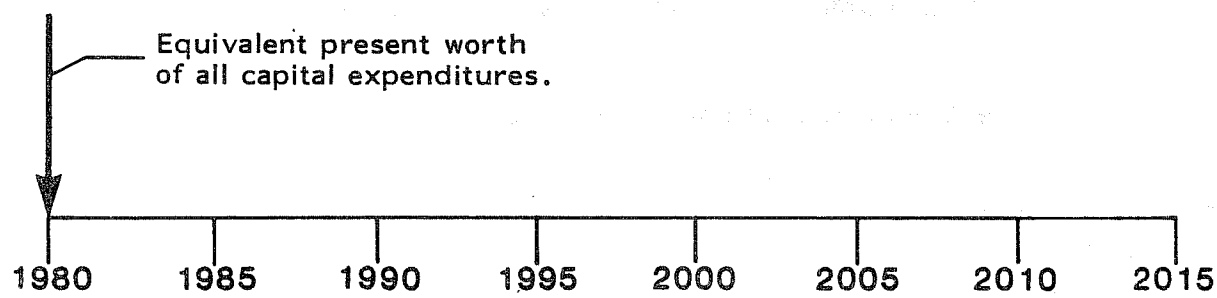
FIGURE E.15

Capital Cost Levelizing for Current Practice and Non-Hazardous Waste Disposal

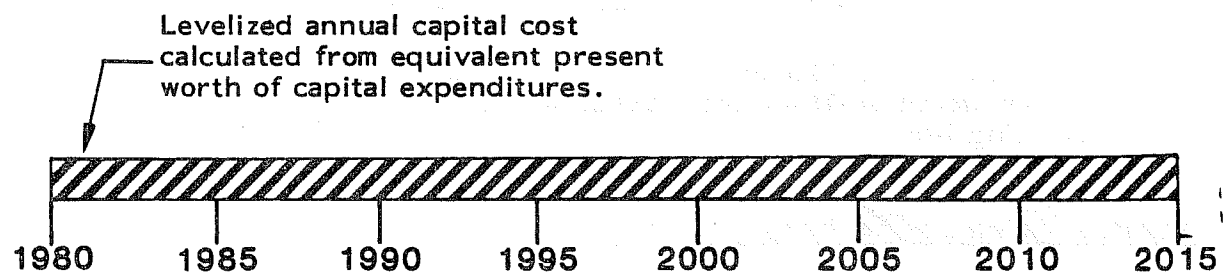
ACTUAL EXPENDITURES



PRESENT WORTH CONVERSION



COST LEVELIZATION



LEGEND

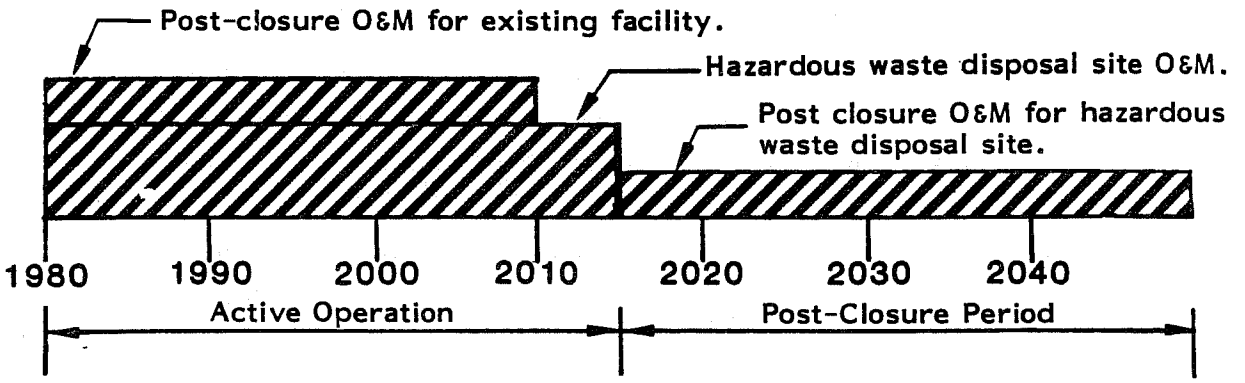
Capital Expenditure (e.g., construction expenditure)

Annual Expenditures (e.g., O&M cost)

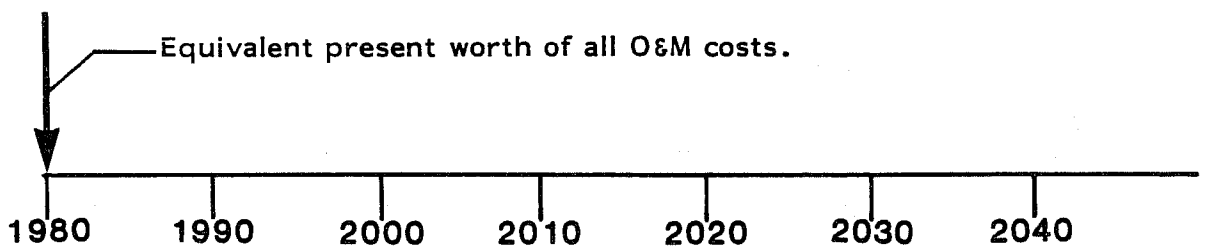
FIGURE E.16

O&M Cost Levelizing for Hazardous Waste Disposal

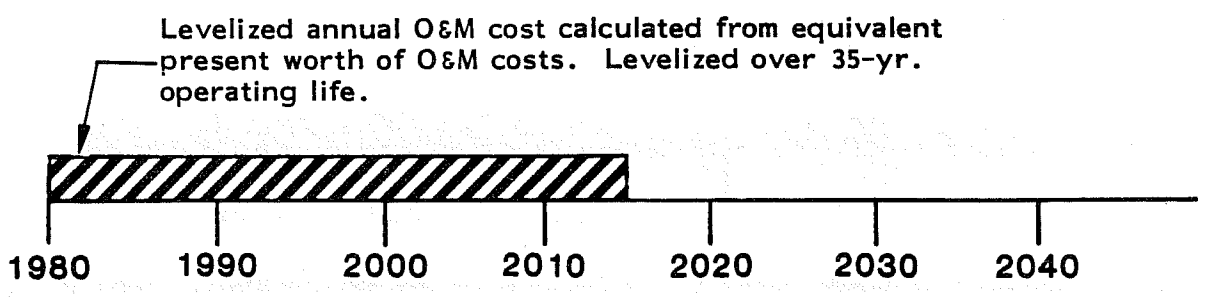
ACTUAL EXPENDITURES



PRESENT WORTH CONVERSION



COST LEVELIZATION



LEGEND

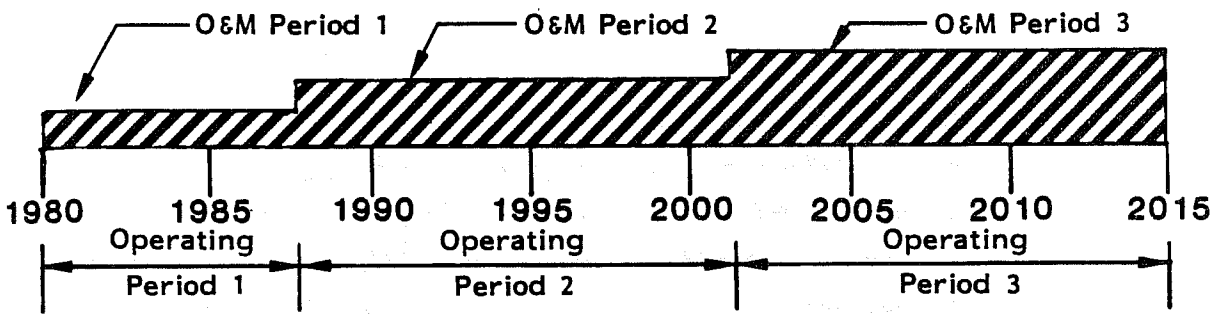
Capital Expenditure (e.g., construction expenditure)

Annual Expenditure (e.g., O&M cost)

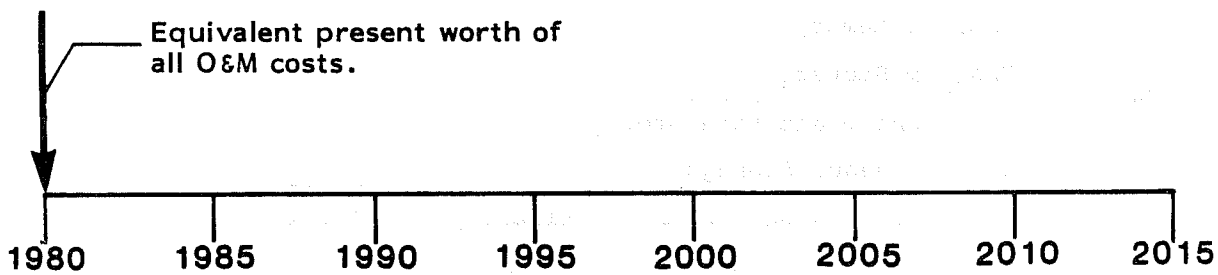
FIGURE E.17

O&M Cost Levelizing for Current Practice and Non-Hazardous Waste Disposal

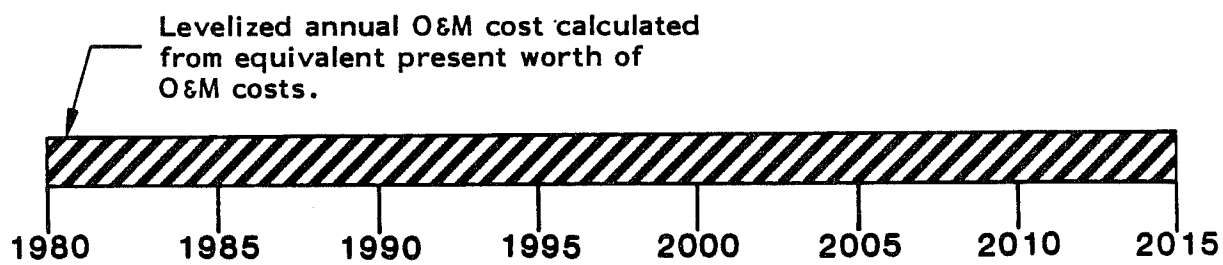
ACTUAL EXPENDITURES



PRESENT WORTH CONVERSION



COST LEVELIZATION



LEGEND

Capital Expenditure (e.g., construction expenditure)

Annual Expenditure (e.g., O&M cost)

5.0 LFDESIGN OUTPUT REPORTS

Example output reports for hazardous minimum and current practice LFDESIGN runs are presented in Tables E.18 and E.19, respectively. References have been included in the left-hand margins to assist readers in becoming familiar with the output format and locating applicable sections of this Appendix. Though not shown, the hazardous maximum output format is the same as hazardous minimum (Table E.18) and the non-hazardous output format is the same as current practice (Table E.19).

6.0 TECHNICAL DESCRIPTION OF LFDESIGN

LFDESIGN is a system of related programs written in the BASIC programming language. They are designed to be run on an IBM Personal Computer with access to expanded memory (hard disk drive) and dot-matrix printer. The approximate storage and operating requirements are as follows:

Active Workspace Capacity	65 K (minimum)
Addressable Memory	
Program Storage	228 K
Permanent Plant Data Storage	3,083 K
Miscellaneous Storage	22 K
Total Addressable Memory Requirement	3,333 K

TABLE E.18

Example Hazardous Minimum LFDESIGN Report

REFERENCE COMMENTS

Input data summary

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code:

Design Mode: Hazardous Min

Date 11-11-1982

Power Plant Information (1980)

Generating capacity of plant	1020 mw
Generating capacity of largest boiler	510 mw

Waste Production Information *

Fly ash	161584 dry ton/yr
Bottom Ash	48396 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	84 lb/cu ft
Bottom ash	90 lb/cu ft

General Disposal Site Information

Site area	463 acres
Percent heavily wooded	25 %
Percent lightly wooded	25 %
Site perimeter	18000 ft
Distance to plant	1 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	3000 ft
Thickness of soils above bedrock	50 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	25 ft

Construction Materials

Clay availability on-site	yes
Sand availibility on-site	no
Sand import distance	5 mi

Climatic Information

Maxieum frost penetration	13.73 in
Total annual precipitation	44.7 in
10-yr, 24-hr rainfall event	6.3 in

---

* note: Average for period 1730-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

TABLE E.18 (cont'd)

REFERENCE COMMENTS

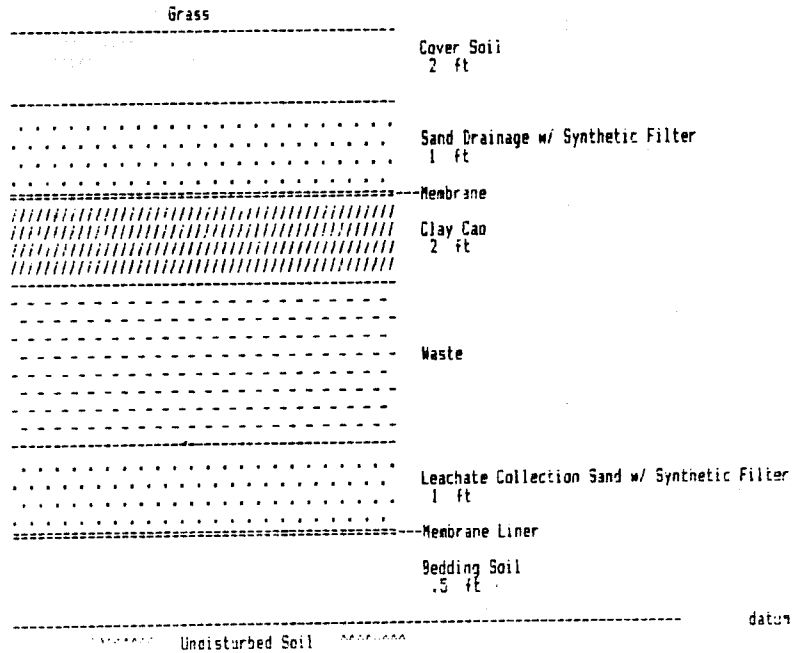
Section 2.1

HAZARDOUS MIN CELL GEOMETRY

Number of cells	7
Cell volume	679900.7 cu yd
Depth of waste at edge of fill	40 ft
Cell dimensions	
length at top	1446 ft
width at top	482 ft
length at bottom	1286 ft
width at bottom	322 ft
Cell dike information	
Dike side slopes	
exterior	3 horiz : 1 vert
interior	2 horiz : 1 vert
Average width at top of dike	20 ft
Total length of exterior dike	11800 ft

Section 2.3
Figures E.4 - E.7
Tables E.2 - E.6

Disposal Cell Cross-Section
Dry Landfill w/ Single Liner



NOTE: Datum is below existing ground surface an average of 19 feet at this site

TABLE E.18 (cont'd)

REFERENCE COMMENTS

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980-2014)

Reference	ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
Section 2.5, Tables E.8, E.9	real estate	463	[acres]	3,252	1,505,676
Section 2.4, Table E.7	clear and grub	334	[acres]	1,425	475,424
	heavy stump removal	83	[acres]	975	81,335
	light stump removal	83	[acres]	565	46,895
	final grading	333	[acres]	591	196,942
Section 2.2	cut & fill non-compacted	953,303	[cy]	1.65	1,578,739
	on-site structural cut/fill	1,598,822	[cy]	2.59	4,116,256
	topsoil removal & stockpile	452,833	[cy]	1.65	744,866
	sand collection zone placmt	485,426	[cy]	9.55	4,635,833
	sand import	485,426	[cy]	6.88	3,341,378
Section 2.4, Table E.7	clay liner/cap placement	474,652	[cy]	5.09	2,428,445
	synthetic membrane	10,639,300	[sf]	0.61	6,458,481
	seeding and mulching -grass	1,613,463	[sy]	0.46	734,577
	gravel stabilization	3,927	[sy]	0.76	2,980
	plastic filter fabric	1,182,145	[sy]	0.78	922,641
	light duty bituminous road	10,832	[lf]	13.75	148,867
	heavy duty bituminous road	399	[lf]	18.84	5,411
	perimeter fencing	16,800	[ft]	13.81	244,550
Section 2.4	riprap, machine placed	175	[sy]	9.88	1,729
	riprap, grouted	9,778	[sy]	83.12	812,758
Section 2.4, Table E.7	plastic pipe, pvc-4"	23,189	[lf]	10.79	250,114
	plastic pipe, pvc-6"	23,244	[lf]	15.53	361,066
	leachate collect sumps	1,400	[lf]	102	142,654
	soil borings	7,501	[lf]	16.26	121,960
	groundwater monitoring wells	827	[lf]	13.01	10,752

CELL CONSTRUCTION COST SUBTOTAL $29,364,220.

Reference			
Section 2.6.1, Table E.10	Leachate Treatment Plant Construction Cost	$2,013,414.	
Section 2.6.2, Tables E.11, E.12	Wet-to-dry conversion cost of Bottom ash	$2,164,039.	
Section 2.6.3	Construction Cost for Closure of Existing Disposal Site(s)		$602,680

CONSTRUCTION COST TOTAL $34,144,350.

Section 2.7

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%
	50%

Other Capital Items = $34,144,350. x 0.50 = $17,072,175.

Permitting Cost $250,000

TOTAL CAPITAL REQUIREMENT = ... $51,466,525.

Section 2.5, Tables E.9

* Site Cost Adjustment Factor (SCAF) = 1.004
Site Unit Cost = SCAF x National-Average Unit Cost

TABLE E.18 (cont'd)

REFERENCE COMMENTS

Section 4.0
Figure E.14

HAZARDOUS MIN CAPITAL COST LEVELIZING SUMMARY

First year expenditure includes capital for leachate treatment plant (if applicable), wet-to-dry conversion (if applicable), permitting, and closure costs for existing disposal site.

Basis of Cost Levelizing Calculations
Nominal Return : 8.4
Inflation Rate : 6.0
Real Return : 2.3

YEAR OF EXPENDITURE	EXPENDITURE IN 1980 $	PRESENT WORTH FACTOR	PRESENT WORTH EXPRESSED IN 1980 $
1980	13,712,530	1.0000	13,712,530
1985	6,292,332	0.8925	5,615,906
1990	6,292,332	0.7966	5,012,472
1995	6,292,332	0.7110	4,473,848
2000	6,292,332	0.6346	3,993,114
2005	6,292,332	0.5664	3,563,977
2010	6,292,332	0.5055	3,180,774

Total Cap Exp $51,466,522

Present Worth of all Capital Costs $39,552,621

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST $2,926,894

TABLE E.18 (cont'd)

REFERENCE COMMENTS

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost ($)	total annual $	comments
Section 2.8.1 Tables E.13				
Ash handling				
Flyash	161,584	3.79	613,059	Dry disposal
Bottom ash	40,396	3.79	153,262	Dry disposal
Total handling			766,312	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	161,584	4.55	735,765	bulk pneumatic tanker 1 mi. haul
Bottom ash	40,396	0.53	21,457	open on road truck (locy) 1 mi. haul
Total transportation			757,221	
Landfill costs				
Flyash	161,584	1.02	165,272	
Bottom ash	40,396	0.95	38,563	
Total landfill cost			203,835	
Section 2.6.1, 2.8.1 Tables E.10, E.13				
Leachate Treatment Plant O and M			$215,103	
Total non-administrative O and M			$1,942,471	

Administrative O&M Cost Items

Section 2.8.2 Table E.14	
Manifesting	$13,971
Groundwater monitoring	$24,585
Inspection	$6,073
Personnel training	$1,381
Non-sudden occurrance insurance	$27,165
General administration	$51,730
Total Annual Administration cost	$124,825
Total annual operation and maintenance cost	$2,067,297

Post closure O&M costs

Section 2.8.3 Table E.15	
Existing site (1980-2010)	$25,650
New site	
Groundwater monitoring	$47,174
Inspection	$12,146
Maintenance	$43,559
Administrative services	$6,070
Total annual post closure cost (2014-2044)	$107,925

TABLE E.18 (cont'd)

REFERENCE COMMENTS

Section 4.0
Figure E.15

HAZARDOUS MIN O&M COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations
Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR	O&M COST EXPRESSED IN 1980 $	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 $	
1980	2,092,947	1.0000	2,092,947	Begin post closure operation and maintenance of existing site
1981	2,092,947	0.9775	2,045,856	
1982	2,092,947	0.9555	1,999,811	
1983	2,092,947	0.9341	1,955,022	
1984	2,092,947	0.9131	1,911,070	
1985	2,092,947	0.8925	1,867,955	
1986	2,092,947	0.8725	1,826,096	
1987	2,092,947	0.8528	1,784,865	
1988	2,092,947	0.8337	1,744,890	
1989	2,092,947	0.8149	1,705,543	
1990	2,092,947	0.7966	1,667,242	
1991	2,092,947	0.7787	1,629,778	
1992	2,092,947	0.7612	1,593,151	
1993	2,092,947	0.7441	1,557,362	
1994	2,092,947	0.7273	1,522,200	
1995	2,092,947	0.7110	1,488,085	
1996	2,092,947	0.6950	1,454,598	
1997	2,092,947	0.6794	1,421,948	
1998	2,092,947	0.6641	1,389,926	
1999	2,092,947	0.6492	1,358,741	
2000	2,092,947	0.6346	1,328,184	
2001	2,092,947	0.6203	1,298,255	
2002	2,092,947	0.6064	1,269,163	
2003	2,092,947	0.5927	1,240,490	
2004	2,092,947	0.5794	1,212,653	
2005	2,092,947	0.5664	1,185,445	
2006	2,092,947	0.5536	1,158,655	
2007	2,092,947	0.5412	1,132,703	
2008	2,092,947	0.5290	1,107,169	
2009	2,092,947	0.5171	1,082,263	
2010	2,092,947	0.5055	1,057,985	End post closure operation and maintenance of existing site
2011	2,067,297	0.4941	1,021,451	
2012	2,067,297	0.4830	998,504	
2013	2,067,297	0.4722	976,178	
2014	2,067,297	0.4616	954,264	
2015	107,925	0.4512	48,696	Begin post closure operation and maintenance
2016	107,925	0.4410	47,595	
2017	107,925	0.4311	46,526	
2018	107,925	0.4214	45,480	
2019	107,925	0.4120	44,465	
2020	107,925	0.4027	43,461	
2021	107,925	0.3936	42,479	
2022	107,925	0.3848	41,530	
2023	107,925	0.3761	40,591	
2024	107,925	0.3677	39,684	
2025	107,925	0.3594	38,788	

(continued next page)

TABLE E.18 (cont'd)

REFERENCE COMMENTS

Section 4.0
Figure E.15

YEAR	O&M COST EXPRESSED IN 1980 $	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 $	
2026	107,925	0.3513	37,914	
2027	107,925	0.3434	37,061	
2028	107,925	0.3357	36,230	
2029	107,925	0.3282	35,421	
2030	107,925	0.3208	34,622	
2031	107,925	0.3136	33,845	
2032	107,925	0.3065	33,079	
2033	107,925	0.2996	32,334	
2034	107,925	0.2929	31,611	
2035	107,925	0.2863	30,899	
2036	107,925	0.2799	30,208	
2037	107,925	0.2736	29,528	
2038	107,925	0.2674	28,859	
2039	107,925	0.2614	28,212	
2040	107,925	0.2555	27,575	
2041	107,925	0.2498	26,960	
2042	107,925	0.2442	26,355	
2043	107,925	0.2387	25,762	
2044	107,925	0.2333	25,179	End post closure operation and maintenance

Total Present Worth of Future Costs : $52,111,400

Sum of Present Worth Factors : 34.3334

Levelized O&M Cost = (Present Worth of all O&M Costs) / (Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST $1,517,805

TABLE E.18 (cont'd)

REFERENCE COMMENTS	HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 39
Figure E.14 →	Levelized Capital Cost $2,926,894
Figure E.15 →	Levelized Operation and Maintenance Costs $1,517,805
Section 2.9 →	Total Levelized Revenue Requirement $4,444,699
	Levelized Revenue Requirement per Ton of Waste Disposed $22.00
	Levelized Revenue Requirement per Cubic Yard of Waste Disposed $25.29

TABLE E.19

Example Current Practice LFDESIGN Report

REFERENCE COMMENTS

Input data summary

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code:

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	1020 MW
Generating capacity of largest boiler	510 MW

Waste Production Information*

Fly ash	58978 dry ton/yr
Bottom Ash	40396 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	70 lb/cu ft
Bottom ash	75 lb/cu ft

---

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

TABLE E.19 (cont'd)

REFERENCE COMMENTS

Section 3.1
Figure E.13

Sections 3.1, 3.2
Tables E.8, E.9

Section 3.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1991

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
CONSTRUCTION COST TOTAL				$0.
Contractor Overhead 15%				
Contractor Profit 10%				
Engineering & Legal Costs 10%				
Contingency 15%				
50%				
Other Capital Items =	$0. x 0.50 =			$0.
CONSTRUCTION CAPITAL REQUIREMENT =				$0.

