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

Final Report, Volume II

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RCRA Impact
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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal in the utility industry. These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 2 is located in eastern Pennsylvania and has a current nameplate capacity of 1,489 MW. The plant has four boilers, two are oil-fired and the other two are pulverized coal-fired, dry-bottom.

Bituminous coal for the plant is primarily obtained from western Pennsylvania. Coal is transported to the facility by rail. Normally a 60-day stockpile is maintained on-site. Coal consumption for 1980 was 800,000 tons. The average analysis of the coal consumed during 1980 was

1.8 percent sulfur, 8.1 percent ash, and 12,980 BTU's/lb. Projected 1985 and 1990 rates of coal consumption are 959,000 and 913,000 tons, respectively.

Each of the coal-fired boilers is equipped with combination mechanical collectors and electrostatic precipitators. The two oil-fired units have electrostatic precipitators. The two coal fired units are operating under consent orders and will be in compliance sometime in 1983 by the installation of magnesium oxide regenerative scrubber systems. Table 1.1 summarizes plant characteristics including year of boiler start-up, 1980 capacity factors, coal used, and air pollution control equipment.

EXISTING DISPOSAL

The schematic flow diagram of the existing disposal facilities for the plant is shown in Figure 1.2. The quantities of waste materials generated are summarized in Table 1.2.

Fly ash from Units 1 and 2 is collected dry and stored in silos for disposal through an outside contractor. The bottom ash is transferred to hydrobins for dewatering and disposal by an outside contractor. The contractor hauls the moisture conditioned ash approximately 15 miles from the plant to a solid waste landfill. Small amounts of fly ash and bottom ash have been sold in the past, however, no sales of either ash are expected in the future.

Other low volume wastes such as coal pile runoff, demineralizer waste, boiler blowdown, and cooling water blowdown are piped to a wastewater treatment plant. Sludge from the plant is hauled to the landfill.

No significant quantities of waste would be expected from the sulfur dioxide scrubber system. The magnesium sulfite formed in the scrubber would be calcined, and the SO_2 rich gas would be fed into a sulfuric acid plant. The regenerated magnesium oxide would be returned to the scrubber for reuse.

The diagram illustrates the integrated water and ash management system of a coal-fired power plant. The process begins with coal being transported from a **COAL PILE** to **UNITS 1 & 2**. **MAKEUP WATER** from a **RIVER** is added to the system. Flue gas from the units passes through a **MECHANICAL COLLECTOR** and then an **ELECTROSTATIC PRECIPITATOR** before being released into the **STACK** and **TO ATMOSPHERE**. Fly ash is collected from both the mechanical collector and the electrostatic precipitator and stored in a **SILO**. Bottom ash from the units is sent to **HYDROBINS**, which produce **SLUICE WATER** and **RECYCLE WATER**. Cooling water and boiler blowdown are sent to a **NEUTRALIZATION** tank, which also receives **CAUSTIC** and **CONDIONING WATER** from the silo. The neutralization tank produces **DECANT WATER** and **SLUDGE**. The sludge is sent to a **SEDIMENTATION POND**, which produces **OVERFLOW** and **SOLIDS**. The overflow is sent to a **WASTEWATER TREATMENT PLANT**, which produces **SLUDGE** and **EFFLUENT**. The effluent is sent **TO RIVER**. The sludge from the sedimentation pond and the sludge from the neutralization tank are sent **TO OFF-SITE DISPOSAL**. The runoff from the coal pile is also sent **TO OFF-SITE DISPOSAL**.

1-5 PLANT 2

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 2

Boiler	Stack	MW (Nameplate)	Year of Start-up	1980 Availability Factor	1980 Coal Used (tons)	1985 Coal Projections (tons)	1990 Coal Projections (tons)	Type of Control	
								Particulate	SO ₂
1	1	353	1959	19%	163,000	959,000 ¹	913,000 ¹	Combination ²	None
2	2	354	1960	64%	637,000	(1)	(1)	Combination ²	None
3	3	391	1974	20%	Oil-Fired	Oil-Fired	Oil-Fired	ESP	None
4	3	391	1976	23%	Oil-Fired	Oil-Fired	Oil-Fired	ESP	None
Totals		1,489			800,000	959,000 ¹	913,000 ¹		

¹ Coal consumption is for both Units 1 and 2

² Combination - mechanical dust collector and electrostatic precipitators. SO₂ scrubber is no longer in service.

TABLE 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 2

Waste Product	1980 Values	1985 Values	1990 Values	35-Year Average*
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	63,900	76,600	72,900	72,786
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	63,900	76,600	72,900	72,786
<u>Bottom Ash (Dry Weight)</u>				
Tons Produced	27,400	32,800	31,300	31,236
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	27,400	32,800	31,300	31,236

* Average if for 1980-2014, assuming that the 1990 values remain constant through 2014.

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates.

In 1980, Plant 2 used a contractor to haul its fly ash and bottom ash to a county landfill approximately 15 miles from the power plant (See Figure 1.4). Plant 2 is landlocked and is located in a high density population area so that their continued use of the county landfill in the future is expected. During the 35 year design period the county would be expected to develop additional landfill capacity as it is needed for refuse disposal. Miscellaneous wastes, e.g. coal pile runoff, etc., currently generated by the plant would continue to be sent to the wastewater treatment plant.