Closure Cost $72,702

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items) $109,053

* Site cost adjustment factor (SCAF)= 1.004
Site unit cost= SCAF x National Average Unit Cost

TABLE E.19 (cont'd)

REFERENCE COMMENTS

Section 3.1
Figure E.13

Sections 3.1, 3.2
Tables E.8, E.9

Section 3.2

Construction Cost Items for Period 2
1992 - 2008

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	65	[acres]	3,252	211,380
clear and grub	65	[acres]	1,425	92,655
heavy stump removal	32	[acres]	975	31,200
light stump removal	33	[acres]	585	19,317
final grading	56	[acres]	591	33,084
on-site structural cut/fill	321,870	[cy]	2.59	833,888
topsoil placement & grading	24,836	[cy]	1.83	45,499
topsoil removal & stockpile	209,735	[cy]	1.65	345,576
seeding and mulching -grass	80,000	[sy]	0.46	36,422
drainage cap-48"	898	[lf]	51.44	46,189
misc drainage structures	1,523	[is]	1.08	1,651
soil borings	660	[lf]	16.26	10,732
CONSTRUCTION COST TOTAL				$1,707,612.

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%
	50%

Other Capital Items = $1,707,612. x 0.50 = $853,806

CONSTRUCTION CAPITAL REQUIREMENT = $2,561,417.

Closure Cost $0.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items) $0.

* Site cost adjustment factor (SCAF)= 1.084
Site Unit cost= SCAF x National Average Unit Cost

TABLE E.19 (cont'd)

REFERENCE COMMENTS

Section 3.3

Section 3.3
Table E.13

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1991

	quantity (tons)	unit cost ($)	total annual $	comments
Ash handling				
Flyash	58,978	3.79	223,763	Dry disposal
Bottom ash	48,396	2.71	109,473	Wet disposal
Total handling			333,236	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	58,978	4.55	268,553	bulk pneumatic tanker 1 mi. haul
Total transportation			268,553	
Landfill costs				
Flyash	58,978	1.23	72,389	
Total landfill cost			72,389	
Annual operation and maintenance cost			$674,178	

TABLE E.19 (cont'd)

REFERENCE COMMENTS

Section 3.3

Section 3.3
Table E.13

O&M Costs for Period 2
1992 to 2008

	quantity (tons)	unit cost ($)	total annual $	comments
Ash handling				
Flyash	58,978	3.79	223,763	Dry disposal
Bottom ash	40,396	2.71	109,473	Wet disposal
Total handling			333,236	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	58,978	4.55	268,553	bulk pneumatic tanker 1 mi. haul
Total transportation			268,553	
Landfill costs				
Flyash	58,978	1.23	72,389	
Total landfill cost			72,389	
Annual operation and maintenance cost			$674,178	

TABLE E.19 (cont'd)

REFERENCE COMMENTS

Section 3.3

Section 3.3
Table E.13

O&M Costs for Period 3
2009 to 2014

	quantity (tons)	unit cost ($)	total annual $	comments
Ash handling				
Flyash	58,978	3.79	223,763	Dry disposal
Bottom ash	40,396	2.71	109,473	Wet disposal
Total handling			333,236	
Ash excavation				
Bottom ash	40,396	1.65	66,603	
Total excavation			66,603	
Ash transportation				
Flyash	58,978	4.55	268,553	bulk pneumatic tanker 1 mi. haul
Bottom ash	40,396	0.53	21,457	open on road truck (16cy) 1 mi. haul
Total transportation			299,310	
Landfill costs				
Flyash	53,979	1.23	72,389	
Bottom ash	40,396	1.15	46,276	
Total landfill cost			118,665	
Annual operation and maintenance cost			$868,514	

TABLE E.19 (cont'd)

REFERENCE COMMENTS

Section 4.0
Figure E.17

CURRENT PRACTICE O & M COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations
Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR	O&M COST EXPRESSED IN 1980 $	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 $
1980	674,178	1.0000	674,178
1981	674,178	0.9775	659,009
1982	674,178	0.9555	644,177
1983	674,178	0.9341	629,750
1984	674,178	0.9131	615,592
1985	674,178	0.8925	601,704
1986	674,178	0.8723	588,220
1987	674,178	0.8528	574,959
1988	674,178	0.8337	562,062
1989	674,178	0.8149	549,388
1990	674,178	0.7966	537,050
1991	674,178	0.7787	524,982
1992	674,178	0.7612	513,184
1993	674,178	0.7441	501,656
1994	674,178	0.7273	490,330
1995	674,178	0.7110	479,341
1996	674,178	0.6950	468,554
1997	674,178	0.6794	458,037
1998	674,178	0.6641	447,722
1999	674,178	0.6492	437,676
2000	674,178	0.6346	427,833
2001	674,178	0.6203	418,193
2002	674,178	0.6064	408,822
2003	674,178	0.5927	399,585
2004	674,178	0.5794	390,619
2005	674,178	0.5664	381,854
2006	674,178	0.5536	373,225
2007	674,178	0.5412	364,865
2008	674,178	0.5290	356,640
2009	808,514	0.5171	418,083
2010	808,514	0.5055	408,704
2011	808,514	0.4941	399,487
2012	808,514	0.4830	390,512
2013	808,514	0.4722	381,730
2014	808,514	0.4616	373,210

Total Present Worth of Future Costs : $16,350,752

Sum of Present Worth Factors : 24.4192

Levelized O&M Cost = (Present Worth of all O&M Costs) / (Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST $670,000

TABLE E.19 (cont'd)

REFERENCE COMMENTS

Section 3.4

Figure E.16

Figure E.17

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 39
Levelized Capital Cost
$177,874
Levelized Operation and Maintenance Costs
$690,322
Total Levelized Revenue Requirement
$868,196
Levelized Revenue Requirement per Ton of Waste Disposed
$8.74
Levelized Revenue Requirement per Cubic Yard of Waste Disposed
$8.49

APPENDIX F

STATISTICAL ANALYSIS OF RCRA UTILITY COST MODELS

This Appendix describes the linear regression procedures used to develop the RCRA Utility Levelized Cost Models. Data from 23 representative utility plants were used as input for the cost model development. These 23 utility plants were carefully selected to be representative of the utility industry as a whole. The process used to screen and select these utility plants is presented in Section 3 of this report. Specific features of these 23 plants are described in Appendix H. The regression analyses were performed with a widely used commercial statistical package, SSPS/PC + (RF.1). A glossary of output terminology is presented after the figures at the end of this Appendix. References used in this appendix are listed following the glossary.

The independent variable selected for the model was the log base (10) of the 35-year average waste disposal volume expressed in thousands of dry tons and the dependent variable was the log base (10) of the 35 year levelized disposal cost expressed in terms of millions of 1980 dollars. The resulting four models were statistically evaluated for "goodness of fit" using a variety of tools. The results of the SPSS regression and evaluation are provided in Figures F.1 through F.14 and are summarized below.

MODEL EVALUATION

Coefficient of Determination

The Coefficient of Determination (r^2) is a direct measure of the reduction of total variation in the dependent variable (y) attributable to the dependent variable (x) in the model. For the four levelized cost models developed for this study, the r^2 ranged from 0.947 to 0.955 as shown in Figures F.1, F.4, F.7 and F.10. This indicates that approximately 95% of the variability in the levelized cost (y variable) for the

23 sample plants can be accounted for by the models using the waste disposal volume (x variable) as the independent variable. A related statistic, the coefficient of correlation (r), ranged from 0.973 to 0.977. These numbers indicate the models are very effective in describing the data.

Analysis of Variance

By using standard statistical methods (analysis of variance and the F statistic), the significance of the coefficient of the independent variable (B_θ) can be tested. For the four models developed in this study, the F statistic ranged from 375 to 447 with 21 degrees of freedom for the B_0 coefficient. This corresponds to a probability of less than 0.001 that $B_1 = 0$. This indicates that the independent variable is significant to the model at the 99.99% confidence level.

"t"-Test for Significance of B Coefficients

The format of the selected cost model is $y = B_0X^{B_1}$. The student's "t" statistic was used to check the significance of the model regression coefficients, previously identified as B_0 (intercept) and B_1 (slope). If the B_0 coefficient is not significantly different from 0, then the independent variable (x) is not a significant variable that can be used in evaluating the independent variable (y). For B_0, the test evaluates the hypothesis that the regression line passes through the origin (B_0 = 0). For B_1, the test confirms the significance of the F test for the dependent variable. The "t" statistics for the RCRA cost models ranged from 8.5 to 24.8 and from 19.4 to 20.8 for B_0 and B_1, respectively. These numbers correspond to a probabilty of less than 0.001 that any of the coefficients are equal to 0. This indicates that the hypothesis that the regression line passes through the origin is not an acceptable model thus confirming that the independent variable is statistically significant to each of the models.

Residual Analysis

The models developed for this study were developed using linear regression models. Linear regression models are based on the assumption of normal random distribution of the residuals. It is important to verify this assumption through two commonly applied techniques which analyze the distribution of the residuals.

The first technique involved plotting of residuals versus the independent variable. Using this technique, the plots are visually analyzed to determine if any unique or non-random patterns are discernible. This was done for the four models in Figures F.1, F.4, F.7 and F.10. No unique or non-random patterns were identified and the expected distribution was present (most of the residuals grouped close to the residual = 0 axis).

The second technique utilized was the Durbin-Watson test criteria. This test also examines correlation of the residuals with the independent variable. If a correlation exists, there will be groupings of residuals with similar signs. If no correlation exists, then the residuals will change signs too frequently, thus indicating a random distribution. For the four models developed in this study, the Durbin- Watson test statistic ranged from 1.67 to 2.86. These values were evaluated against the corresponding Durbin-Watson test statistic of 1.32 at a 0.025 significance where values greater than the test statistic (1.32) indicate a correlation does not exist. All models were well above the level for a correlation which indicates that the Durbin-Watson test found no evidence of correlation at the 95% confidence level.

FGD Evaluation

Several of the 23 utility plants included in this study were FGD plants. These plants are required to dispose of FGD sludge in addition to the normal combustion ash. Since the levelized disposal cost calculations for the 23 plants assumed that the FGD plant wastes were disposed of in the same manner as ash, it was expected that the FGD plants would not bias the models in any way. This expectation was supported by the residuals analysis. As part of the residuals analysis, non-FGD plant residuals were plotted using a "0" and FGD plant residuals were plotted using a "1" (see Figures F.1, F.4, F.7 and F.10). The resulting pattern of 0's and 1's were then examined. While FGD plants were found to be primarily associated with plants with large waste volumes, as expected, they displayed no apparent pattern with respect to residual sign or magnitude.

Outlier Analysis

Outliers are data points that fall far from their predicted value based on the regression model. Such points are candidates for being

suspect data and should be evaluated more closely to verify that they are correct and appropriate data. The screening of the sample population with respect to the various models for outliers was conducted using "studentized" residuals which normalizes the residuals distribution. This technique basically examines each observation to determine if it is within the confidence interval for a new prediction at that location. This is accomplished by comparing the studentized residual for the observation to the corresponding student's "t" statistic.

For the sample population and model, the "t" statistic criteria that should be used with the studentized residual is 2.086 at the 95% confidence interval and 2.845 at the 99% confidence interval. Using these values, Plant 2 (Case 5) for the current practice model and Plant 10 (Case 14) for the hazardous minimum model had residuals of -2.252 and -2.205, respectively. It is not, however, unexpected to have an observation outside the 95% confidence interval with a sample population of 23. Note that both observations are within the 99% confidence interval and therefore are not excessive outliers. Furthermore, a review of the case histories of these sites (see Appendix H) found no abnormalities with respect to the development of the levelized costs. For these reasons, neither observation was considered to be a suspect observation.

Influence Analysis

Influence analysis is the evaluation of the impact of each observation on the regression model. Highly influential observations exert a disproportionate influence during the regression process and can result in models that are significantly biased with respect to one particular observation. Cook's D statistic, the DFFITS and DFBETAS statistics, and the Mahalanobis distance, were used to evaluate the influence of each observation on the four RCRA levelized cost models.

Cook's D statistic is a normalized measure of the squared distance between the predicted value of an observation and the predicted value of that same observation when the regression is performed without that particular observation. Cook's D statistics were generated for each of the 23 observations and evaluated by using the F statistic for the models at the 0.5 confidence interval. For these conditions, this correponds to a value of 0.72 and defines the boundary at which deleting

the observation from the regression would significantly move the predicted value of the full model (i.e., model with all the observations) to the 50% confidence interval of the reduced model (i.e., model with that observation deleted). The F statistics for the various models and observations in this study were all less than 0.22 except for Plant 4 (Case 1) for the current practice model. The Cook's D statistic for Plant 4 was 1.27. This is significantly higher than 0.72 value used to evaluate the various models and indicates that Plant 4 is a highly influential observation as measured by Cook's D statistic.

DFFITS, as with Cook's D statistic, is a measure of the change of predicted values for an observation when the regression is performed first with the observation and then without the observation. As such, it measures the affect of deleting each observation on the area of the regression curve close to the observation. No absolute criteria values for DFFITS values have been established, but since DFFITS follows distribution similar to the "t" test distribution, an absolute value of 2 or greater is considered to be a large value. Values greater than the "t" statistic for the 50th percentile (0.69) are considered highly significant. As with Cook's D test, all values were less than 0.69 except for Plant 4 (Case 1) for the current practice model. Its DFFITS value is -1.63 which provides supporting evidence that Plant 4 should be considered a highly influential plant.

$DFBETA_0$ and $DFBETA_1$ are similar to DFFITS except they evaluate the impact of each observation on the regression coefficients (i.e., B_0 and B_1). By evaluating the changes to the regression coefficients, the DFBETAs provide insight into the influence of each observation on the entire model, not just the area of the regression curve close to the observation. The criteria used for evaluating the DFBETAs was the same "t" statistic used for DFFITS evaluation. The results were the same. All observations were less than 0.69 except for Plant 4 (Case 1) of the current practice model. The values for Plant 4 were $DFBETA_0 = -1.63$ and $DFBETA_1 = 1.55$. This provides additional evidence that Plant 4 exerts a significant influence on both the regression curve and the model coefficients.

In order to verify the impact of Plant 4 on the Current Practice model that was predicted by the influence statistics, Plant 4 was

deleted from the data set and a new model for the Current Practice scenario was developed and compared to the original model. The impact was significant as shown below:

$$\text{Full Model:} \quad \text{Levelized cost} = 9.78 \times (\text{Avg. Waste Vol.})^{0.922}$$

$$\text{Reduced Model:} \quad \text{Levelized cost} = 14.98 \times (\text{Avg. Waste Vol.})^{0.869}$$

The r^2 for the reduced model dropped slightly from 0.95 to 0.92 but this was not judged significant and is expected since there are fewer observations used in the model devlopment. The remaining model analyses all indicated that the reduced data set model also represented a good fit of the data of interest. See Figure F.13 and Figure F.14 for details.

As a final step in the influence analysis, the data was reviewed to determine the source of Plant 4's strong influence on the regression model. In general, the influence of an observation is a function of the magnitude of its residual and the distance between an observation and the mean of the independent variable. Thus, outliers and extreme observations are likely to be the most influential observations. The observed value of Plant 4's dependent variable of 1.15 is well within the 95% confidence interval of 0.97 to 1.17 and not considered an outlier from that perspective. However, the value of the independent variable for Plant 4 (0.380) is isolated at the low end of independent variable distribution. The affect of this isolation and the resulting leverage applied to the regression model is quantified by the Mahalanobis distance. The Mahalanobis distance for Plant 4 is 8.92 compared to an average distance for all observations of 0.95 and a distance of 4.12 for the next closest observation. This indicates that the influence exerted by Plant 4 is primarily the result of the small magnitude of its independent variable (i.e., small waste volume).

Present Worth Models

Similar analysis and models were developed using present worth as the dependent variable (y) in place of levelized costs to aid in the comparison of results with EPA studies in Sections 4 and 5 of this study. These models also indicated an excellent "goodness of fit" to the data with r^2 values greater than 0.90. Subsequent outlier and

influence analysis did not indicate Plant 4 was highly influential and it was included as a data point for all present worth models.

CONCLUSION

The statistical tests that were applied to the data base found the four regression models to represent a "good fit" of the levelized disposal costs for the 23 plants studied. The Current Practice model, however, was found to be highly biased by Plant 4. The influence was further shown to be primarily the result of large amounts of ash utilized (sold) and thus the small waste volume disposed of by the plant under the current practice scenario. A review of Plant 4's case history found that the small volume of waste was the direct result of the sale of 94% of the plant's ash. The remaining 2.4 thousand tons that were disposed of was less than a fourth the volume of the closest other plant in the study. This made its ash volume uncharacteristically low for power plants in the megawatt size range investigated by this study. It was concluded to use the Current Practice Model developed from the data set from which Plant 4 had been deleted.

SUMMARY

In conclusion, the total levelized annual revenue (LY) can be successfully modeled using log transformations of the levelized revenue data and the total waste disposed. The final models are summarized and shown graphically in Section 5.

CITED REFERENCES

RF.1 SPSS/PC + User's Guide; SPSS Inc.; Chicago, Illinois 1986

GLOSSARY OF SAS STATISTICAL ANALYSIS OUTPUT TERMINOLOGY

A PRED = A predicted is the predicted value with that case deleted.

ADJ R - SQ = The adjusted R^2. ADJ R-SQ is a version of R^2 that has been adjusted for degrees of freedom. It is calculated:
ADJ R - SQ = $1 - (1 - R^2)(n - 1)/dfe$
where dfe is the degrees of freedom for error.

B = Regression coefficients, B_1, is slope and B_0 is the intercept.

BETA = Standardized regression coefficient, BETA = $B_1 \frac{Sx}{Sy}$

CASE # = SPSS case number assigned to each plant, ranked by waste.

COOK's D = COOK's D influence statistic. It is a measure of the influence each data point exerts on the regression parameters.

COST = See Log Cost

DFB_0 and DFB_1 = Scaled measures of the change in each parameter estimate by deleting the ith observation.

DEL RES = Residuals for deleted case.

DEP MEAN = The sample mean of the dependent variable (LOGY).

DEP VARIABLE = Dependent variable used in regression model, (LOGY) total levelized annual revenue.

DF = Degrees of freedom.

DFFITS = A scaled measure of the change in the predicted value for the ith observation by deleting the ith observation. A large value indicates that the observation is very influential in its neighborhood of the LOGX space.

F VALUE = The F VALUE for testing the hypothesis that all parameters are zero except for the intercept. This is formed by dividing the mean square for MODEL by the mean square for error.

INDEPENDENT VARIABLE = $\log_{10}$ of the average annual utility waste disposal quantities expressed as thousands of tons (x)/yr.

INTRVL B LEVER, LEVERAGE = interpreted as the amount of potential leverage exerted by an individual observation based on its location in the independent variable space.

LOWER 95% MEAN = Lower bound of a 95% confidence interval for the expected value (mean) of the dependent variable.

LOWER 95% PREDICT = Lower bound of a 95% confidence interval for an individual prediction. This includes the variance of the error as well as the variance of the parameter estimates.

LOG COST = See Log X

LOG WASTE = See Log Y

LOG X = Log_{10} of the total utility waste disposal quantities expressed as thousands of tons (Independent Variable).

LOG Y = Log_{10} of total levelized annual revenue for waste disposal expressed in thousands of dollars.

MAHALS' D = The Mahalanobis' distance is a measure of the distance of cases from the average indepenent variable value and indicates the influence on the regression line.

MEAN SQUARE = The sum of squares divided by the degrees of freedom.

PARAMETER ESTIMATE = Estimated intercept and regression coefficient for independent model variable.

*PRED, PREDICT, PREDICTED = The model prediction for LY values at each observation.

PRML95 = Predicted mean lower 95% Confidence Bound Limit

PRMU95 = Predicted mean upper 95% Confidence Bound Limit

R - SQUARE = The coefficient of determination, "R^2". It is a measure between 0 and 1 that indicates the portion of the (corrected) total variation that is explained by the model. It is calculated as SS(MODEL) divided by SS(TOTAL).

RESIDUAL = Actual value minus predicted LY values for each observation expressed in a log_{10} format.

RSTUDENT = Studentized residual for influence analyses with the error variance estimated without the "i^{th}" observation.

SER = Standard error.

SER PRED = Standard error of the mean predicted value.

SER RESIDUALS = Standard error of residuals.

SIGNIF F = The probability of getting a greater F statistic than that observed if the hypothesis is true. This is the significance probability.

SIG T = The probability that a t statistic would obtain a greater absolute value than that observed given that the true parameter is zero. This is the two-tailed significance probability.

SOURCE = Sources of variation for ANOVA analyses. Sources include MODEL for the fitted regression, ERROR for the residual error, and C TOTAL for the total variation after correcting for the mean.

*SRESID = Studentized residuals.

STANDARD ERROR = The estimate of the standard deviation of the parameter estimate.

STDL RES = Studentized residuals of deleted case.

STDZ PRD = Standardized predicted values.

STDZ RES = Standardized residual values.

STNT RES = See student residuals.

STUDENT RESIDUAL = Studentized residuals, the residual divided by its standard error.

SUM OF SQUARE = The sum of the squares for the source terms.

T FOR HO:PARAMETER=0 = The t test that the parameter is zero. This is computed as PARAMETER ESTIMATE divided by the STANDARD ERROR.

UPPER 95% MEAN = Upper bound of a 95% confidence interval for the expected value (mean) of the dependent variable.

UPPER 95% PREDICT = Upper bound of a 95% confidence interval for an individual prediction.

VARIABLE = List of variables used as regressions including the name INTERCEP to estimate the intercept parameter.

95% CONFDNCE INTVL B = Upper and lower 95% confidence limits for the B_1, coefficient.

FIGURE F.1

Statistical Analysis of Current Practice Power Curve Model

Dependent Variable: LOGCOST ($1000/yr)
Independent Variable: LOGWASTE (1000 tons/yr)

Multiple R	.97434
R Square	.94933
Adjusted R Square	.94692
Standard Error	.14865

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	8.69410	8.69410
Residual	21	.46400	.02210

F = 393.47958 Signif F = .0000

Variable	B	SE B	95% Confdnce Intrvl B		Beta
LOGWASTE	.92173	.04647	.82510	1.01837	.97434
LOGCOST	.99016	.11653	.74781	1.23250	

FULL MODEL: LY = 0.9902 + 0.9217 * LX
FULL MODEL: SE = 0.14865

Variable	SE Beta	T	Sig T
LOGWASTE	.04912	19.836	.0000
LOGCOST		8.497	.0000

Case#	PLANT	WASTE	LOGWASTE	COST	LOGCOST	PREDICT	RESIDUAL
1	4	2.4	.3802	14	1.1461	1.3406	-.1945
2	8	10.8	1.0334	101	2.0043	1.9427	.0616
3	12	35.7	1.5528	316	2.4997	2.4215	.0782
4	39	99.4	1.9974	868	2.9385	2.8312	.1073
5	2	104.0	2.0172	1493	3.1741	2.8494	.3246
6	20	136.9	2.1364	1205	3.0810	2.9594	.1216
7	16	180.1	2.2555	1005	3.0022	3.0692	-.0670
8	18	193.6	2.2869	1342	3.1278	3.0981	.0297
9	14	227.5	2.3570	1176	3.0704	3.1627	-.0923
10	24	321.3	2.5069	1913	3.2817	3.3009	-.0192
11	28	364.9	2.5622	2889	3.4607	3.3518	.1089
12	11	410.0	2.6128	2195	3.3414	3.3984	-.0570
13	52	440.5	2.6440	1465	3.1658	3.4272	-.2613
14	13	526.8	2.7216	2668	3.4262	3.4988	-.0726
15	10	609.9	2.7852	1919	3.2831	3.5574	-.2743
16	50	642.8	2.8081	5526	3.7424	3.5785	.1640
17	3	685.7	2.8361	4613	3.6640	3.6043	.0597
18	9	769.5	2.8862	2616	3.4176	3.6505	-.2329
19	6	841.3	2.9250	5438	3.7354	3.6862	.0493
20	5	892.9	2.9508	6132	3.7876	3.7100	.0776
21	51	1022.0	3.0095	5431	3.7349	3.7641	-.0292
22	23	1056.4	3.0238	6079	3.7838	3.7773	.0065
23	22	2059.1	3.3137	14313	4.1557	4.0445	.1112

FIGURE F.1 (continued)

Statistical Analysis of Current Practice Power Curve Model

Casewise Plot of Studentized Residual

*: Selected M: Missing

```
          -3.0      0.0      3.0
  Case #  O:........:........:O    LOGCOST      *PRED      *RESID
    1     .    *    .         .      1.15      1.3406      -.1945
    2     .         .*        .      2.00      1.9427       .0616
    3     .         . *       .      2.50      2.4215       .0782
    4     .         . *       .      2.94      2.8312       .1073
    5     .         .      *  .      3.17      2.8494       .3246
    6     .         .  *      .      3.08      2.9594       .1216
    7     .        *.         .      3.00      3.0692      -.0670
    8     .         .*        .      3.13      3.0981       .0297
    9     .       * .         .      3.07      3.1627      -.0923
   10     .         *         .      3.28      3.3009      -.0192
   11     .         . *       .      3.46      3.3518       .1089
   12     .        *.         .      3.34      3.3984      -.0570
   13     .    *    .         .      3.17      3.4272      -.2613
   14     .       * .         .      3.43      3.4988      -.0726
   15     .   *     .         .      3.28      3.5574      -.2743
   16     .         .  *      .      3.74      3.5785       .1640
   17     .         .*        .      3.66      3.6043       .0597
   18     .    *    .         .      3.42      3.6505      -.2329
   19     .         .*        .      3.74      3.6862       .0493
   20     .         . *       .      3.79      3.7100       .0776
   21     .        *.         .      3.73      3.7641      -.0292
   22     .         *         .      3.78      3.7773 6.51601E-03
   23     .         . *       .      4.16      4.0445       .1112
  Case #  O:........:........:O    LOGCOST      *PRED      *RESID
          -3.0      0.0      3.0
```

	Min	Max	Mean	Std Dev	N
*MAHAL	.0079	8.9232	.9565	1.9528	23
*COOK D	.0001	1.2664	.0846	.2609	23
*LEVER	.0004	.4056	.0435	.0888	23

Durbin-Watson Test = 1.67002

Outliers - Studentized Residual

Case #	*SRESID
5	2.25151
15	-1.90021
13	-1.80240
1	-1.76271
18	-1.61998
16	1.13672
6	.83982
23	.79870
11	.75014
4	.74488

Current Practice Case

FIGURE F.1 (continued)

Statistical Analysis of Current Practice Power Curve Model

Case#	STDZ_PRD	SER_PRED	STDZ_RES	STNT_RES	SER_RES	PRML95	PRMU95
1	-2.98717	.09961	-1.30835	-1.76271	.1103	1.133	1.548
2	-2.02941	.07139	.41458	.47267	.1304	1.794	2.091
3	-1.26782	.05074	.52626	.55990	.1397	2.316	2.527
4	-.61601	.03663	.72191	.74488	.1441	2.755	2.907
5	-.58703	.03615	2.18392	2.25151	.1442	2.774	2.925
6	-.41211	.03363	.81804	.83982	.1448	2.889	3.029
7	-.23748	.03190	-.45075	-.46150	.1452	3.003	3.136
8	-.19151	.03158	.19968	.20435	.1453	3.032	3.164
9	-.08872	.03112	-.62080	-.63487	.1454	3.098	3.227
10	.13110	.03127	-.12889	-.13184	.1453	3.236	3.366
11	.21213	.03172	.73287	.75014	.1452	3.286	3.418
12	.28631	.03230	-.38352	-.39291	.1451	3.331	3.466
13	.33202	.03273	-1.75816	-1.80240	.1450	3.359	3.495
14	.44593	.03406	-.48840	-.50176	.1447	3.428	3.570
15	.53918	.03539	-1.84556	-1.90021	.1444	3.484	3.631
16	.57265	.03592	1.10303	1.13672	.1442	3.504	3.653
17	.61381	.03659	.40138	.41412	.1441	3.528	3.680
18	.68725	.03788	-1.56649	-1.61998	.1437	3.572	3.729
19	.74403	.03894	.33136	.34335	.1435	3.605	3.767
20	.78193	.03968	.52198	.54164	.1433	3.627	3.793
21	.86792	.04144	-.19633	-.20444	.1428	3.678	3.850
22	.88900	.04189	.04384	.04569	.1426	3.690	3.864
23	1.31399	.05191	.74842	.79870	.1393	3.937	4.152

Case#	A_PRED	DEL_RES	STDL_RES	COOK_D	MAHAL_D	LEVERAGE
1	1.4991	-.3530	-1.86361	1.2664	8.9232	.4056
2	1.9242	.0801	.46375	.0335	4.1185	.1872
3	2.4111	.0885	.55053	.0207	1.6074	.0731
4	2.8243	.1142	.73673	.0179	.3795	.0172
5	2.8290	.3450	2.52274	.1593	.3446	.0157
6	2.9528	.1282	.83370	.0190	.1698	.0077
7	3.0724	-.0702	-.45267	.0051	.0564	.0026
8	3.0967	.0311	.19962	.0010	.0367	.0017
9	3.1669	-.0965	-.62561	.0092	.0079	.0004
10	3.3018	-.0200	-.12872	.0004	.0172	.0008
11	3.3466	.1141	.74207	.0134	.0450	.0020
12	3.4013	-.0598	-.38485	.0038	.0820	.0037
13	3.4405	-.2747	-1.91315	.0828	.1102	.0050
14	3.5028	-.0766	-.49263	.0070	.1989	.0090
15	3.5739	-.2908	-2.03788	.1085	.2907	.0132
16	3.5683	.1741	1.14511	.0401	.3279	.0149
17	3.6005	.0635	.40580	.0055	.3768	.0171
18	3.6667	-.2490	-1.69007	.0911	.4723	.0215
19	3.6826	.0529	.33602	.0043	.5536	.0252
20	3.7041	.0835	.53231	.0113	.6114	.0278
21	3.7665	-.0316	-.19971	.0018	.7533	.0342
22	3.7768	.0071	.04459	.0001	.7903	.0359
23	4.0290	.1267	.79157	.0443	1.7266	.0785

Current Practice Case

FIGURE F.1 (continued)

Statistical Analysis of Current Practice Power Curve Model

OBS	PLANT	DFFITS	DF $BETA_0$	DF $BETA_1$	LOW95% PREDICTED	UP95% PREDICTED
1	4	1.6311	-1.6295	1.5523	0.9684	1.7128
2	8	0.2615	0.2567	-0.2343	1.5997	2.2857
3	12	0.2254	0.2101	-0.1808	2.0948	2.7482
4	39	0.2194	0.1720	-0.1294	2.5128	3.1497
5	2	0.6666	0.4950	-0.3583	2.5312	3.1676
6	20	0.2195	0.1502	-0.1020	2.6424	3.2764
7	16	0.0772	-0.0189	-0.0025	2.7529	3.3854
8	18	0.0627	0.0481	-0.0341	2.7820	3.4142
9	14	-0.1167	-0.0182	-0.0138	2.8468	3.4786
10	24	-0.0148	0.0252	-0.0292	2.9849	3.6168
11	28	0.1716	0.0382	0.0083	3.0357	3.6680
12	11	-0.0779	0.0303	-0.0498	3.0820	3.7148
13	52	-0.4260	0.0568	-0.1674	3.1106	3.7438
14	13	-0.1127	0.0474	-0.0740	3.1816	3.8160
15	10	-0.4992	0.1483	-0.2700	3.2396	3.8752
16	50	0.2854	-0.0439	0.1178	3.2604	3.8965
17	3	0.1020	-0.0007	0.0289	3.2859	3.9227
18	9	-0.4493	0.1816	-0.2847	3.3314	3.9696
19	6	0.0876	-0.0051	0.0295	3.3666	4.0058
20	5	0.1432	-0.0292	0.0662	3.3900	4.0300
21	51	-0.0641	0.0547	-0.0646	3.4431	4.0850
22	23	0.0068	0.0230	-0.0170	3.4561	4.0985
23	22	0.2825	-0.1516	0.2100	3.7170	4.3720

FIGURE F.2

Current Practice Residual Analysis

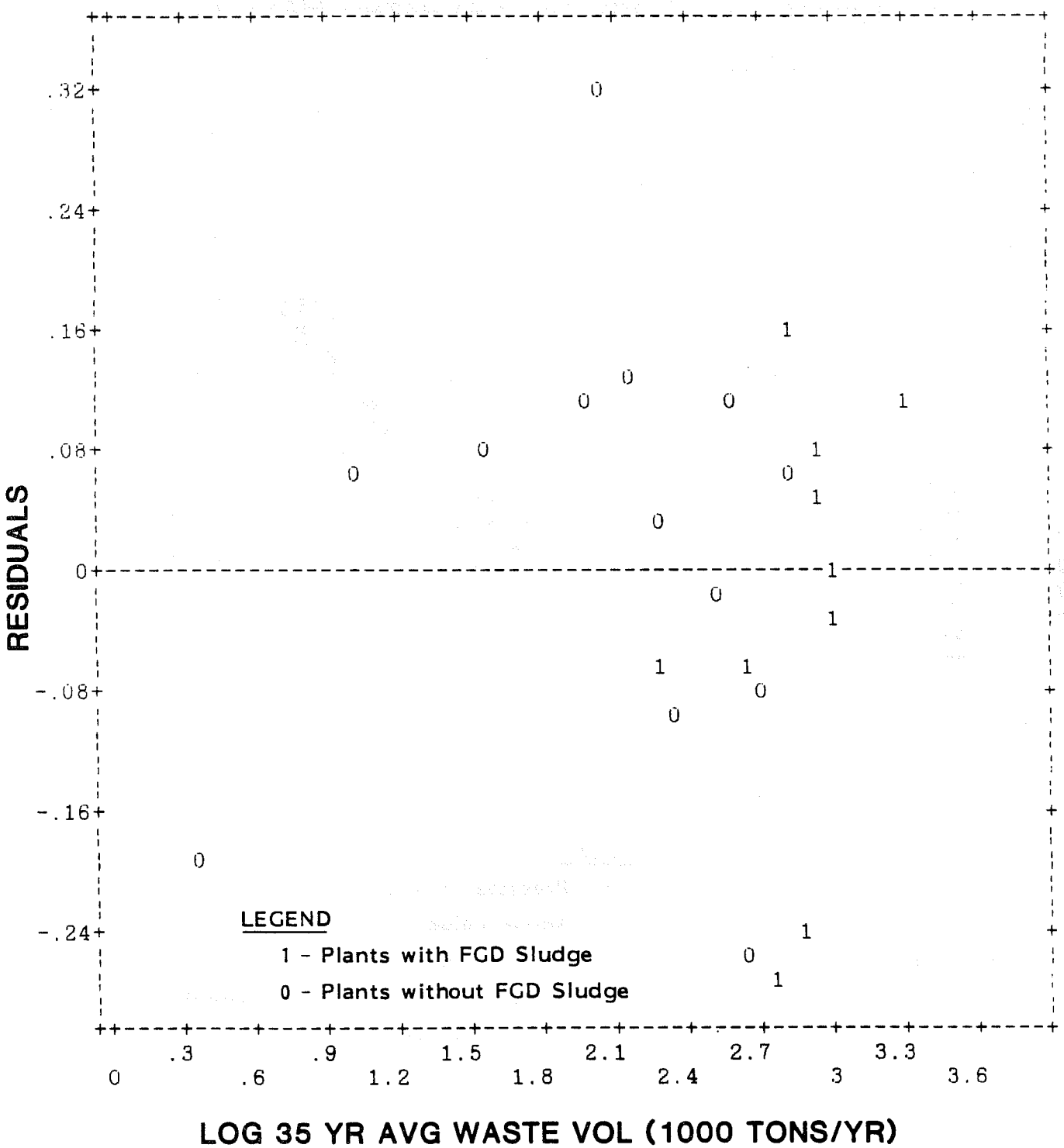


FIGURE F.3

Current Practice Residual Analysis of Actual and Predicted Levelized Revenue

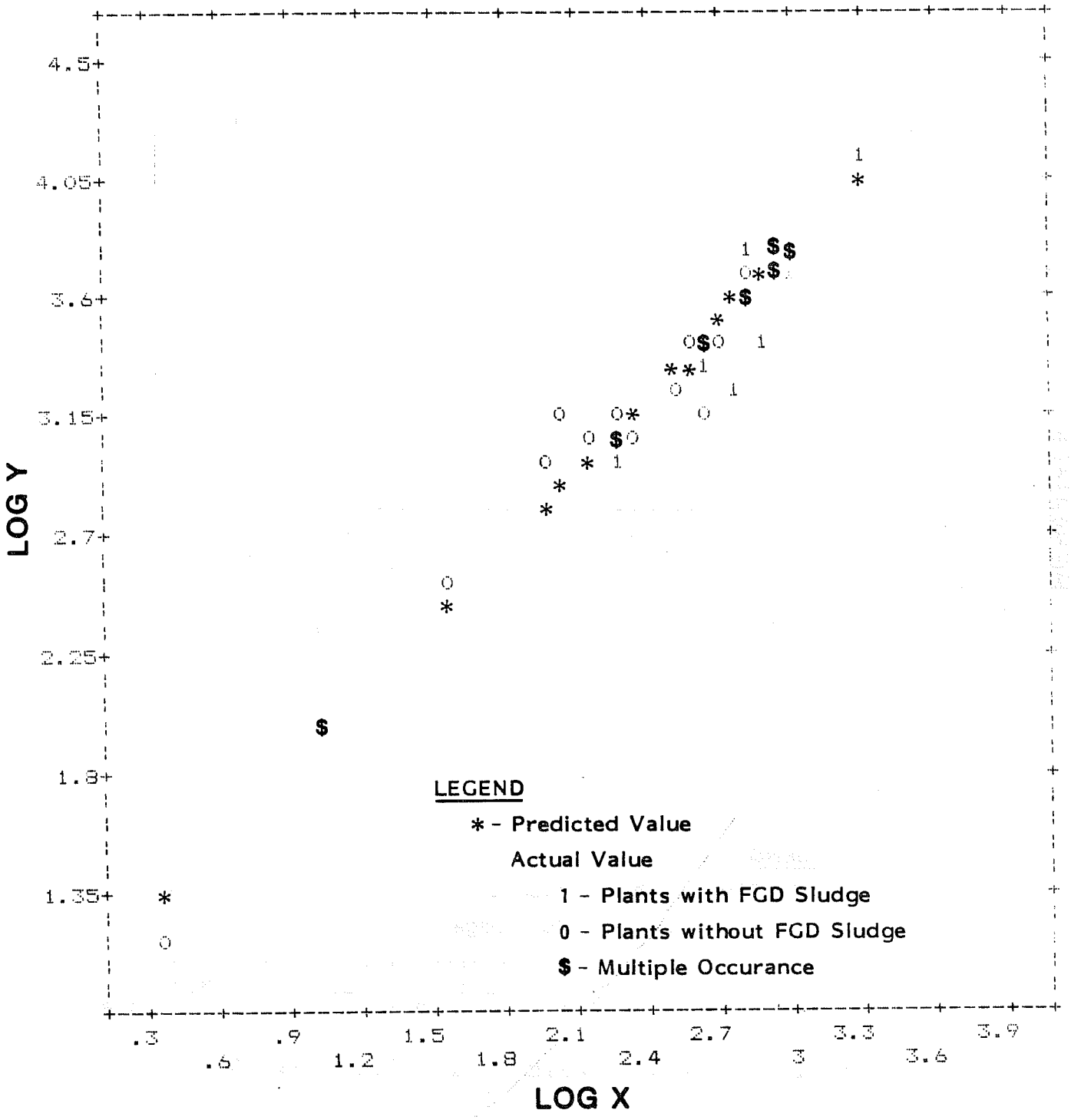


FIGURE F.4

Statistical Analysis of Non-Hazardous Power Curve Model

Dependent Variable: LOGCOST ($1000/yr)
Independent Variable: LOGWASTE (1000 tons/yr)

Multiple R	.97311
R Square	.94695
Adjusted R Square	.94442
Standard Error	.12391

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	5.75545	5.75545
Residual	21	.32243	.01535

F = 374.85176 Signif F = .0000

Variable	B	SE B	95% Confdnce Intrvl B		Beta
LOGWASTE	.74995	.03873	.66940	.83050	.97311
LOGCOST	1.52866	.09714	1.32665	1.73068	

FULL MODEL: LY = 1.5287 + 7.5 * LX
FULL MODEL: SE = 0.12391

Variable	SE Beta	T	Sig T
LOGWASTE	.05026	19.361	.0000
LOGCOST		15.736	.0000

Case#	PLANT	WASTE	LOGWASTE	COST	LOGCOST	PREDICT	RESIDUAL
1	4	2.4	.3802	61	1.7853	1.8138	-.0285
2	8	10.8	1.0334	272	2.4346	2.3037	.1309
3	12	35.7	1.5528	504	2.7024	2.6932	.0092
4	39	99.4	1.9974	1046	3.0195	3.0266	-.0071
5	2	104.0	2.0172	1500	3.1761	3.0414	.1347
6	20	136.9	2.1364	1225	3.0881	3.1309	-.0428
7	16	180.1	2.2555	1225	3.0881	3.2202	-.1321
8	18	193.6	2.2869	2138	3.3300	3.2437	.0863
9	14	227.5	2.3570	1686	3.2269	3.2963	-.0694
10	24	321.3	2.5069	2146	3.3316	3.4087	-.0771
11	28	364.9	2.5622	3416	3.5335	3.4502	.0833
12	11	410.0	2.6128	2165	3.3355	3.4881	-.1527
13	52	440.5	2.6440	1878	3.2737	3.5115	-.2378
14	13	526.8	2.7216	3751	3.5741	3.5698	.0044
15	10	609.9	2.7852	2743	3.4382	3.6175	-.1792
16	50	642.8	2.8081	6304	3.7996	3.6346	.1650
17	3	685.7	2.8361	5279	3.7226	3.6556	.0669
18	9	769.5	2.8862	3215	3.5072	3.6932	-.1860
19	6	841.3	2.9250	7051	3.8483	3.7222	.1260
20	5	892.9	2.9508	7100	3.8513	3.7416	.1096
21	51	1022.0	3.0095	5646	3.7517	3.7856	-.0339
22	23	1056.4	3.0238	7053	3.8484	3.7964	.0520
23	22	2059.1	3.3137	15555	4.1919	4.0138	.1781