CURRENT PRACTICE HANDLING & DISPOSAL

FIGURE 2.1

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extentions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 2

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	707 MW
Generating capacity of largest boiler	354 MW

Waste Production Information*

Fly ash	72786 dry ton/yr
Bottom Ash	31236 dry ton/yr
No FGD	
Waste densities (as disposed)	--
Fly ash	66.5 lb/cu ft
Bottom ash	66.5 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

[0011-20-1980#11107155]

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TABLE 2.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 2014

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. + 0.50 =

\$0.

CONSTRUCTION CAPITAL REQUIREMENT =

\$0.

Closure Cost

\$0.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$0.

* Site cost adjustment factor (SCAF) = 1.136

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 2.3
CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations
 Nominal Return : 8.4 %
 Inflation Rate : 6.0 %
 Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	0	0	0.9131	0
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	0	0.4512	0

Total Present Worth of Future Capital Expenditures :

\$0

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$0

[Plant # 2]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	72,786	3.98	289,397	Dry disposal
Bottom ash	31,236	3.98	124,194	Dry disposal
Total handling			413,592	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	72,786	4.49	326,789	open on road truck (16cy) 20 mi. haul
Bottom ash	31,236	4.49	140,241	open on road truck (16cy) 20 mi. haul
Total transportation			467,030	
Landfill costs				
Flyash	72,786	1.35	98,550	
Bottom ash	31,236	1.35	42,262	
Total landfill cost			140,812	

Annual operation and maintenance cost \$1,621,463

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 1982

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 1987

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 1992

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 1997

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 2002

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 2007

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 2012

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Notes for Plant 2

The non-annual ash excavation cost designation was used for inserting the tipping fees charged by the landfill operators. The waste quantities represent 5 year volumes which would be periodically contracted for landfilling.

TABLE 2.5
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	1,021,463	1.0000	1,021,463
1981	1,021,463	0.9775	998,480
1982	3,378,935	0.9555	3,228,572
1983	1,021,463	0.9341	954,149
1984	1,021,463	0.9131	932,698
1985	1,021,463	0.8925	911,656
1986	1,021,463	0.8725	891,226
1987	3,378,935	0.8528	2,881,556
1988	1,021,463	0.8337	851,594
1989	1,021,463	0.8149	832,390
1990	1,021,463	0.7966	813,697
1991	1,021,463	0.7787	795,413
1992	3,378,935	0.7612	2,572,045
1993	1,021,463	0.7441	760,071
1994	1,021,463	0.7273	742,910
1995	1,021,463	0.7110	726,260
1996	1,021,463	0.6950	709,917
1997	3,378,935	0.6794	2,295,648
1998	1,021,463	0.6641	678,354
1999	1,021,463	0.6492	663,134
2000	1,021,463	0.6346	648,220
2001	1,021,463	0.6203	633,613
2002	3,378,935	0.6064	2,048,986
2003	1,021,463	0.5927	605,421
2004	1,021,463	0.5794	591,836
2005	1,021,463	0.5664	578,557
2006	1,021,463	0.5536	565,482
2007	3,378,935	0.5412	1,828,680
2008	1,021,463	0.5290	540,354
2009	1,021,463	0.5171	528,199
2010	1,021,463	0.5055	516,350
2011	1,021,463	0.4941	504,705
2012	3,378,935	0.4830	1,632,026
2013	1,021,463	0.4722	482,335
2014	1,021,463	0.4616	471,507

Total Present Worth of Future Costs : \$36,437,503

Sum of Present Worth Factors : 24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
 (Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST \$1,492,710

[Plant # 2]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 2

Levelized Capital Cost

\$0

Levelized Operation and Maintenance Costs

\$1,492,710

Total Levelized Revenue Requirement

\$1,492,710

Levelized Revenue Requirement per Ton of Waste Disposed

\$14.35

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$12.88

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of additional ground-water monitoring wells around the existing fly ash and bottom ash facilities. These costs would be expected to be passed on to the utility. Miscellaneous wastes, e.g. coal pile runoff and boiler cleaning wastes, would continue to be discharged to the wastewater treatment plant.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge

NON-HAZARDOUS HANDLING & DISPOSAL

FIGURE 3.1

rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5.

A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

TABLE 3.1

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 2

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	707 MW
Generating capacity of largest boiler	354 MW

Waste Production Information*

Fly ash	72736 dry ton/yr
Bottom Ash	31236 dry ton/yr
No FGD	--
Waste densities (as disposed)	
Fly ash	66.5 lb/cu ft
Bottom ash	66.5 lb/cu ft

 * Average for design period, 1980-2014.
 Does not include wastes being sold
 or reused (if applicable).