Non-Hazardous Case

FIGURE F.4 (continued)

Statistical Analysis of Non-Hazardous Power Curve Model

Casewise Plot of Studentized Residual

*: Selected M: Missing

```
          -3.0      0.0      3.0
  Case #  O:........:........:O    LOGCOST      *PRED      *RESID
    1     .        *.         .       1.79      1.8138      -.0285
    2     .         .   *     .       2.43      2.3037       .1309
    3     .         *         .       2.70      2.6932 9.21411E-03
    4     .         *         .       3.02      3.0266 -7.0708E-03
    5     .         .  *      .       3.18      3.0414       .1347
    6     .        *.         .       3.09      3.1309      -.0428
    7     .      *  .         .       3.09      3.2202      -.1321
    8     .         . *       .       3.33      3.2437       .0863
    9     .       * .         .       3.23      3.2963      -.0694
   10     .       * .         .       3.33      3.4087      -.0771
   11     .         . *       .       3.53      3.4502       .0833
   12     .     *   .         .       3.34      3.4881      -.1527
   13     .   *     .         .       3.27      3.5115      -.2378
   14     .         *         .       3.57      3.5698 4.38637E-03
   15     .     *   .         .       3.44      3.6175      -.1792
   16     .         .   *     .       3.80      3.6346       .1650
   17     .         . *       .       3.72      3.6556       .0669
   18     .    *    .         .       3.51      3.6932      -.1860
   19     .         .  *      .       3.85      3.7222       .1260
   20     .         .  *      .       3.85      3.7416       .1096
   21     .        *.         .       3.75      3.7856      -.0339
   22     .         .*        .       3.85      3.7964       .0520
   23     .         .    *    .       4.19      4.0138       .1781
  Case #  O:........:........:O    LOGCOST      *PRED      *RESID
          -3.0      0.0      3.0
```

	Min	Max	Mean	Std Dev	N
*MAHAL	.0079	8.9232	.9565	1.9528	23
*COOK D	.0000	.2175	.0424	.0548	23
*LEVER	.0004	.4056	.0435	.0888	23

Durbin-Watson Test = 2.12970

Outliers - Studentized Residual

Case #	*SRESID
13	-1.96745
18	-1.55243
23	1.53401
15	-1.48930
16	1.37257
12	-1.26218
2	1.20433
5	1.12043
7	-1.09130
19	1.05380

FIGURE F.4 (continued)

Statistical Analysis of Non-Hazardous Power Curve Model

Case#	STDZ_PRD	SER_PRED	STDZ_RES	STNT_RES	SER_RES	PRML95	PRMU95
1	-2.98717	.08304	-.22978	-.30958	.0920	1.641	1.987
2	-2.02941	.05951	1.05632	1.20433	.1087	2.180	2.427
3	-1.26782	.04230	.07436	.07911	.1165	2.605	2.781
4	-.61601	.03054	-.05706	-.05888	.1201	2.963	3.090
5	-.58703	.03013	1.08679	1.12043	.1202	2.979	3.104
6	-.41211	.02804	-.34506	-.35424	.1207	3.073	3.189
7	-.23748	.02659	-1.06588	-1.09130	.1210	3.165	3.276
8	-.19151	.02633	.69631	.71258	.1211	3.189	3.298
9	-.08872	.02594	-.56043	-.57313	.1212	3.242	3.350
10	.13110	.02607	-.62226	-.63651	.1211	3.355	3.463
11	.21213	.02644	.67258	.68843	.1211	3.395	3.505
12	.28631	.02692	-1.23203	-1.26218	.1210	3.432	3.544
13	.33202	.02729	-1.91916	-1.96745	.1209	3.455	3.568
14	.44593	.02840	.03540	.03637	.1206	3.511	3.629
15	.53918	.02950	-1.44647	-1.48930	.1203	3.556	3.679
16	.57282	.02994	1.33190	1.37257	.1202	3.572	3.697
17	.61381	.03050	.54009	.55724	.1201	3.592	3.719
18	.68725	.03158	-1.50117	-1.55243	.1198	3.628	3.759
19	.74403	.03246	1.01699	1.05380	.1196	3.655	3.790
20	.78193	.03308	.88480	.91812	.1194	3.673	3.810
21	.86792	.03454	-.27325	-.28453	.1190	3.714	3.857
22	.88900	.03492	.41959	.43731	.1189	3.724	3.869
23	1.31399	.04327	1.43743	1.53401	.1161	3.924	4.104

Case#	A_PRED	DEL_RES	STDL_RES	COOK_D	MAHAL_D	LEVERAGE
1	1.8370	-.0517	-.30281	.0391	8.9232	.4056
2	2.2644	.1701	1.21812	.2175	4.1185	.1872
3	2.6920	.0104	.07722	.0004	1.6074	.0731
4	3.0271	-.0075	-.05746	.0001	.3795	.0172
5	3.0330	.1431	1.12765	.0395	.3446	.0157
6	3.1332	-.0451	-.34674	.0034	.1698	.0077
7	3.2266	-.1384	-1.09655	.0287	.0564	.0026
8	3.2396	.0904	.70397	.0120	.0367	.0017
9	3.2995	-.0726	-.56375	.0075	.0079	.0004
10	3.4123	-.0807	-.62725	.0094	.0172	.0008
11	3.4462	.0873	.67956	.0113	.0450	.0020
12	3.4957	-.1602	-1.28132	.0395	.0820	.0037
13	3.5236	-.2499	-2.12594	.0986	.1102	.0050
14	3.5695	.0046	.03549	.0000	.1989	.0090
15	3.6282	-.1900	-1.53684	.0667	.2907	.0132
16	3.6243	.1753	1.40395	.0584	.3279	.0149
17	3.6513	.0712	.54788	.0100	.3768	.0171
18	3.7061	-.1989	-1.61023	.0837	.4723	.0215
19	3.7129	.1353	1.05672	.0409	.5536	.0252
20	3.7332	.1180	.91454	.0323	.6114	.0278
21	3.7885	-.0367	-.27821	.0034	.7533	.0342
22	3.7919	.0565	.42872	.0082	.7903	.0359
23	3.9890	.2029	1.58870	.1634	1.7266	.0785

FIGURE F.4 (continued)

Statistical Analysis of Non-Hazardous Power Curve Model

OBS	PLANT	DFFITS	DF $BETA_0$	DF $BETA_1$	LOW95% PREDICTED	UP95% PREDICTED
1	4	-0.2205	-0.2205	0.2112	1.5035	2.1241
2	8	0.6752	0.6637	-0.6069	2.0178	2.5896
3	12	0.0544	0.0522	-0.0460	2.4209	2.9656
4	39	0.0167	0.0222	-0.0212	2.7612	3.2920
5	2	0.3134	0.2380	-0.1751	2.7762	3.3067
6	20	-0.0555	-0.0197	0.0043	2.8666	3.3951
7	16	-0.2193	-0.0864	0.0294	2.9566	3.4838
8	18	0.1732	0.0985	-0.0565	2.9802	3.5072
9	14	-0.1039	-0.0127	-0.0160	3.0330	3.5596
10	24	-0.1226	0.0117	-0.0446	3.1454	3.6721
11	28	0.1583	0.0384	0.0046	3.1866	3.7137
12	11	-0.2781	0.0354	-0.1080	3.2244	3.7519
13	52	-0.4756	0.0614	-0.1849	3.2476	3.7754
14	13	0.0112	0.0285	-0.0232	3.3053	3.8342
15	10	-0.3778	0.1196	-0.2110	3.3525	3.8824
16	50	0.3489	-0.0593	0.1490	3.3694	3.8997
17	3	0.1372	-0.0101	0.0471	3.3902	3.9211
18	9	-0.4301	0.1757	-0.2741	3.4272	3.9592
19	6	0.2835	-0.0766	0.1469	3.4558	3.9887
20	5	0.2484	-0.0698	0.1312	3.4749	4.0084
21	51	-0.0880	0.0659	-0.0810	3.5180	4.0532
22	23	0.1186	-0.0271	0.0578	3.5286	4.0642
23	22	0.5791	-0.3329	0.4472	3.7408	4.2868

FIGURE F.5

Non-Hazardous Residual Analysis

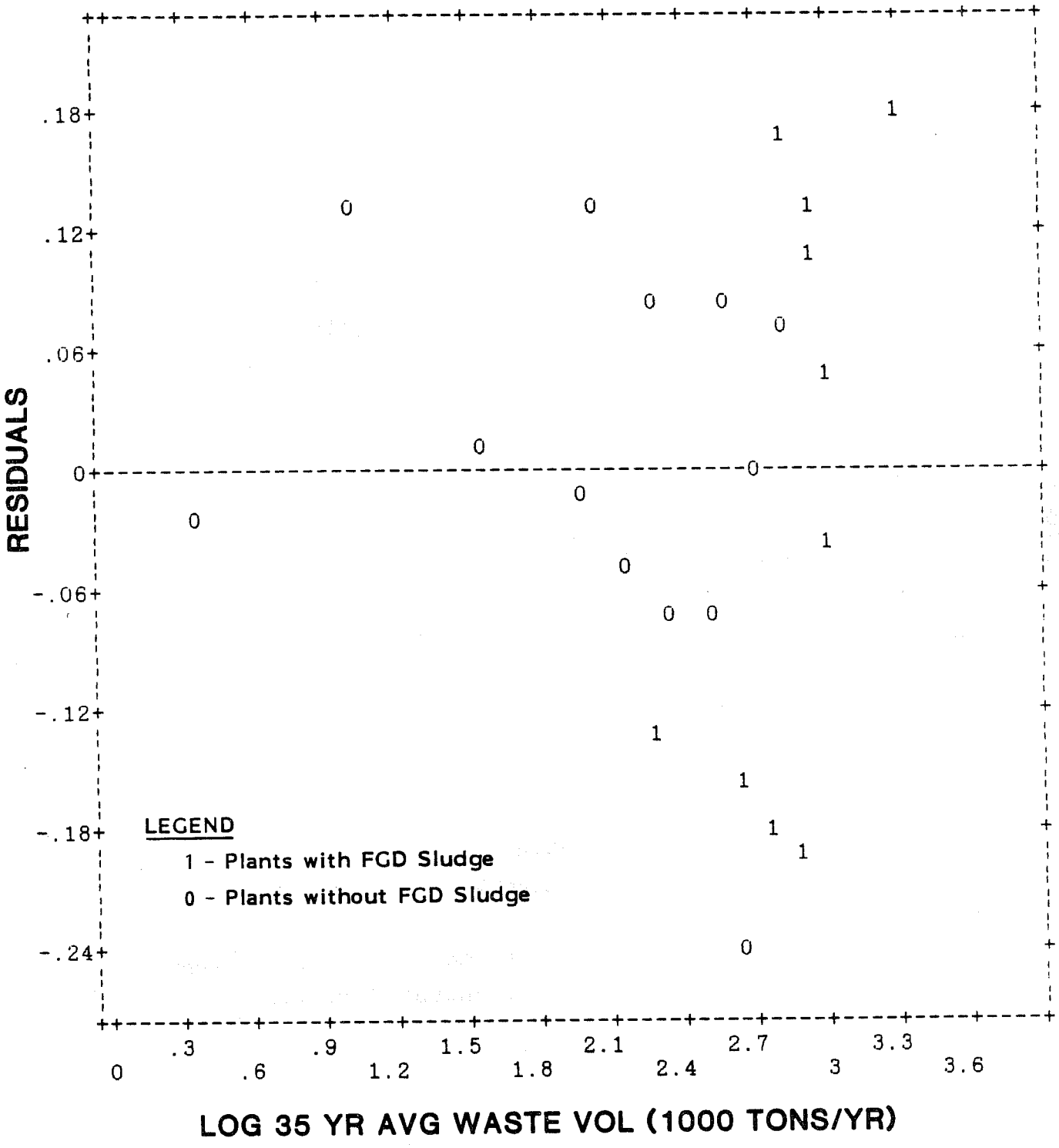


FIGURE F.6

Non-Hazardous Residual Analysis of Actual and Predicted Levelized Revenue

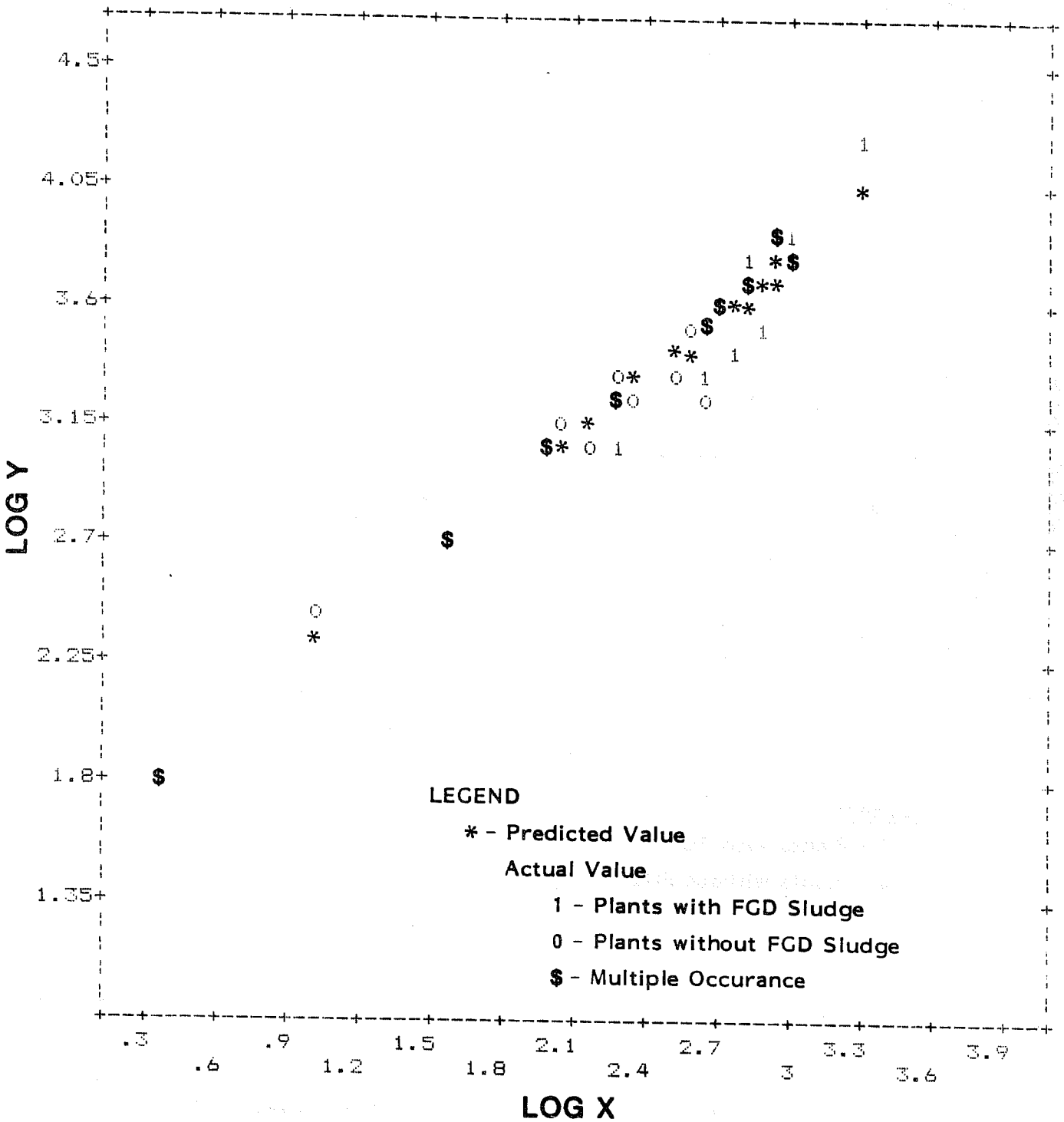


FIGURE F.7

Statistical Analysis of Hazardous Minimum Power Curve Model

Dependent Variable: LOGCOST ($1,000/yr)
Independent Variable: LOGWASTE (1000 tons/yr)

Multiple R	.97733
R Square	.95517
Adjusted R Square	.95303
Standard Error	.07901

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	2.79304	2.79304
Residual	21	.13110	.00624

F = 447.40439 Signif F = .0000

Variable	B	SE B	95% Confdnce Intrvl B		Beta
LOGWASTE	.70846	.03349	.63881	.77812	.97733
LOGCOST	2.04146	.08816	1.85813	2.22478	

FULL MODEL: LY = 2.0415 + 0.7085 * LX
FULL MODEL: SE = 0.07901

Variable	SE Beta	T	Sig T
LOGWASTE	.04621	21.152	.0000
LOGCOST		23.157	.0000

Case#	PLANT	WASTE	LOGWASTE	COST	LOGCOST	PREDICT	RESIDUAL
1	8	15.0	1.1761	813	2.9101	2.8747	.0354
2	4	39.8	1.5999	1417	3.1514	3.1749	-.0235
3	2	104.0	2.0172	3102	3.4916	3.4705	.0211
4	16	180.1	2.2555	3995	3.6015	3.6394	-.0379
5	18	193.6	2.2869	5575	3.7462	3.6616	.0846
6	39	202.0	2.3054	4445	3.6479	3.6747	-.0268
7	20	206.1	2.3141	4850	3.6857	3.6809	.0048
8	14	227.5	2.3570	5334	3.7271	3.7113	.0157
9	28	410.0	2.6128	6903	3.8390	3.8925	-.0535
10	11	418.0	2.6212	6273	3.7975	3.8985	-.1010
11	24	434.1	2.6376	8928	3.9508	3.9101	.0407
12	52	505.1	2.7034	8695	3.9393	3.9567	-.0174
13	12	547.4	2.7383	11416	4.0575	3.9814	.0761
14	10	615.7	2.7894	7045	3.8479	4.0176	-.1697
15	50	676.7	2.8304	12836	4.1084	4.0467	.0617
16	3	755.8	2.8784	11580	4.0637	4.0807	-.0170
17	13	791.7	2.8986	9536	3.9794	4.0950	-.1156
18	5	892.9	2.9508	15202	4.1819	4.1320	.0499
19	6	904.6	2.9565	17356	4.2394	4.1360	.1035
20	23	1056.4	3.0238	15469	4.1895	4.1837	.0057
21	9	1145.4	3.0590	22174	4.3458	4.2086	.1372
22	51	1222.0	3.0871	12540	4.0983	4.2285	-.1302
23	22	2343.4	3.3698	30556	4.4851	4.4289	.0562

Hazardous Minimum Case

FIGURE F.7 (continued)

Statistical Analysis of Hazardous Minimum Power Curve Model

Casewise Plot of Studentized Residual

*: Selected M: Missing

```
          -3.0      0.0      3.0
  Case #   O:........:........:O    LOGCOST      *PRED      *RESID
    1      .         . *       .      2.91      2.8747       .0354
    2      .        *.         .      3.15      3.1749      -.0235
    3      .         .*        .      3.49      3.4705       .0211
    4      .        *.         .      3.60      3.6394      -.0379
    5      .         .  *      .      3.75      3.6616       .0846
    6      .        *.         .      3.65      3.6747      -.0268
    7      .         *         .      3.69      3.6809 4.82877E-03
    8      .         .*        .      3.73      3.7113       .0157
    9      .       * .         .      3.84      3.8925      -.0535
   10      .     *   .         .      3.80      3.8985      -.1010
   11      .         . *       .      3.95      3.9101       .0407
   12      .        *.         .      3.94      3.9567      -.0174
   13      .         .  *      .      4.06      3.9814       .0761
   14      .  *      .         .      3.85      4.0176      -.1697
   15      .         . *       .      4.11      4.0467       .0617
   16      .        *.         .      4.06      4.0807      -.0170
   17      .    *    .         .      3.98      4.0950      -.1156
   18      .         . *       .      4.18      4.1320       .0499
   19      .         .   *     .      4.24      4.1360       .1035
   20      .         *         .      4.19      4.1837 5.73953E-03
   21      .         .    *    .      4.35      4.2086       .1372
   22      .    *    .         .      4.10      4.2285      -.1302
   23      .         . *       .      4.49      4.4289       .0562
  Case #   O:........:........:O    LOGCOST      *PRED      *RESID
          -3.0      0.0      3.0
```

	Min	Max	Mean	Std Dev	N
*MAHAL	.0029	7.8545	.9565	1.7421	23
*COOK D	.0001	.1504	.0402	.0495	23
*LEVER	.0001	.3570	.0435	.0792	23

Durbin-Watson Test = 2.82278

Outliers - Studentized Residual

Case #	*SRESID
14	-2.20506
21	1.81443
22	-1.72657
17	-1.51011
19	1.35647
10	-1.30698
5	1.10415
13	.98663
15	.80350
23	.77378

FIGURE F.7 (continued)

Statistical Analysis of Hazardous Minimum Power Curve Model

Case#	STDZ_PRD	SER_PRED	STDZ_RES	STNT_RES	SER_RES	PRML95	PRMU95
1	-2.80260	.05000	.44828	.57897	.0612	2.771	2.979
2	-1.95996	.03690	-.29796	-.33696	.0699	3.098	3.252
3	-1.13028	.02518	.26718	.28188	.0749	3.418	3.523
4	-.65627	.01984	-.47979	-.49567	.0765	3.598	3.681
5	-.59392	.01927	1.07079	1.10415	.0766	3.622	3.702
6	-.55725	.01896	-.33967	-.34989	.0767	3.635	3.714
7	-.53984	.01882	.06112	.06293	.0767	3.642	3.720
8	-.45454	.01817	.19930	.20478	.0769	3.674	3.749
9	.05403	.01650	-.67681	-.69207	.0773	3.858	3.927
10	.07072	.01652	-1.27810	-1.30698	.0773	3.864	3.933
11	.10338	.01657	.51457	.52627	.0773	3.876	3.945
12	.23419	.01694	-.22066	-.22591	.0772	3.921	3.992
13	.30361	.01725	.96282	.98663	.0771	3.946	4.017
14	.40512	.01783	-2.14817	-2.20506	.0770	3.981	4.055
15	.48674	.01840	.78141	.80350	.0768	4.008	4.085
16	.58218	.01917	-.21501	-.22164	.0766	4.041	4.121
17	.62227	.01953	-1.46327	-1.51011	.0766	4.054	4.136
18	.72614	.02052	.63167	.65411	.0763	4.089	4.175
19	.73737	.02063	1.30940	1.35647	.0763	4.093	4.179
20	.87133	.02206	.07264	.07565	.0759	4.138	4.230
21	.94119	.02286	1.73680	1.81443	.0756	4.161	4.256
22	.99707	.02353	-1.64825	-1.72657	.0754	4.180	4.277
23	1.55932	.03101	.71171	.77378	.0727	4.364	4.493

Case#	A_PRED	DEL_RES	STDL_RES	COOK_D	MAHAL_D	LEVERAGE
1	2.8510	.0591	.56958	.1120	7.8545	.3570
2	3.1815	-.0301	-.32973	.0158	3.8414	.1746
3	3.4681	.0235	.27561	.0045	1.2775	.0581
4	3.6420	-.0405	-.48658	.0083	.4307	.0196
5	3.6563	.0900	1.11024	.0386	.3527	.0160
6	3.6763	-.0285	-.34246	.0037	.3105	.0141
7	3.6806	.0051	.06142	.0001	.2914	.0132
8	3.7104	.0166	.20005	.0012	.2066	.0094
9	3.8950	-.0559	-.68323	.0109	.0029	.0001
10	3.9031	-.1056	-1.33075	.0390	.0050	.0002
11	3.9082	.0425	.51700	.0064	.0107	.0005
12	3.9575	-.0183	-.22074	.0012	.0548	.0025
13	3.9776	.0799	.98597	.0244	.0922	.0042
14	4.0267	-.1788	-2.45480	.1305	.1641	.0075
15	4.0431	.0653	.79648	.0185	.2369	.0108
16	4.0818	-.0181	-.21655	.0015	.3389	.0154
17	4.1025	-.1231	-1.56091	.0742	.3872	.0176
18	4.1284	.0535	.64495	.0155	.5273	.0240
19	4.1284	.1110	1.38588	.0673	.5437	.0247
20	4.1832	.0062	.07384	.0002	.7592	.0345
21	4.1961	.1498	1.92829	.1504	.8858	.0403
22	4.2412	-.1429	-1.81901	.1450	.9942	.0452
23	4.4186	.0665	.76614	.0545	2.4315	.1105

FIGURE F.7 (continued)

Statistical Analysis of Hazardous Minimum Power Curve Model

OBS	PLANT	DFFITS	DF $BETA_0$	DF $BETA_1$	LOW95% PREDICTED	UP95% PREDICTED
1	8	0.4836	0.4780	-0.4559	2.6802	3.0692
2	4	-0.1717	-0.1656	0.1543	2.9935	3.3563
3	2	0.1049	0.0915	-0.0803	3.2980	3.6430
4	16	-0.1147	-0.0780	0.0609	3.4700	3.8089
5	18	0.2877	0.1959	-0.1530	3.4925	3.8308
6	39	-0.0747	-0.0447	0.0327	3.5057	3.8437
7	20	0.0260	0.0201	-0.0166	3.5120	3.8499
8	14	0.0552	0.0364	-0.0280	3.5427	3.8799
9	28	-0.1393	-0.0094	-0.0168	3.7246	4.0604
10	11	-0.2774	-0.0226	-0.0295	3.7306	4.0664
11	24	0.1154	0.0191	0.0026	3.7422	4.0780
12	52	-0.0447	0.0121	-0.0201	3.7886	4.1248
13	12	0.2245	-0.0147	0.0564	3.8132	4.1497
14	10	-0.5659	0.1272	-0.2280	3.8491	4.1861
15	50	0.1925	-0.0416	0.0760	3.8780	4.2154
16	3	-0.0539	0.0285	-0.0367	3.9116	4.2498
17	13	-0.3977	0.1579	-0.2234	3.9257	4.2643
18	5	0.1730	-0.0656	0.0945	3.9622	4.3018
19	6	0.3733	-0.1555	0.2162	3.9661	4.3058
20	23	0.0197	-0.0014	0.0055	4.0131	4.3543
21	9	0.5817	-0.3082	0.3950	4.0375	4.3797
22	51	-0.5693	0.3346	-0.4148	4.0571	4.4000
23	22	0.3224	-0.2294	0.2678	4.2523	4.6054

FIGURE F.8

Hazardous Minimum Residual Analysis

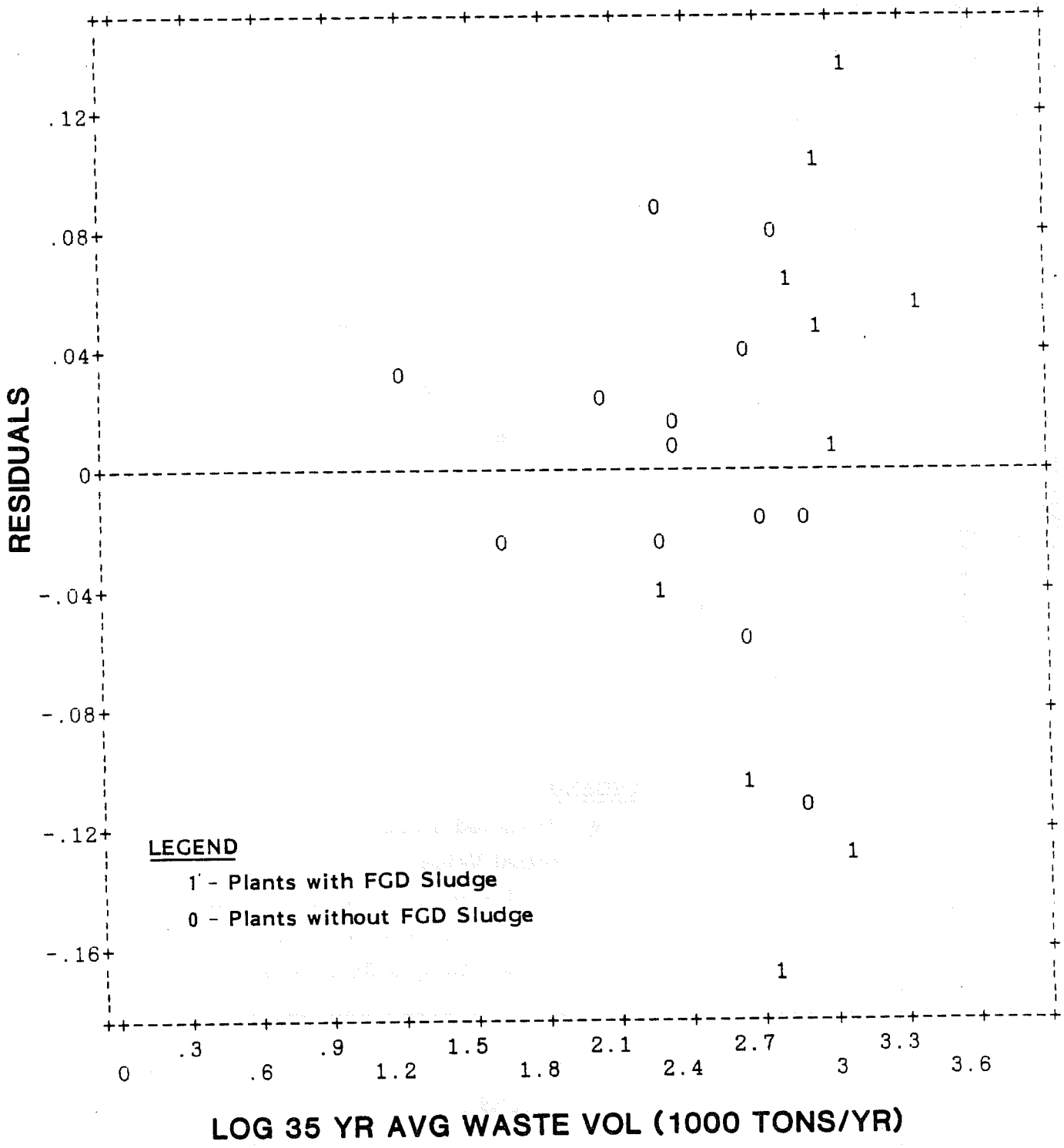


FIGURE F.9

Hazardous Minimum Residual Analysis of Actual and Predicted Levelized Revenue

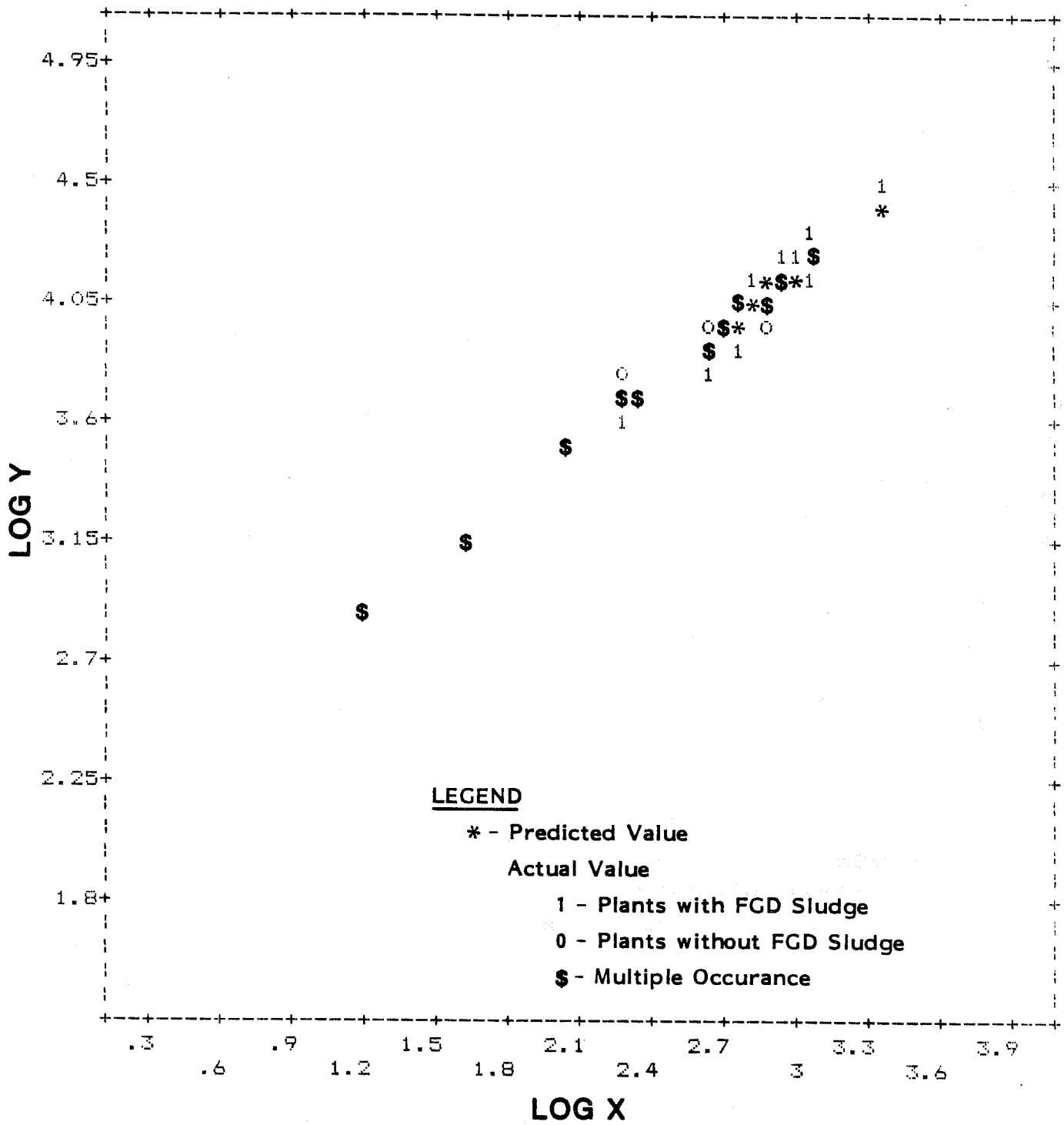


FIGURE F.10

Statistical Analysis of Hazardous Maximum Power Curve Model

Dependent Variable: LOGCOST ($1000/yr)
Independent Variable: LOGWASTE (1000 tons/yr)

Multiple R	.97666
R Square	.95387
Adjusted R Square	.95168
Standard Error	.07824

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	2.65859	2.65859
Residual	21	.12856	.00612

F = 434.27939 Signif F = .0000

Variable	B	SE B	95% Confdnce Intrvl B		Beta
LOGWASTE	.69120	.03317	.62222	.76018	.97666
LOGCOST	2.16714	.08730	1.98559	2.34868	

FULL MODEL: LY = 2.1671 + 0.6912 LX
FULL MODEL: SE = 0.07824

LOGWASTE	.04687	20.839	.0000
LOGCOST		24.825	.0000

Case#	PLANT	WASTE	LOGWASTE	COST	LOGCOST	PREDICT	RESIDUAL
1	8	15.0	1.1761	1069	3.0290	2.9801	.0489
2	4	39.8	1.5999	1703	3.2312	3.2730	-.0418
3	2	104.0	2.0172	3730	3.5717	3.5614	.0103
4	16	180.1	2.2555	4642	3.6667	3.7262	-.0595
5	18	193.6	2.2869	7200	3.8573	3.7478	.1095
6	39	202.0	2.3054	5329	3.7266	3.7606	-.0340
7	20	206.1	2.3141	5739	3.7588	3.7667	-.0078
8	14	227.5	2.3570	6800	3.8325	3.7963	.0362
9	28	410.0	2.6128	8438	3.9262	3.9731	-.0469
10	11	418.0	2.6212	6984	3.8441	3.9789	-.1348
11	24	434.1	2.6376	10819	4.0342	3.9903	.0439
12	52	505.1	2.7034	10835	4.0348	4.0357	-.0009
13	12	547.4	2.7383	13325	4.1247	4.0599	.0648
14	10	615.7	2.7894	9049	3.9566	4.0951	-.1385
15	50	676.7	2.8304	14919	4.1737	4.1235	.0502
16	3	755.8	2.8784	14202	4.1523	4.1567	-.0043
17	13	791.7	2.8986	12764	4.1060	4.1706	-.0646
18	5	892.9	2.9508	18183	4.2597	4.2067	.0529
19	6	904.6	2.9565	20843	4.3190	4.2106	.1083
20	23	1056.4	3.0238	17295	4.2379	4.2572	-.0193
21	9	1145.4	3.0590	25469	4.4060	4.2815	.1245
22	51	1222.0	3.0871	14307	4.1555	4.3009	-.1454
23	22	2343.4	3.3698	35032	4.5445	4.4964	.0481

FIGURE F.10 (continued)

Statistical Analysis of Hazardous Maximum Power Curve Model

Casewise Plot of Studentized Residual

*: Selected M: Missing

```
          -3.0      0.0      3.0
 Case #   O:........:........:O    LOGCOST      *PRED      *RESID
   1      .         . *       .      3.03      2.9801       .0489
   2      .       * .         .      3.23      3.2730      -.0418
   3      .         *         .      3.57      3.5614       .0103
   4      .       * .         .      3.67      3.7262      -.0595
   5      .         .   *     .      3.86      3.7478       .1095
   6      .        *.         .      3.73      3.7606      -.0340
   7      .         *         .      3.76      3.7667 -7.8150E-03
   8      .         .*        .      3.83      3.7963       .0362
   9      .       * .         .      3.93      3.9731      -.0469
  10      .    *    .         .      3.84      3.9789      -.1348
  11      .         . *       .      4.03      3.9903       .0439
  12      .         *         .      4.03      4.0357 -8.9373E-04
  13      .         .  *      .      4.12      4.0599       .0648
  14      .    *    .         .      3.96      4.0951      -.1385
  15      .         . *       .      4.17      4.1235       .0502
  16      .         *         .      4.15      4.1567 -4.3451E-03
  17      .      *  .         .      4.11      4.1706      -.0646
  18      .         . *       .      4.26      4.2067       .0529
  19      .         .   *     .      4.32      4.2106       .1083
  20      .        *.         .      4.24      4.2572      -.0193
  21      .         .    *    .      4.41      4.2815       .1245
  22      .   *     .         .      4.16      4.3009      -.1454
  23      .         . *       .      4.54      4.4964       .0481
 Case #   O:........:........:O    LOGCOST      *PRED      *RESID
          -3.0      0.0      3.0
```

	Min	Max	Mean	Std Dev	N
*MAHAL	.0029	7.8545	.9565	1.7421	23
*COOK D	.0000	.2179	.0455	.0599	23
*LEVER	.0001	.3570	.0435	.0792	23

Durbin-Watson Test = 2.86383

Outliers - Studentized Residual

Case #	*SRESID
22	-1.94630
14	-1.81761
10	-1.76169
21	1.66252
5	1.44289
19	1.43415
17	-.85265
13	.84882
1	.80758
4	-.78523

Hazardous Maximum Case

FIGURE F.10 (continued)

Statistical Analysis of Hazardous Maximum Power Curve Model

Case#	STDZ_PRD	SER_PRED	STDZ_RES	STNT_RES	SER_RES	PRML95	PRMU95
1	-2.80260	.04952	.62529	.80758	.0606	2.877	3.083
2	-1.95996	.03654	-.53378	-.60365	.0692	3.197	3.349
3	-1.13028	.02493	.13181	.13906	.0742	3.510	3.613
4	-.65627	.01965	-.76007	-.78523	.0757	3.685	3.767
5	-.59392	.01909	1.39929	1.44289	.0759	3.708	3.788
6	-.55725	.01878	-.43395	-.44701	.0760	3.722	3.800
7	-.53984	.01863	-.09988	-.10284	.0760	3.728	3.805
8	-.45454	.01799	.46273	.47547	.0761	3.759	3.834
9	.05403	.01634	-.59886	-.61237	.0765	3.939	4.007
10	.07072	.01636	-1.72276	-1.76169	.0765	3.945	4.013
11	.10338	.01641	.56153	.57430	.0765	3.956	4.024
12	.23419	.01678	-.01142	-.01169	.0764	4.001	4.071
13	.30361	.01708	.82834	.84882	.0764	4.024	4.095
14	.40512	.01766	-1.77071	-1.81761	.0762	4.058	4.132
15	.48674	.01822	.64190	.66005	.0761	4.086	4.161
16	.58218	.01899	-.05553	-.05724	.0759	4.117	4.196
17	.62227	.01934	-.82620	-.85265	.0758	4.130	4.211
18	.72614	.02032	.67644	.70047	.0756	4.164	4.249
19	.73737	.02043	1.38439	1.43415	.0755	4.168	4.253
20	.87133	.02185	-.24653	-.25675	.0751	4.212	4.303
21	.94119	.02264	1.59138	1.66252	.0749	4.234	4.329
22	.99707	.02330	-1.85801	-1.94630	.0747	4.252	4.349
23	1.55932	.03070	.61460	.66820	.0720	4.433	4.560

Case#	A_PRED	DEL_RES	STDL_RES	COOK_D	MAHAL_D	LEVERAGE
1	2.9474	.0816	.80065	.2179	7.8545	.3570
2	3.2846	-.0534	-.59428	.0508	3.8414	.1746
3	3.5602	.0115	.13577	.0011	1.2775	.0581
4	3.7302	-.0635	-.77781	.0207	.4307	.0196
5	3.7409	.1164	1.48357	.0659	.3527	.0160
6	3.7627	-.0360	-.43833	.0061	.3105	.0141
7	3.7671	-.0083	-.10039	.0003	.2914	.0132
8	3.7943	.0382	.46653	.0063	.2066	.0094
9	3.9752	-.0490	-.60302	.0085	.0029	.0001
10	3.9851	-.1410	-1.86235	.0709	.0050	.0002
11	3.9882	.0460	.56491	.0076	.0107	.0005
12	4.0358	-.0009	-.01141	.0000	.0548	.0025
13	4.0566	.0681	.84295	.0180	.0922	.0042
14	4.1026	-.1460	-1.93230	.0887	.1641	.0075
15	4.1206	.0531	.65093	.0125	.2369	.0108
16	4.1570	-.0046	-.05587	.0001	.3389	.0154
17	4.1748	-.0688	-.84689	.0236	.3872	.0176
18	4.2029	.0568	.69172	.0177	.5273	.0240
19	4.2027	.1162	1.47361	.0753	.5437	.0247
20	4.2588	-.0209	-.25096	.0028	.7592	.0345
21	4.2701	.1359	1.74107	.1263	.8858	.0403
22	4.3151	-.1595	-2.09802	.1843	.9942	.0452
23	4.4876	.0568	.65914	.0406	2.4315	.1105

FIGURE F.10 (continued)

Statistical Analysis of Hazardous Maximum Power Curve Model

OBS	PLANT	DFFITS	DF $BETA_0$	DF $BETA_1$	LOW95% PREDICTED	UP95% PREDICTED
1	8	0.6730	0.6654	-0.6348	2.7875	3.1727
2	4	-0.3112	-0.2998	0.2788	3.0934	3.4526
3	2	0.0581	0.0507	-0.0445	3.3906	3.7322
4	16	-0.1904	-0.1312	0.1030	3.5584	3.8940
5	18	0.3818	0.2588	-0.2017	3.5803	3.9154
6	39	-0.0976	-0.0601	0.0446	3.5932	3.9280
7	20	-0.0137	-0.0053	0.0026	3.5994	3.9339
8	14	0.1172	0.0732	-0.0547	3.6293	3.9633
9	28	-0.1230	-0.0071	-0.0160	3.8068	4.1393
10	11	-0.3925	-0.0355	-0.0382	3.8126	4.1452
11	24	0.1267	0.0199	0.0039	3.8240	4.1565
12	52	0.0014	0.0099	-0.0094	3.8693	4.2022
13	12	0.1924	-0.0113	0.0470	3.8933	4.2264
14	10	-0.4466	0.1019	-0.1814	3.9283	4.2620
15	50	0.1567	-0.0322	0.0604	3.9564	4.2906
16	3	-0.0140	0.0146	-0.0162	3.9892	4.3242
17	13	-0.2155	0.0901	-0.1252	4.0030	4.3383
18	5	0.1848	-0.0712	0.1018	4.0386	4.3749
19	6	0.3970	-0.1659	0.2304	4.0424	4.3788
20	23	-0.0741	0.0471	-0.0572	4.0882	4.4262
21	9	0.5248	-0.2775	0.3559	4.1121	4.4509
22	51	-0.6574	0.3845	-0.4774	4.1311	4.4707
23	22	0.2762	-0.1960	0.2290	4.3216	4.6712

FIGURE F.11

Hazardous Maximum Residual Analysis

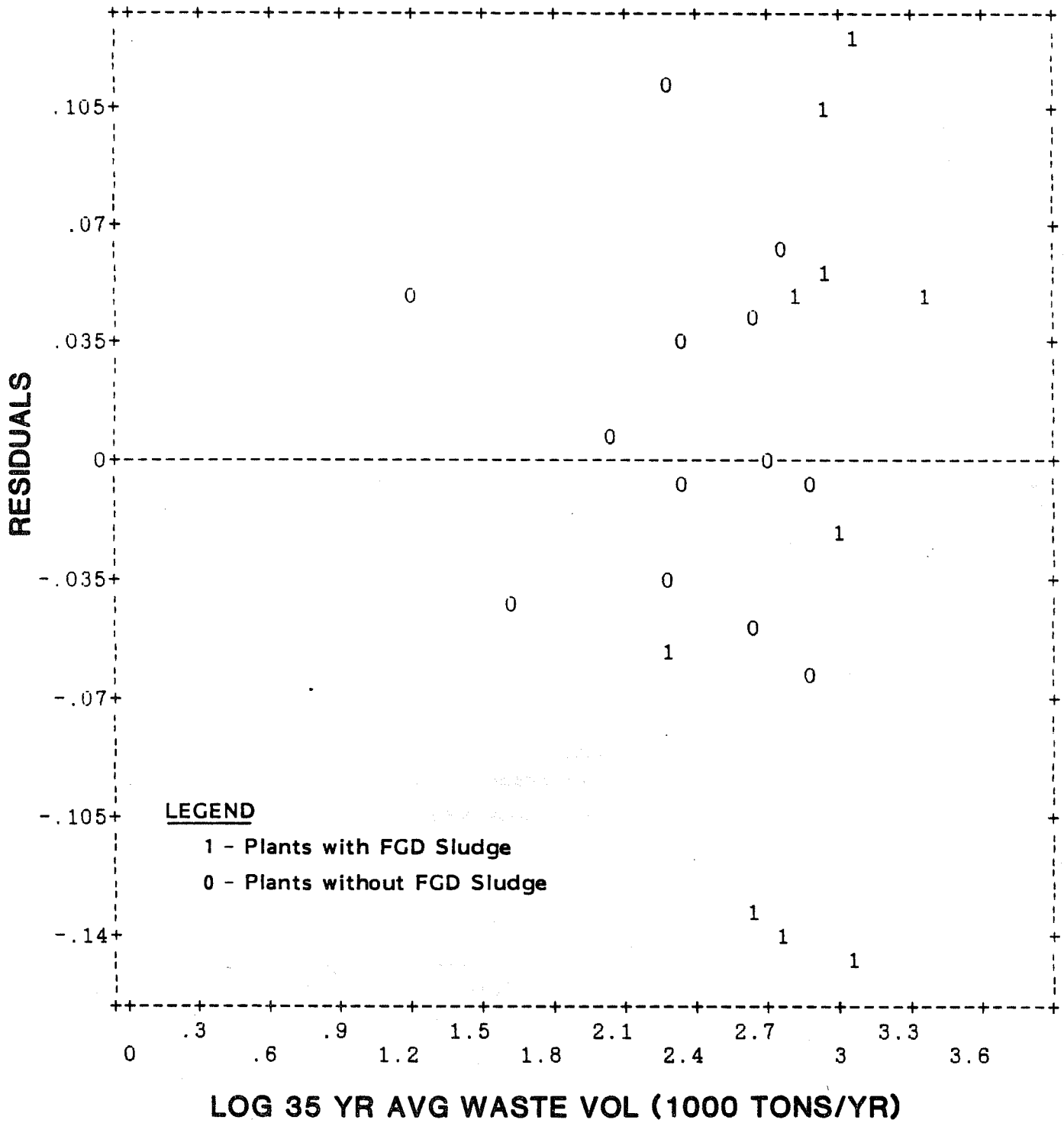


FIGURE F.12

Hazardous Maximum Residual Analysis of Actual and Predicted Levelized Revenue

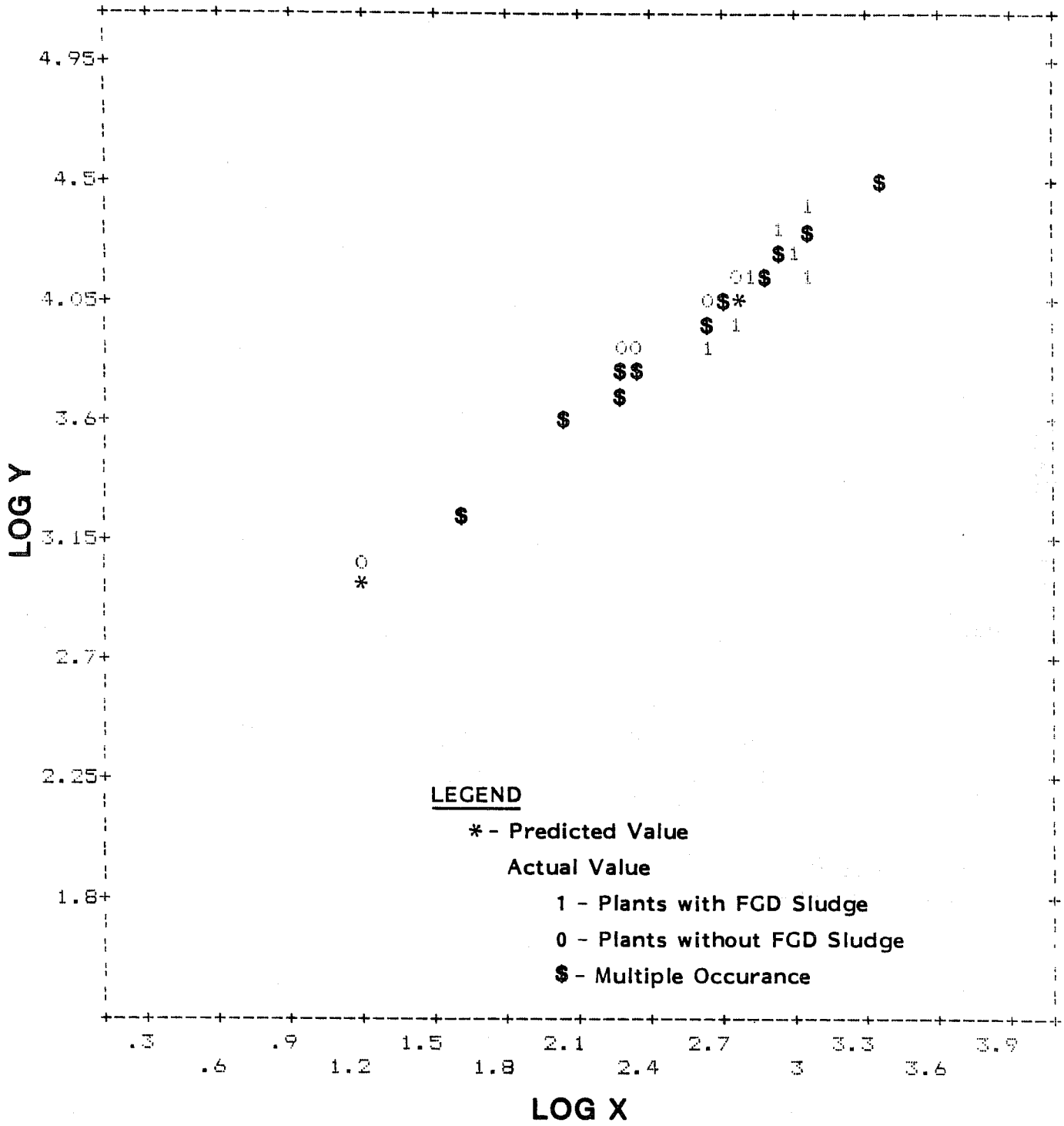


FIGURE F.13

Statistical Analysis of the Revised Current Practice Power Curve Model

Dependent Variable: LOGCOST ($1000/yr)
Independent Variable: LOGWASTE (1000 tons/yr)

Multiple R	.95672
R Square	.91531
Adjusted R Square	.91108
Standard Error	.14060

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	4.27299	4.27299
Residual	20	.39535	.01977

F = 216.16226 Signif F = .0000

Variable	B	SE B	95% Confdnce Intrvl B		Beta
LOGWASTE	.85145	.05791	.73065	.97226	.95672
LOGCOST	1.17540	.14843	.86580	1.48501	

FULL MODEL: LY = 1.1754 + 0.8515 LX
FULL MODEL: SE = 0.1406

Variable	SE Beta	T	Sig T
LOGWASTE	.06507	14.702	.0000
LOGCOST		7.919	.0000

Case#	PLANT	WASTE	LOGWASTE	COST	LOGCOST	PREDICT	RESIDUAL
1	8	10.8	1.0334	101	2.0043	2.0553	-.0510
2	12	35.7	1.5528	316	2.4997	2.4976	.0021
3	39	99.4	1.9974	868	2.9385	2.8761	.0624
4	2	104.0	2.0172	1493	3.1741	2.8929	.2811
5	20	136.9	2.1364	1205	3.0810	2.9945	.0865
6	16	180.1	2.2555	1005	3.0022	3.0959	-.0937
7	18	193.6	2.2869	1342	3.1278	3.1226	.0052
8	14	227.5	2.3570	1176	3.0704	3.1823	-.1119
9	24	321.3	2.5069	1913	3.2817	3.3099	-.0282
10	28	364.9	2.5622	2889	3.4607	3.3570	.1038
11	11	410.0	2.6128	2195	3.3414	3.4001	-.0586
12	52	440.5	2.6440	1465	3.1658	3.4266	-.2608
13	13	526.8	2.7216	2668	3.4262	3.4928	-.0666
14	10	609.9	2.7852	1919	3.2831	3.5469	-.2638
15	50	642.8	2.8081	5526	3.7424	3.5664	.1761
16	3	685.7	2.8361	4613	3.6640	3.5902	.0737
17	9	769.5	2.8862	2616	3.4176	3.6329	-.2153
18	6	841.3	2.9250	5438	3.7354	3.6659	.0696
19	5	892.9	2.9508	6132	3.7876	3.6879	.0997
20	51	1022.0	3.0095	5431	3.7349	3.7378	-.0029
21	23	1056.4	3.0238	6079	3.7838	3.7501	.0338
22	22	2059.1	3.3137	14313	4.1557	3.9968	.1589

Current Practice Case
(Plant 4 Deleted)

FIGURE F.13 (continued)

Statistical Analysis of the Revised Current Practice Power Curve Model

Casewise Plot of Studentized Residual

*: Selected M: Missing

```
          -3.0      0.0      3.0
  Case #  O:........:........:O    LOGCOST       *PRED      *RESID
     1    .        *.         .       2.00      2.0553      -.0510
     2    .         *         .       2.50      2.4976 2.10995E-03
     3    .         .*        .       2.94      2.8761       .0624
     4    .         .     *   .       3.17      2.8929       .2811
     5    .         . *       .       3.08      2.9945       .0865
     6    .       * .         .       3.00      3.0959      -.0937
     7    .         *         .       3.13      3.1226 5.15478E-03
     8    .       * .         .       3.07      3.1823      -.1119
     9    .        *.         .       3.28      3.3099      -.0282
    10    .         . *       .       3.46      3.3570       .1038
    11    .        *.         .       3.34      3.4001      -.0586
    12    .   *     .         .       3.17      3.4266      -.2608
    13    .        *.         .       3.43      3.4928      -.0666
    14    .   *     .         .       3.28      3.5469      -.2638
    15    .         .   *     .       3.74      3.5664       .1761
    16    .         . *       .       3.66      3.5902       .0737
    17    .    *    .         .       3.42      3.6329      -.2153
    18    .         . *       .       3.74      3.6659       .0696
    19    .         . *       .       3.79      3.6879       .0997
    20    .         *         .       3.73      3.7378 -2.9316E-03
    21    .         .*        .       3.78      3.7501       .0338
    22    .         .   *     .       4.16      3.9968       .1589
  Case #  O:........:........:O    LOGCOST       *PRED      *RESID
          -3.0      0.0      3.0
```

	Min	Max	Mean	Std Dev	N
*MAHAL	.0000	7.7695	.9545	1.7095	22
*COOK D	.0000	.2078	.0415	.0562	22
*LEVER	.0000	.3700	.0455	.0814	22

Durbin-Watson Test = 1.80470

Outliers - Studentized Residual

Case #	*SRESID
4	2.09239
14	-1.93377
12	-1.90145
17	-1.58715
15	1.29194
22	1.22934
8	-.81618
10	.75552
19	.73882
6	-.68633

FIGURE F.13 (continued)

Statistical Analysis of the Revised Current Practice Power Curve Model

Case#	STDZ_PRD	SER_PRED	STDZ_RES	STNT_RES	SER_RES	PRMIL95	PRMU95
1	-2.78738	.09062	-.36271	-.47439	.1075	1.867	2.244
2	-1.80694	.06302	.01501	.01679	.1257	2.366	2.629
3	-.96782	.04219	.44406	.46552	.1341	2.788	2.964
4	-.93051	.04140	1.99964	2.09239	.1344	2.807	2.979
5	-.70533	.03697	.61521	.63765	.1356	2.918	3.071
6	-.48052	.03340	-.66667	-.68633	.1366	3.026	3.165
7	-.42134	.03264	.03666	.03769	.1368	3.055	3.190
8	-.28901	.03126	-.79575	-.81618	.1371	3.117	3.247
9	-.00602	.02998	-.20074	-.20546	.1374	3.248	3.372
10	.09829	.03013	.73797	.75552	.1373	3.294	3.420
11	.19378	.03056	-.41703	-.42725	.1372	3.337	3.464
12	.25263	.03096	-1.85477	-1.90145	.1371	3.362	3.491
13	.39927	.03238	-.47350	-.48658	.1368	3.425	3.560
14	.51932	.03395	-1.87656	-1.93377	.1364	3.476	3.618
15	.56241	.03459	1.25224	1.29194	.1363	3.494	3.638
16	.61539	.03543	.52444	.54193	.1361	3.517	3.664
17	.70994	.03705	-1.53104	-1.58715	.1356	3.556	3.710
18	.78304	.03841	.49481	.51439	.1352	3.586	3.746
19	.83183	.03937	.70927	.73882	.1350	3.606	3.770
20	.94252	.04165	-.02085	-.02183	.1343	3.651	3.824
21	.96966	.04223	.24025	.25189	.1341	3.662	3.838
22	1.51678	.05535	1.13005	1.22934	.1292	3.882	4.112

Case#	A_PRED	DEL_RES	STDL_RES	COOK_D	MAHAL_D	LEVERAGE
1	2.0916	-.0872	-.46500	.0800	7.7695	.3700
2	2.4970	.0026	.01636	.0000	3.2650	.1555
3	2.8699	.0686	.45621	.0107	.9367	.0446
4	2.8662	.3078	2.30755	.2078	.8659	.0412
5	2.9881	.0929	.62791	.0151	.4975	.0237
6	3.1015	-.0993	-.67697	.0141	.2309	.0110
7	3.1223	.0054	.03674	.0000	.1775	.0085
8	3.1881	-.1177	-.80910	.0173	.0835	.0040
9	3.3113	-.0296	-.20047	.0010	.0000	.0000
10	3.3520	.1088	.74713	.0137	.0097	.0005
11	3.4030	-.0615	-.41834	.0045	.0376	.0018
12	3.4399	-.2741	-2.04760	.0921	.0638	.0030
13	3.4965	-.0703	-.47710	.0066	.1594	.0076
14	3.5632	-.2802	-2.09033	.1157	.2697	.0128
15	3.5550	.1874	1.31531	.0538	.3163	.0151
16	3.5852	.0787	.53213	.0100	.3787	.0180
17	3.6490	-.2313	-1.65467	.0940	.5040	.0240
18	3.6603	.0752	.50471	.0107	.6131	.0292
19	3.6794	.1082	.73015	.0232	.6919	.0329
20	3.7381	-.0032	-.02128	.0000	.8884	.0423
21	3.7467	.0371	.24590	.0031	.9402	.0448
22	3.9677	.1880	1.24622	.1386	2.3006	.1096

Current Practice Case
(Plant 4 Deleted)

FIGURE F.13 (continued)

Statistical Analysis of the Revised Current Practice Power Curve Model

OBS	PLANT	DFFITS	DF $BETA_0$	DF $BETA_1$	LOW95% PREDICTED	UP95% PREDICTED
1	8	-0.3811	-0.3781	0.3605	1.7074	2.4032
2	12	0.0416	0.0404	-0.0376	2.1771	2.8180
3	39	0.1845	0.1613	-0.1396	2.5707	3.1814
4	2	0.7545	0.6299	-0.5329	2.5880	3.1978
5	20	0.2047	0.1632	-0.1346	2.6921	3.2969
6	16	-0.1354	-0.0653	0.0396	2.7953	3.3965
7	18	0.0359	0.0401	-0.0361	2.8224	3.4228
8	14	-0.1608	-0.0515	0.0191	2.8827	3.4819
9	24	-0.0274	0.0261	-0.0323	3.0109	3.6089
10	28	0.1759	0.0524	-0.0167	3.0579	3.6561
11	11	-0.0846	0.0344	-0.0508	3.1008	3.6993
12	52	-0.4552	0.0621	-0.1522	3.1271	3.7261
13	13	-0.1119	0.0560	-0.0757	3.1926	3.7923
14	10	-0.5222	0.1856	-0.2807	3.2460	3.8478
15	50	0.3290	-0.0685	0.1325	3.2652	3.8675
16	3	0.1327	-0.0135	0.0408	3.2886	3.8918
17	9	-0.4607	0.2251	-0.3020	3.3305	3.9353
18	6	0.1338	-0.0300	0.0567	3.3627	3.9690
19	5	0.2014	-0.0670	0.1046	3.3842	3.9916
20	51	-0.0197	0.0391	-0.0380	3.4328	4.0428
21	23	0.0642	-0.0070	0.0214	3.4447	4.0554
22	22	0.5104	-0.3434	0.4128	3.6825	4.3111

Current Practice Case
(Plant 4 Deleted)

FIGURE F.14

Revised Current Practice Residual Analysis

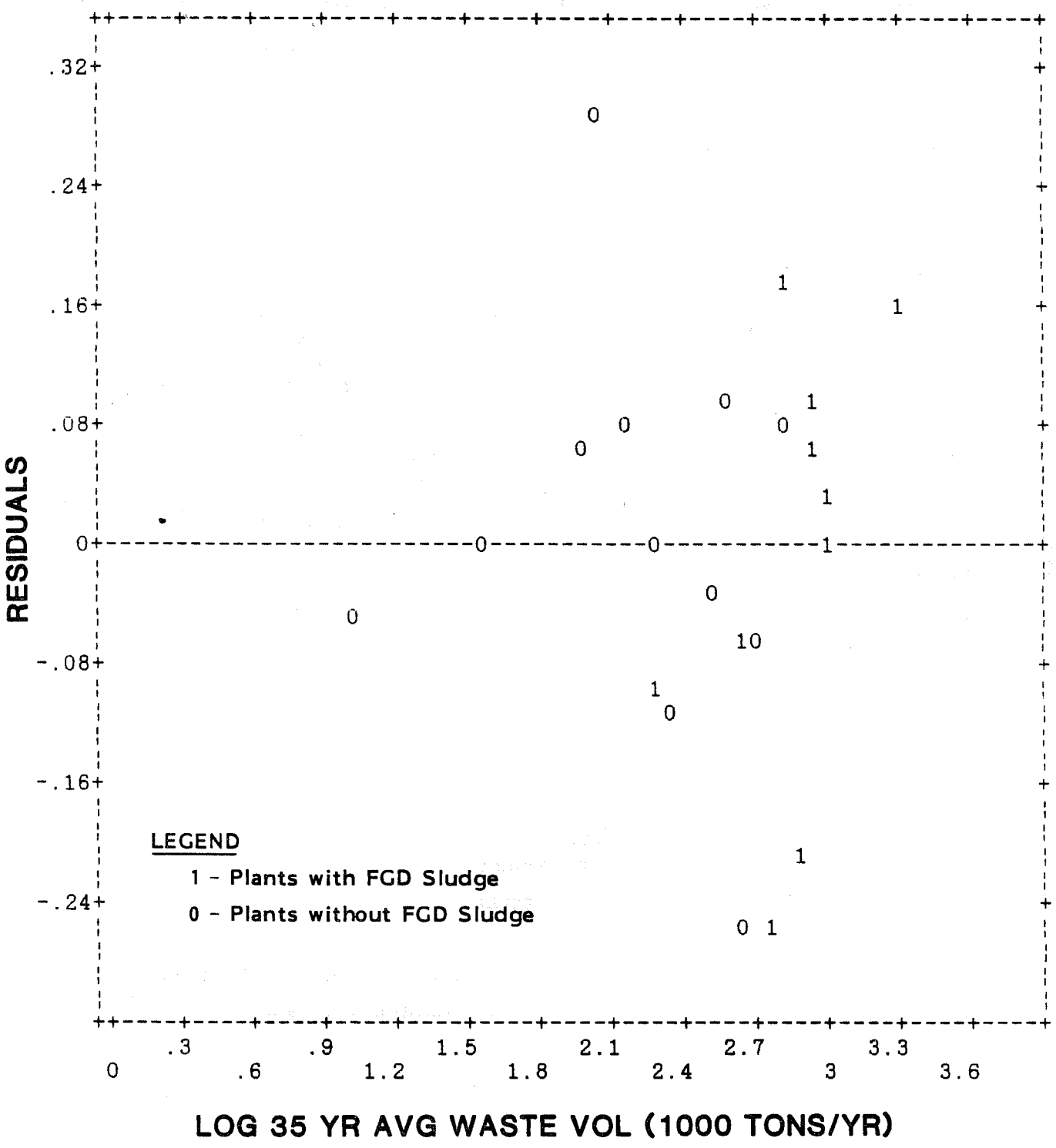
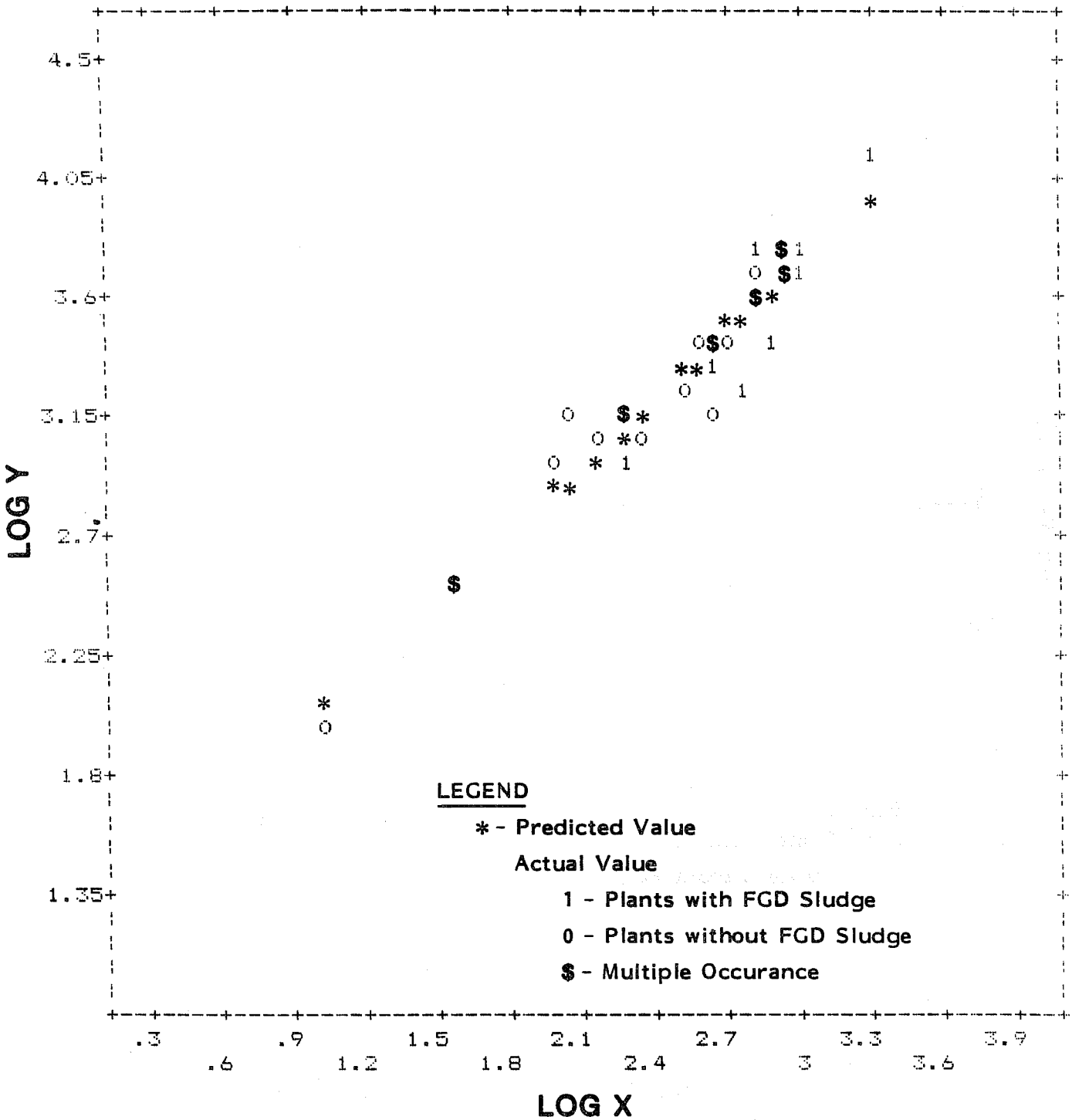


FIGURE F.15

Revised Current Practice Residual Analysis of Actual and Predicted Levelized Revenue



APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
FERC REGION 1										
New Hampshire										
Merrimack	80.90	72.90	88	180	2473	3061	1851	2811	47260	55315
New Hampshire Total	80.90	72.90	88	180	2473	3061	1851	2811	47260	55315
FERC Region 1 Total	80.90	72.90	88	180	2473	3061	1851	2811	47260	55315
FERC REGION 2										
New Jersey										
B.L. England	65.67	65.67	0	0	2133	2650	0	0	40610	47680
Deepwater	1.25	0.90	6	17	129	171	122	233	2278	2839
Down	20.00	0.00	192	357	919	1165	4104	5829	17107	20448
Hudson	82.60	27.10	458	768	2509	3106	9960	13133	47980	56140
Mercer	94.00	15.50	615	996	2750	3396	13461	17305	52710	61554
New Jersey Total	263.52	109.17	1271	2138	8440	10488	27647	36500	160685	188661
New York										
Beebee	22.40	4.20	177	333	996	1260	3781	5407	18576	22167
Carlson	7.20	0.00	80	166	445	575	1689	2585	8138	9879
Dunkirk	190.00	0.00	1305	1933	4528	5524	29012	34970	87928	101599
Goudey	95.40	6.10	686	1097	2779	3431	15056	19175	53279	62205
Greenidge	123.30	10.00	840	1312	3333	4097	18515	23174	64206	74673
Hickling	285.00	124.00	1133	1707	6034	7310	25125	30651	118078	135608
Jennison	106.00	96.00	106	212	2994	3690	2247	3357	57522	67052
Milliken	158.00	30.20	931	1436	3973	4862	20557	25505	76892	89095
R. Huntley	233.20	0.24	1552	2252	5235	6364	34633	41129	102053	117557
Russell	65.40	8.50	468	783	2127	2643	10178	13395	40488	47540
New York Total	1285.90	279.24	7278	11231	32444	39756	160793	199348	627160	727375
Pennsylvania										
Armstrong	208.00	32.50	1220	1821	4827	5880	27079	32829	93910	108363
Brunner Island	510.00	25.00	2898	3903	9113	10930	65486	73721	180277	205235
Cheswick	188.60	0.00	1297	1922	4504	5495	28827	34765	87456	101066
Conemaugh	689.00	29.20	3767	4917	11278	13456	85561	94183	224358	254265
Cromby Gen.	33.60	0.00	299	527	1327	1668	6441	8808	24946	29587
Eddystone	91.30	0.00	699	1116	2694	3328	15349	19516	51604	60289
Elrama	497.50	0.00	2962	3979	8954	10744	66950	75229	177053	201640

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
Pennsylvania (Continued)										
F R Phillips	317.90	0.00	2023	2844	6520	7884	45371	52674	127841	146579
Front Street	43.50	0.00	372	640	1593	1994	8060	10818	30099	35560
Hatfield's Ferry	588.00	60.80	3112	4155	10080	12060	70409	78782	199932	227124
Holtwood	41.00	0.00	354	612	1528	1914	7656	10320	28831	34092
Homer City	874.90	23.20	4682	5954	13357	15872	106806	115401	266916	301411
Honlock	47.50	0.00	401	683	1696	2119	8701	11602	32088	37859
Keystone	767.20	128.00	3667	4801	12170	14494	83236	91835	242600	274494
Mansfield	1579.20	0.00	7920	9461	20297	23873	182621	188632	410085	458984
Martins Creek	111.00	5.00	794	1248	3094	3809	17474	21978	59482	69289
Mitchell	86.10	19.70	533	879	2584	3196	11639	15147	49450	57824
Montour	536.00	91.10	2693	3659	9440	11312	60756	68828	186914	212632
New Castle	94.40	0.00	719	1144	2758	3406	15801	20042	52873	61740
Portland	99.80	11.80	678	1085	2869	3539	14866	18953	55055	64235
Seward	75.46	0.00	595	967	2354	2918	13007	16770	44927	52640
Shawville	236.60	0.00	1573	2279	5289	6428	35103	41640	103132	118775
Sunbury	240.00	50.00	1305	1933	5342	6491	29012	34970	104208	119988
Titus	67.50	30.60	323	566	2175	2701	6987	9490	41429	48622
Warren	37.50	0.00	328	572	1434	1799	7085	9613	27020	31993
Williamsburg	19.30	0.00	186	348	896	1137	3979	5666	16670	19936
Pennsylvania Total	8080.86	506.90	45400	62015	148173	178447	1024262	1162212	2919156	3334222
FERC Region 2 Total	9630.28	895.31	53949	75384	189057	228691	1212702	1398060	3707001	4250258
FERC REGION 3										
Illinois										
Baldwin	455.00	52.00	2476	3397	8405	10101	55754	63617	165922	189217
Coffen	429.00	0.00	2611	3560	8062	9698	58866	66863	158972	181452
Crawford	48.10	10.80	326	570	1711	2137	7053	9572	32382	38198
Dallman	76.30	0.00	600	975	2372	2940	13133	16918	45291	53056
Duck Creek	280.00	0.00	1816	2585	5959	7221	40633	47612	116568	133909
E.D. Edwards	128.50	9.00	879	1365	3432	4215	19392	24178	66164	76902
Fisk	37.60	4.20	297	525	1437	1803	6407	8767	27072	32054
Grand Tower	52.20	49.20	38	86	1813	2261	790	1288	34366	40490
Havana	40.00	0.00	346	601	1501	1881	7494	10119	28318	33498
Hennepin	84.50	0.00	655	1053	2550	3155	14351	18350	48780	57056
Hutsonville	86.20	0.00	666	1069	2586	3199	14601	18643	49492	57871
Joliet	114.40	34.60	624	1008	3161	3890	13655	17533	60802	70794
Joppa	227.60	29.00	1355	1998	5145	6258	30150	36224	100265	115540
Kincaid	211.60	13.60	1352	1994	4886	5950	29071	36137	95089	109696
Lakeside	3.80	0.00	47	103	283	370	970	1554	5114	6267

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
Illinois (Continued)										
Marion	109.00	31.00	612	991	3054	3762	13387	17218	58701	68398
Meredosia	64.80	8.20	465	779	2113	2626	10132	13339	40218	47229
Newton	263.00	0.00	1721	2467	5700	6915	38482	45297	111378	128068
Powerton	258.00	15.00	1609	2325	5623	6824	35926	42533	109835	126329
R.S. Wallace	6.50	0.00	74	154	414	536	1546	2383	7555	9185
Vermilion	68.00	0.00	544	894	2186	2715	11883	15437	41652	48879
Waukegan	142.10	23.10	876	1361	3685	4519	19322	24098	71185	82614
Will County	181.90	64.90	864	1344	4390	5360	19040	23775	85186	98496
Wood River	90.00	14.50	595	967	2667	3295	13013	16777	51069	59677
Illinois Total	3458.10	359.10	21448	32171	83135	101631	476051	578232	1611376	1864875
Indiana										
AB Brown	153.60	0.00	1089	1648	3894	4768	24118	29525	75329	87321
Bailly	86.30	52.20	302	533	2588	3201	6524	8912	49534	57919
Breed	81.20	0.06	632	1021	2479	3069	13854	17767	47387	55461
Cayuga	313.70	0.00	2000	2815	6459	7811	44850	52119	126611	145197
Clifty Creek	583.00	72.00	3030	4059	10019	11989	68526	76849	198695	225747
Crawfordsville	3.81	0.00	47	103	284	370	972	1558	5123	6279
Culley Station	141.30	0.00	1014	1548	3671	4501	22431	27627	70893	82282
E.W. Stout	140.00	64.50	595	967	3647	4472	13013	16777	70419	81742
Edwardsport	24.80	0.00	231	420	1070	1352	4947	6917	20003	23833
Frank E. Ratts	89.00	0.00	684	1094	2646	3270	15013	19124	50656	59204
Gibson	597.60	0.00	3462	4565	10196	12195	78509	87046	202301	229759
H.T. Pritchard	47.50	0.00	401	683	1696	2119	8701	11602	32088	37859
Logansport	8.03	0.00	88	180	481	620	1857	2820	8810	10677
Michigan City	177.00	107.10	557	913	4306	5259	12171	15779	83511	96599
Mitchell	177.40	0.00	1231	1836	4313	5268	27334	33111	83648	96754
Noblesville	9.40	0.00	101	203	538	691	2130	3196	9880	11944
Perry	37.00	18.20	182	341	1421	1783	3889	5549	26758	31689
Peru Lght and Pwr	10.00	5.00	59	126	562	722	1231	1934	10334	12482
Petersburg	568.30	0.00	3317	4396	9839	11779	75154	83632	195039	221679
R.H. Gallagher	101.90	0.00	768	1211	2912	3591	16886	21299	55895	65194
R.N. Schafer	191.40	50.50	1012	1545	4551	5552	22376	27565	88398	102132
State Line	50.00	18.00	286	508	1758	2195	6173	8473	33307	39267
Tanners Creek	276.30	35.30	1598	2310	5903	7155	35669	42255	115446	132647
Wabash River	154.10	6.70	1051	1598	3903	4779	23270	28572	75508	87523
Whitewater Valley	30.00	2.00	256	460	1224	1542	5497	7619	22973	27293
Indiana Total	4052.64	431.56	23993	35083	90360	110053	535095	637627	1758546	2028483

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
Michigan										
Advance	9.20	0.00	99	200	530	681	2090	3142	9726	11763
B.C. Cobb	117.50	23.70	716	1138	3221	3962	15713	19940	61995	72155
Bayside	5.20	0.00	61	130	354	459	1273	1995	6424	7835
Conners Creek	60.11	7.28	439	740	2003	2493	9543	12627	38079	44769
D.E. Karn	137.90	23.20	849	1324	3608	4426	18714	23402	69649	80867
Eckert	57.54	11.03	394	673	1942	2419	8543	11410	36889	43397
Erickson	29.92	5.87	225	410	1222	1539	4817	6750	22928	27241
Harbor Beach	26.90	0.00	247	446	1133	1430	5309	7379	21221	25253
J.H. Campbell	203.00	22.90	1247	1857	4745	5782	27695	33512	92263	106502
J.L. Weadock	79.10	7.00	572	935	2434	3014	12503	16173	46493	54435
J.R. Whiting	85.10	25.80	484	807	2563	3170	10550	13843	49032	57345
James Deyoung	13.90	0.00	141	272	710	906	2992	4363	13130	15781
Marysville	49.72	0.00	417	707	1751	2187	9053	12032	33171	39110
Monroe	595.10	10.50	3398	4490	10166	12160	77023	85536	201685	229074
Ottawa Street	1.34	0.00	19	47	135	180	392	678	2396	2983
Presque Isle	133.00	0.00	963	1479	3517	4317	21282	26328	67840	78811
River Rouge	216.74	33.10	1268	1884	4970	6050	28167	34035	96763	111587
Shiras	8.40	0.00	92	186	497	640	1932	2922	9104	11025
St. Clair	158.00	0.00	1115	1683	3973	4862	24717	30196	76892	89095
Trenton Channel	121.84	36.70	659	1059	3305	4063	14445	18461	63652	74042
Wyandotte	20.40	0.00	195	363	932	1181	4175	5921	17355	20739
Michigan Total	2129.91	207.08	13600	20830	53711	65921	300928	370645	1036687	1203809
Ohio										
Acme	27.90	0.00	255	459	1163	1467	5480	7597	21792	25918
Ashtabula	187.00	10.00	1229	1833	4477	5463	27280	33052	86916	100454
Avon Lake	320.60	0.50	2035	2858	6559	7930	45644	52963	128630	147464
Bay Shore	117.00	3.80	840	1311	3211	3951	18501	23158	61803	71936
Cardinal	504.41	11.00	2941	3954	9042	10847	66472	74736	178838	203630
Conesville	685.14	0.00	3890	5058	11233	13404	88409	97050	223443	253249
East Lake	384.00	11.60	2315	3202	7453	8983	52057	59742	146665	167684
Edgewater	53.70	14.40	341	593	1850	2306	7380	9978	35082	41315
Frank M Tait	35.95	0.19	315	552	1392	1748	6799	9256	26203	31046
Gen J.M. Gavin	1265.16	16.50	6484	7933	17346	20481	148917	156475	349024	391947
Gorge	90.00	0.00	691	1104	2667	3295	15159	19295	51069	59677
Hamiton Municipal	17.10	0.00	168	318	822	1046	3582	5146	15265	18290
J.M. Stuart	819.00	2.50	4516	5769	12747	15164	102961	111589	254404	287567
Kyger Creek	271.48	120.00	1076	1631	5830	7069	23829	29200	113978	130995
Lake Shore	49.40	0.00	414	704	1743	2177	9002	11970	33016	38931
Mad River	8.82	0.00	96	193	514	662	2015	3038	9433	11415
Miami Fort	509.00	60.00	2714	3684	9100	10915	61242	69332	180020	204948
Muskingum River	482.38	96.00	2388	3291	8761	10517	53751	61520	173124	197257
Niles	94.20	30.00	518	857	2754	3401	11304	14746	52791	61647

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
Ohio (Continued)										
O.H. Hutchings	80.60	0.00	629	1016	2466	3054	13774	17673	47133	55169
Painsville	8.13	0.00	89	182	486	625	1877	2847	8890	10771
Picway	30.80	0.00	277	494	1247	1570	5972	8219	23417	27809
Piqua	9.60	0.00	103	206	546	702	2169	3250	10032	12125
Poston	50.50	0.00	422	716	1771	2210	9176	12182	33549	39546
R.E. Burger	172.00	53.50	873	1357	4219	5156	19251	24017	81789	94648
Shelby	4.80	0.00	57	123	334	435	1188	1872	6060	7401
Toronto	90.00	0.00	691	1104	2667	3295	15159	19295	51069	59677
Vine Street	11.00	0.00	115	228	602	771	2441	3622	11076	13359
W.C. Beckjord	466.00	0.00	2802	3788	8549	10269	63252	71413	168829	192463
W.H. Sammis	496.00	17.50	2865	3864	8935	10722	64723	72934	176665	201207
Ohio Total	7341.67	447.49	42149	58382	140486	169635	948766	1087167	2760005	3159545
Wisconsin										
Alma	55.80	0.00	460	771	1901	2368	10007	13189	36074	42459
Bayfront	25.90	0.00	239	434	1103	1393	5137	7160	20645	24581
Blackhawk	3.00	0.00	38	86	240	314	790	1288	4306	5296
Blount Street	17.00	0.00	167	316	819	1041	3564	5122	15200	18213
Columbia	252.70	34.40	1469	2145	5541	6727	32732	39056	108189	124476
E.J. Stoneman	8.10	0.00	89	181	484	624	1871	2839	8866	10743
Edgewater	101.40	14.80	668	1072	2902	3579	14660	18712	55696	64967
Genoa	97.10	7.30	689	1102	2814	3473	15130	19260	53968	62992
J.P. Pulliam	121.90	0.90	889	1378	3306	4064	19604	24419	63675	74068
Madget	37.40	8.30	264	473	1431	1796	5684	7856	26968	31932
Manitowoc	9.92	0.00	106	211	559	718	2232	3336	10274	12411
Menasha	3.60	0.00	45	99	273	356	925	1489	4916	6030
Nelson Dewey	59.30	47.90	119	234	1984	2470	2518	3726	37706	44339
Oak Creek	228.70	16.80	1432	2098	5163	6279	31896	38142	100617	115937
Pleasant Praire	39.80	0.00	345	599	1496	1875	7461	10079	28215	33378
Port Washington	74.40	0.00	587	957	2330	2889	12848	16582	44468	52112
Rock River	22.10	8.00	143	275	986	1248	3029	4413	18395	21955
Valley	56.40	1.40	454	763	1915	2386	9882	13038	36356	42783
Weston	56.60	2.60	447	752	1920	2392	9726	12849	36449	42891
Wildwood	4.80	0.00	57	123	334	435	1188	1872	6060	7401
Wisconsin Total	1275.92	142.40	8707	14069	37501	46427	190884	244427	717043	838964
FERC Region 3 Total	18258.24	1587.63	109897	160535	405193	493667	2451724	2918098	7883657	9095676

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
FERC REGION 4										
Iowa										
Ames Two	14.54	0.00	146	281	733	935	3111	4523	13567	16295
Boone	0.76	0.00	12	31	91	122	240	432	1587	1992
Burlington	29.50	0.00	267	478	1210	1524	5752	7942	22694	26968
Council Bluff	126.00	9.60	860	1339	3384	4158	18955	23678	65225	75834
Des Moines	32.60	0.00	291	515	1299	1633	6274	8599	24404	28957
Dubuque	18.40	0.00	179	336	866	1100	3817	5455	16101	19269
E.F. Wisdom	4.20	0.00	51	111	304	396	1058	1683	5500	6730
Fair	9.39	3.90	64	135	538	691	1335	2083	9872	11935
George Neal	319.50	319.50	0	0	6543	7911	0	0	128309	147104
Humboldt	0.70	0.00	11	29	85	115	223	404	1494	1879
Lansing	46.10	5.80	349	604	1660	2075	7543	10180	31397	37061
M.L. Kapp	62.90	1.60	498	827	2069	2573	10859	14214	39357	46239
Muscatine	31.16	0.00	280	498	1258	1583	6032	8295	23616	28040
Pella	9.20	0.00	99	200	530	681	2090	3142	9726	11763
Prairie Creek	32.50	0.00	290	514	1296	1630	6257	8578	24350	28894
Riverside	32.00	11.00	200	371	1282	1612	4282	6060	24077	28576
Sixth Street	14.90	0.00	149	286	746	951	3178	4611	13811	16581
Streeter	14.54	0.00	146	281	733	935	3111	4523	13567	16295
Sutherland	25.00	0.00	232	422	1076	1360	4982	6962	20121	23970
Iowa Total	823.89	351.40	4124	7258	25703	31985	89099	121364	488775	574382
Kansas										
Jeffrey	230.80	0.00	1540	2237	5197	6318	34354	40825	101288	116694
Kaw	31.10	0.00	280	497	1256	1581	6022	8283	23583	28002
LaCygne	926.00	318.00	3514	4624	13905	16507	79695	88249	278164	313844
Lawrence	141.70	0.00	1017	1551	3678	4510	22486	27690	71039	82448
Quindaro Three	47.40	0.00	400	682	1693	2116	8685	11583	32039	37802
Quindaro Two	0.30	0.00	5	15	47	64	107	206	807	1028
Riverton	24.80	0.00	231	420	1070	1352	4947	6917	20003	23833
Tecumseh	55.60	13.20	364	628	1896	2362	7883	10600	35980	42350
Kansas Total	1457.70	331.20	7351	10654	28742	34810	164179	194353	562903	646001
Minnesota										
A.S. King	179.80	91.20	682	1091	4354	5317	14954	19055	84470	97685
Black Dog	50.30	25.80	228	416	1766	2204	4895	6851	33452	39435
Boswell	411.10	5.80	2488	3412	7822	9417	56030	63906	154121	176028
Elk River	1.80	0.00	25	59	167	221	507	858	2970	3681
Foxlake	6.40	0.00	73	152	410	530	1525	2354	7470	9084
High Bridge	56.50	56.50	0	0	1917	2389	0	0	36403	42837
Hoot Lake	34.80	1.30	298	526	1360	1709	6424	8787	25591	30335

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tonsx1000)	Ash Sold (tonsx1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
Minnesota (Continued)										
Minnesota Valley	2.00	0.00	27	64	180	237	555	933	3206	3968
Moorhead	7.24	0.00	81	167	447	577	1698	2596	8171	9918
New Ulm	5.42	0.00	63	134	364	473	1320	2062	6620	8070
Northeast	3.00	0.00	38	86	240	314	790	1288	4306	5296
Riverside	52.30	15.90	320	560	1815	2264	6904	9388	34414	40545
Sherburne County	525.00	0.00	3101	4142	9302	11151	70154	78520	184117	209515
Silver Lake	15.80	0.00	157	299	777	990	3344	4832	14412	17288
Syl Laskin	21.40	0.00	203	376	964	1221	4352	6151	17970	21457
Virginia	11.00	0.00	115	228	602	771	2441	3622	11076	13359
Willmar	6.50	0.00	74	154	414	536	1546	2383	7555	9185
Wilmarth	1.70	0.00	24	56	160	212	482	820	2849	3534
Minnesota Total	1392.06	196.50	7997	11922	33061	40533	177921	214406	639173	741220
Missouri										
Asbury	131.40	22.40	813	1274	3487	4281	17903	22472	67246	78134
Blue Valley	40.80	12.00	262	470	1522	1907	5633	7791	28729	33974
Chamois	11.00	11.00	0	0	602	771	0	0	11076	13359
Chillicothe	3.96	0.00	48	106	292	380	1005	1606	5269	6454
Columbia	9.60	0.00	103	206	546	702	2169	3250	10032	12125
Grand Avenue	3.60	0.00	45	99	273	356	925	1489	4916	6030
Hawthorn	112.00	32.00	625	1010	3113	3833	13685	17568	59871	69733
Iatan	79.20	5.00	586	955	2436	3017	12818	16547	46536	54484
James River	38.00	0.00	332	578	1448	1816	7167	9715	27282	32296
Labodie	553.20	8.90	3198	4256	9653	11562	72389	80809	191257	217469
Lake Road	29.70	14.50	152	291	1216	1531	3233	4685	22806	27098
Meramec	96.40	32.60	515	853	2800	3456	11242	14673	53685	62669
Missouri City	12.40	0.00	128	250	655	837	2709	3984	12084	14548
Montrose	300.00	103.00	1346	1986	6258	7574	29939	35991	122566	140653
New Madrid	388.40	388.40	0	0	7514	9054	0	0	147885	169050
Rush Island	455.30	95.80	2246	3118	8409	10105	50487	58089	166001	189306
Sibley	72.80	0.00	577	941	2295	2846	12608	16298	43770	51311
Sioux	279.90	56.30	1499	2184	5957	7220	33421	39808	116538	133875
Southwest	145.00	0.00	1037	1578	3739	4582	22941	28202	72239	83811
Thomas Hill	231.50	30.00	1372	2020	5208	6332	30532	36644	101511	116946
Missouri Total	2994.16	811.90	14884	22175	67423	82162	330806	399621	1311299	1513325
Nebraska										
Gerald Gentleman	70.40	0.00	560	918	2241	2781	12246	15869	42716	50101
Kramer	6.60	0.00	75	156	419	542	1566	2412	7639	9285
L.D. Wright	16.20	0.00	160	305	791	1007	3417	4929	14677	17599
Nebraska	69.60	0.00	555	910	2223	2759	12125	15725	42363	49695

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
Nebraska (Continued)										
North Omaha	121.70	0.00	893	1384	3302	4060	19702	24532	63599	73982
Sheldon	33.30	27.90	63	134	1318	1657	1316	2056	24784	29398
Nebraska Total	317.80	27.90	2306	3807	10294	12806	50372	65523	195778	230060
North Dakota										
Coal Creek	475.10	96.80	2346	3240	8667	10407	52773	60494	171220	195132
Heskett	41.10	0.00	354	613	1530	1917	7673	10340	28883	34151
Leland Olds	283.90	4.00	1815	2585	6018	7291	40621	47598	117747	135235
Milton Young	418.00	8.00	2512	3441	7915	9526	56594	64495	155998	178127
Neal	21.00	0.00	200	371	951	1205	4282	6060	17725	21171
Stanton	71.70	0.00	569	931	2270	2816	12442	16102	43288	50758
North Dakota Total	1310.80	108.80	7796	11181	27351	33162	174385	205089	534861	614574
South Dakota										
Ben French	5.42	0.00	63	134	364	473	1320	2062	6620	8070
Big Stone	200.10	1.30	1356	2000	4697	5725	30176	36253	91302	105416
Kirk	9.68	0.00	103	207	549	706	2185	3272	10093	12196
South Dakota Total	215.20	1.30	1522	2341	5610	6904	33681	41587	108015	125682
FERC Region 4 Total	8511.61	1829.00	45980	69338	198184	242362	1020443	1241943	3840804	4445244
FERC REGION 5										
Delaware										
Indian River	440.50	0.00	2670	3632	8215	9877	60234	68285	162060	184903
Deleware Total	440.50	0.00	2670	3632	8215	9877	60234	68285	162060	184903
Florida										
Big Bend	282.70	200.00	643	1036	6000	7269	14085	18038	117385	134828
Crist	101.00	0.00	762	1203	2894	3569	16756	21149	55536	64784
Crystal River	206.40	206.40	0	0	4801	5849	0	0	93384	107769
F-J Gannon	164.10	160.70	42	95	4081	4991	880	1423	79040	91531
Lansing Smith	57.10	0.00	469	785	1932	2406	10209	13433	36683	43161
Scholz	7.05	0.00	79	163	439	567	1659	2542	8015	9732
Florida Total	818.35	567.10	1995	3282	20147	24651	43589	56585	390043	451805

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
Georgia										
Arkwright	40.70	10.20	275	490	1520	1904	5921	8155	28678	33914
Bowen	788.00	147.10	3675	4811	12403	14765	83428	92029	247365	279773
Branch	245.00	0.00	1621	2339	5421	6585	36183	42812	105782	121763
Hammond	152.00	0.00	1079	1635	3866	4734	23900	29280	74758	86672
McDonough	84.50	25.00	486	809	2550	3155	10581	13880	48780	57056
Mitchell	51.90	0.00	432	730	1805	2252	9397	12450	34223	40324
Port Wentworth	75.70	75.70	0	0	2359	2924	0	0	45031	52759
Wansley	521.00	67.00	2740	3715	9252	11092	61834	69946	183096	208377
Yates	345.00	45.00	1925	2723	6909	8342	43143	50299	135677	155371
Georgia Total	2303.80	370.00	12233	17252	46085	55753	274387	318851	903390	1036009
Maryland										
C.P. Crane	13.20	0.00	135	262	684	874	2860	4188	12646	15211
Chall Point	224.10	4.10	1479	2158	5089	6191	32953	39297	99141	114272
Dickerson	233.20	17.70	1453	2124	5235	6364	32367	38656	102053	117557
H. A. Wagner	98.20	11.00	672	1078	2837	3500	14748	18815	54412	63500
Morgantown	440.40	20.90	2562	3501	8213	9876	57731	65682	162033	184873
R. Paul Smith	53.40	1.70	431	728	1842	2297	9365	12412	34939	41150
Maryland Total	1062.50	55.40	6732	9851	23900	29102	150024	179050	465224	536563
North Carolina										
Allen	265.00	0.00	1732	2481	5731	6952	38736	45571	111994	128761
Asheville	110.60	0.00	823	1288	3086	3800	18131	22734	59326	69111
Belews Creek	499.40	23.50	2852	3848	8978	10772	64418	72618	177544	202188
Buck	78.70	0.00	616	998	2425	3004	13491	17341	46322	54239
Cape Fear	93.60	0.00	714	1137	2742	3386	15684	19906	52546	61367
Cliffside	228.80	0.00	1529	2222	5165	6281	34095	40543	100649	115973
Dan River	62.90	0.00	509	844	2069	2573	11105	14508	39357	46239
Lee	95.00	0.00	723	1149	2771	3421	15888	20143	53117	62019
Marshall	549.00	68.50	2876	3876	9601	11501	64958	73176	190200	216292
Riverbend	111.00	0.00	826	1292	3094	3809	18188	22799	59482	69289
Roxboro	567.00	36.10	3130	4177	9823	11760	70838	79222	194714	221318
Sutton	134.70	0.00	974	1493	3548	4355	21518	26595	68470	79527
Weatherspoon	29.00	0.00	263	472	1195	1506	5667	7834	22414	26642
North Carolina Total	2824.70	128.10	17567	25277	60228	73120	392717	462990	1176135	1352965
South Carolina										
Canadys	92.02	68.50	220	403	2709	3346	4725	6632	51900	60628
Grainger	39.50	2.40	325	568	1488	1865	7020	9531	28061	33199
H.B Robinson	45.50	0.00	386	662	1645	2057	8381	11212	31099	36716
Jefferies	92.00	15.40	602	978	2708	3346	13178	16971	51892	60618

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tonsx1000)	Ash Sold (tonsx1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
South Carolina (Continued)										
Lee	92.20	0.00	705	1124	2713	3351	15480	19669	51974	60712
McMeekin	71.60	0.00	569	930	2268	2814	12427	16084	43244	50708
Urguhart	70.90	15.60	456	766	2252	2795	9929	13095	42937	50354
Wateree	140.40	18.30	896	1387	3654	4481	19758	24596	70565	81909
Winyah	202.90	0.00	1380	2031	4743	5780	30716	36847	92230	106465
South Carolina Total	847.02	120.20	5539	8849	24180	29835	121614	154637	463902	541309
Virginia										
Bremo Bluff	61.40	0.00	499	829	2034	2530	10874	14232	38672	45451
Chesterfield	101.40	0.00	765	1207	2902	3579	16814	21216	55696	64967
Clinch River	347.00	102.20	1619	2337	6937	8376	36157	42784	136248	156012
Glen Lyn	125.70	21.10	785	1235	3379	4151	17274	21747	65112	75705
Portsmouth	37.80	0.00	330	576	1442	1809	7135	9674	27177	32175
Possum Point	2.90	0.00	37	84	234	307	767	1254	4201	5170
Potomac River	142.80	4.16	998	1526	3698	4534	22064	27213	71440	82903
Virginia Total	819.00	127.46	5033	7794	20626	25286	111085	138120	398546	462383
West Virginia										
Albright	171.30	25.20	1043	1587	4207	5142	23092	28372	81547	94373
Fort Martin	383.60	9.10	2326	3215	7448	8977	52312	60010	146554	167560
Harrison	354.30	98.40	1682	2417	7040	8497	37577	44321	138326	158342
John E. Amos	927.30	626.40	1930	2729	13919	16523	43256	50419	278448	314158
Kammer	321.00	267.00	447	752	6565	7937	9726	12849	128746	147595
Kanawha River	190.40	50.40	1006	1537	4534	5532	22252	27425	88062	101752
Mitchell	477.00	49.00	2606	3554	8691	10436	58746	66739	171718	195687
Mount Storm	452.80	0.00	2734	3707	8377	10067	61692	69799	165338	188565
Mountaineer	186.90	0.00	1287	1909	4475	5461	28601	34515	86882	100416
Philip Sporn	308.30	0.40	1969	2776	6380	7718	44129	51351	125022	143413
Pleasants	356.50	0.00	2230	3099	7071	8533	50121	57703	138950	159042
Rivesville	90.80	13.30	608	987	2683	3316	13312	17130	51399	60054
Willow Island	67.90	67.90	0	0	2184	2712	0	0	41608	48827
West Virginia Total	4288.10	1207.10	19868	28269	83574	100851	444816	520633	1642600	1879784
FERC Region 5 Total	13403.97	2575.36	71637	104206	286955	348475	1598466	1899151	5601900	6445721

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
FERC REGION 6										
Alabama										
Barry	360.00	0.00	2249	3121	7120	8591	50548	58154	139941	160152
Colbert	352.00	0.00	2206	3069	7008	8459	49571	57123	137673	157610
E.C. Gatson	649.60	38.60	3528	4641	10817	12919	80036	88596	214954	243823
Gadsden New	46.20	0.00	392	669	1663	2078	8493	11349	31447	37118
Gorgas Two	390.30	0.00	2409	3317	7540	9085	54224	62017	148411	169639
Greene County	103.90	0.00	781	1229	2952	3639	17173	21631	56691	66103
McWilliams	0.98	0.00	15	37	108	145	299	529	1909	2387
Miller	87.70	0.00	676	1082	2618	3237	14822	18901	50117	58587
Tombigbee	102.60	0.00	772	1218	2926	3608	16987	21415	56174	65513
Widows Creek	292.50	0.00	1884	2671	6146	7443	42205	49296	120330	138140
Alabama Total	2385.78	38.60	14912	21054	48898	59204	334358	389011	957647	1099072
Kentucky										
Big Sandy	344.80	7.80	2126	2971	6906	8339	47730	55177	135619	155307
Cane Run	899.30	2.70	4891	6188	13620	16176	111681	120217	272309	307373
Coleman	169.12	0.00	1182	1771	4169	5096	26222	31875	80791	93516
Dale	31.20	0.00	280	499	1259	1585	6039	8304	23638	28066
E.W. Brown	141.50	0.00	1015	1550	3674	4505	22459	27658	70966	82365
Elmer Smith	87.80	28.60	484	806	2620	3240	10535	13825	50158	58634
Ghent	214.60	0.00	1448	2118	4935	6008	32249	38528	96067	110801
Green River	28.90	0.00	263	471	1192	1503	5650	7813	22357	26576
H.L. Spurlock	81.20	0.00	633	1022	2479	3069	13863	17778	47387	55461
Henderson One	4.40	4.40	0	0	314	409	0	0	5689	6957
J.S. Cooper	78.80	0.00	617	999	2427	3006	13506	17358	46365	54288
Mill Creek	1476.80	0.00	7480	8997	19355	22792	172289	178831	390573	437587
Paddy's Run	2.18	0.00	29	68	191	252	598	999	3414	4219
Paradise	801.80	2.10	4437	5680	12557	14943	101118	109758	250508	283254
Pineville	1.60	0.00	22	54	153	203	457	781	2726	3385
Reid/Green	593.00	25.00	3316	4394	10140	12130	75119	83597	201167	228498
Shawnee	341.00	0.00	2147	2997	6852	8275	48222	55698	134531	154086
Tyrone	2.40	0.00	32	73	205	269	650	1078	3661	4518
Kentucky Total	5300.40	70.60	30402	40658	93048	111800	688387	769275	1837926	2094891
Mississippi										
Jack Watson	140.00	12.00	932	1437	3647	4472	20585	25537	70419	81742
Morrow	67.90	31.60	319	559	2184	2712	6888	9367	41608	48827
V.J. Daniel	85.10	3.80	633	1023	2563	3170	13878	17795	49032	57345
Mississippi Total	293.00	47.40	1884	3019	8394	10354	41351	52699	161059	187914

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
Tennessee										
Bull Run	332.50	0.00	2102	2941	6731	8132	47176	54590	132084	151341
Cumberland	751.10	0.00	4206	5419	11989	14283	95758	104416	238888	270380
Gallatin	230.90	38.10	1321	1954	5198	6320	29384	35379	101320	116730
John Servier	260.00	0.00	1705	2446	5654	6861	38100	44885	110453	127026
Johnsonville	283.10	0.00	1833	2607	6006	7276	41024	48031	117505	134964
Kingston	595.10	6.00	3420	4516	10166	12160	77538	86059	201685	229074
T.H. Allen	147.00	95.50	429	726	3775	4626	9334	12374	72962	84632
Watts BA	43.50	0.00	372	640	1593	1994	8060	10818	30099	35560
Tennessee Total	2643.20	139.60	15388	21249	51112	61652	346374	396552	1004996	1149707
FERC Region 6 Total	10622.38	296.20	62586	85980	201452	243010	1410470	1607537	3961628	4531584
FERC REGION 7										
Arkansas										
Chena	12.00	0.00	124	244	640	819	2633	3882	11799	14213
Flint Creek	69.80	17.00	439	740	2227	2764	9538	12622	42451	49797
Healy	8.00	0.00	88	180	480	619	1851	2811	8786	10648
White Bluff	32.00	0.00	286	508	1282	1612	6173	8473	24077	28576
Arkansas Total	121.80	17.00	937	1672	4629	5814	20195	27788	87113	103234
Oklahoma										
Muskogee	119.80	39.90	624	1009	3266	4016	13670	17551	62875	73158
Northeastern	148.70	10.30	996	1524	3806	4663	22031	27175	73574	85328
Sooner	39.60	13.10	244	441	1491	1868	5240	7292	28112	33259
Oklahoma Total	308.10	63.30	1864	2974	8563	10547	40941	52018	164561	191745
Texas										
Big Brown	855.40	255.00	3476	4581	13146	15626	78828	87370	262577	296611
Coleto Creek	35.10	0.00	310	545	1369	1719	6690	9120	25751	30521
Fayette	169.80	0.00	1186	1777	4181	5111	26313	31977	81027	93784
Harrington	136.20	130.00	71	148	3576	4388	1484	2295	69023	80156
J.T. Deely	189.10	87.20	768	1211	4512	5505	16886	21299	87625	101256
Martin Lake	1869.30	226.80	8189	9744	22872	26824	188964	194625	463587	517550
Monticello	2185.70	86.30	10092	11713	25552	29886	233871	236606	519414	578512

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
Texas (Continued)										
W.A. Parish	319.90	84.30	1567	2271	6549	7918	34974	41499	128425	147235
Welsh	150.03	75.20	590	961	3830	4692	12913	16658	74052	85871
Texas Total	5910.53	944.80	26249	32951	85587	101669	600923	641449	1711481	1931496
FERC Region 7 Total	6340.43	1025.10	29050	37597	98779	118030	662059	721255	1963155	2226475
FERC REGION 8										
Arizona										
Apache	187.30	0.00	1289	1912	4482	5469	28654	34574	87017	100569
Cholla	231.60	20.80	1426	2090	5209	6334	31753	37984	101543	116982
Coronado	155.90	120.00	316	554	3936	4818	6822	9285	76148	88250
Navajo	653.00	139.10	3045	4076	10857	12966	68863	77196	215772	244731
Arizona Total	1227.80	279.90	6076	8632	24484	29587	136092	159039	480480	550532
Colorado										
Araphahoe	79.30	0.00	620	1004	2438	3019	13580	17446	46579	54533
Camanche	138.30	26.50	831	1299	3615	4435	18302	22930	69796	81034
Cameo	19.30	0.00	186	348	896	1137	3979	5666	16670	19936
Cherokee	114.40	0.00	847	1321	3161	3890	18671	23353	60802	70794
Craig	187.70	0.00	1292	1915	4489	5477	28707	34633	87152	100722
Drake	73.20	0.00	579	945	2304	2857	12668	16369	43945	51512
Hayden	149.10	0.00	1062	1612	3813	4671	23503	28834	73718	85492
Nucla	14.20	0.00	143	276	721	920	3048	4438	13336	16023
R.D. Nixon	43.20	0.50	366	631	1585	1984	7932	10659	29948	35385
Valmont	28.90	0.00	263	471	1192	1503	5650	7813	22357	26576
W.N. Clark	34.40	0.00	305	537	1349	1695	6574	8975	25377	30087
Colorado Total	882.00	27.00	6494	10359	25563	31588	142614	181116	489680	572094
Montana										
Colstrip	324.60	0.00	2059	2888	6617	7998	46201	53555	129795	148772
J.E. Corette	47.60	21.00	245	442	1698	2122	5258	7314	32137	37915
Lewis and Clark	21.70	7.30	145	279	973	1233	3085	4488	18153	21671
Montana Total	393.90	28.30	2449	3609	9288	11353	54544	65357	180085	208358

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
Nevada										
Mohave	382.70	108.00	1786	2548	7436	8962	39964	46893	146304	167280
Nevada Total	382.70	108.00	1786	2548	7436	8962	39964	46893	146304	167280
New Mexico										
Four Corners	1700.00	7.50	8401	9965	21385	25120	193951	199325	432664	483718
Reid Gardner	161.10	34.10	926	1429	4028	4928	20446	25378	77987	90336
San Juan	98.00	0.00	743	1176	2832	3495	16323	20647	54331	63408
New Mexico Total	1959.10	41.60	10070	12570	28245	33543	230720	245350	564982	637462
Utah										
Carbon	33.00	0.00	294	520	1310	1647	6341	8683	24622	29209
Gadsby	23.00	0.00	216	397	1014	1283	4634	6515	18937	22588
Hale	8.30	0.00	91	185	493	634	1912	2895	9025	10931
Hunington	295.00	0.00	1898	2688	6183	7487	42518	49631	121077	138979
Hunter	227.00	0.00	1519	2209	5136	6246	33862	40289	100072	115323
Utah Total	586.30	0.00	4018	5999	14136	17297	89267	108013	273733	317030
Wyoming										
Dave Johnston	445.00	40.00	2486	3410	8274	9947	55994	63869	163262	186246
Jim Bridger	721.00	146.00	3351	4435	11646	13885	75923	84416	231888	262619
Laramie River	503.00	0.00	2990	4011	9024	10826	67593	75890	178474	203225
Naughton	132.00	3.30	937	1443	3498	4294	20683	25648	67469	78388
Osage	14.60	0.00	147	282	735	937	3122	4537	13608	16343
Wyodak	129.00	19.00	819	1283	3441	4226	18046	22636	66351	77115
Wyoming Total	1944.60	208.30	10730	14864	36618	44115	241361	276996	721052	823936
FERC Region 8 Total	7376.40	693.10	41623	58581	145770	176445	934562	1082764	2856316	3276692
FERC REGION 9										
Oregon										
Boardman	31.20	0.00	280	499	1259	1585	6039	8304	23638	28066
Oregon Total	31.20	0.00	280	499	1259	1585	6039	8304	23638	28066

APPENDIX G

ESTIMATED WASTE DISPOSAL COSTS FOR COAL-FIRED UTILITY POWER PLANTS OVER 25 MW CAPACITY

Plant Name	Total Waste (tons x 1000)	Ash Sold (tons x 1000)	Levelized Annual Revenue ($000)				Present Worth Costs ($000)			
			Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum	Current Practice	Non-Hazardous	Hazardous Minimum	Hazardous Maximum
Washington										
Centralia	805.00	291.00	3045	4077	12592	14984	68875	77208	251235	284058
Washington Total	805.00	291.00	3045	4077	12592	14984	68875	77208	251235	284058
FERC Region 9 Total	836.20	291.00	3325	4576	13851	16569	74914	85512	274873	312124
US TOTAL	75060.41	9265.60	418135	596377	1541714	1870310	9367191	10957131	30136594	34639089

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NOTE: Due to the voluminous nature of Appendix H (1635 pages), it has been placed in two separately bound volumes which are available upon request.

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