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TABLE 3.2

NON-HAZARDOUS CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1984

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				\$0.
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
* Site cost adjustment factor (SCAF) = 1.136				
Site Unit cost = SCAF x National Average Unit Cost				
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TABLE 3.2 (continued)

Construction Cost Items for Period 2
 1985 - 2014

ITEM	QUANTITY	UNIT	UNIT+ COST	EXTENSION

groundwater monitoring wells	342 [14]		13.63	4,698
CONSTRUCTION COST TOTAL			--	\$4,698
Contractor Overhead 15%				
Contractor Profit 10%				
Engineering & Legal Costs 10%				
Contingency 15%				

50%				
Other Capital Items =		\$4,698 x 0.50 =		\$2,045
CONSTRUCTION CAPITAL REQUIREMENT =				\$6,134

Closure Cost			\$0.	
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.

* Site cost adjustment factor (SCAF)= 1.136				
Site Unit cost= SCAF x National Average Unit Cost				

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TABLE 3.3
NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	6,134	0	0.9131	5,601
1985	0	0	0.8923	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	0	0.4512	0

Total Present Worth of Future Capital Expenditures :

\$5,601

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$414

[Plant # 2]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1984

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	72,786	3.98	289,397	Dry disposal
Bottom ash	31,236	3.98	124,194	Dry disposal
Total handling			413,592	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	72,786	4.47	326,789	open on road truck (16cy) 20 mi. hau
Bottom ash	31,236	4.49	140,241	open on road truck (16cy) 20 mi. hau
Total transportation			467,030	
Landfill costs				
Flyash	72,786	1.35	98,558	
Bottom ash	31,236	1.35	42,292	
Total landfill cost			140,842	

Annual operation and maintenance cost \$1,021,463
 Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y = \$ 2357472 in year 1982

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Notes for Plant 2

The non-annual ash excavation cost designation was used for inserting the tipping fees charged by the landfill operators. The waste quantities represent 5 year volumes which would be periodically contracted for landfilling.

TABLE 3.4 (continued)

O&M Costs for Period 2
1985 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	72,786	3.98	289,397	Dry disposal
Bottom ash	31,236	3.98	124,194	Dry disposal
Total handling			413,592	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	72,786	4.49	326,789	-- open on road truck (16cy) 20 mi. hau
Bottom ash	31,236	4.49	140,241	open on road truck (16cy) 20 mi. hau
Total transportation			467,030	
Landfill costs				
Flyash	72,786	1.35	98,550	
Bottom ash	31,236	1.35	42,292	
Total landfill cost			140,842	
Groundwater monitoring			6,410	

Annual operation and maintenance cost \$1,029,873

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 1987

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 1992

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 1997

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 2002

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 2007

Non-annual ash excavation cost 520110 c.y. @ \$ 4.53264 /c.y. = \$ 2357472 in year 2012

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Notes for Plant 2

The non-annual ash excavation cost designation was used for inserting the tipping fees charged by the landfill operators. The waste quantities represent 5 year volumes which would be periodically contracted for landfiling.

TABLE 3.5
NON-HAZARDOUS 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	1,021,463	1.0000	1,021,463
1981	1,021,463	0.9775	998,480
1982	3,378,935	0.9555	3,228,572
1983	1,021,463	0.9341	954,149
1984	1,021,463	0.9131	932,698
1985	1,029,873	0.8925	919,162
1986	1,029,873	0.8725	898,564
1987	3,387,345	0.8528	2,888,728
1988	1,029,873	0.8337	858,605
1989	1,029,873	0.8149	839,244
1990	1,029,873	0.7966	820,397
1991	1,029,873	0.7787	801,962
1992	3,387,345	0.7612	2,578,447
1993	1,029,873	0.7441	766,328
1994	1,029,873	0.7273	749,027
1995	1,029,873	0.7110	732,240
1996	1,029,873	0.6950	715,762
1997	3,387,345	0.6794	2,301,362
1998	1,029,873	0.6641	683,939
1999	1,029,873	0.6492	668,594
2000	1,029,873	0.6346	653,557
2001	1,029,873	0.6203	638,830
2002	3,387,345	0.6064	2,054,086
2003	1,029,873	0.5927	610,406
2004	1,029,873	0.5794	596,708
2005	1,029,873	0.5664	583,320
2006	1,029,873	0.5536	570,138
2007	3,387,345	0.5412	1,833,231
2008	1,029,873	0.5290	544,803
2009	1,029,873	0.5171	532,547
2010	1,029,873	0.5055	520,601
2011	1,029,873	0.4941	508,860
2012	3,387,345	0.4830	1,636,088
2013	1,029,873	0.4722	486,306
2014	1,029,873	0.4616	475,389

Total Present Worth of Future Costs :

\$36,602,592

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
 (Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$1,499,473

[Plant # 2]

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 2

Levelized Capital Cost

\$414

Levelized Operation and Maintenance Costs

\$1,499,473

Total Levelized Revenue Requirement

\$1,499,887

Levelized Revenue Requirement per Ton of Waste Disposed

\$14.42

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$12.94

SECTION 4
HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

At the present time in the Philadelphia area, there is only one approved hazardous waste landfill which will be operating under interim status in January 1983. A private company operates a hazardous landfill near Gilbertsville which is about 40 miles northwest of Philadelphia. For the purpose of this analysis, it was assumed that the utility would acquire a tract of land in the same general area to utilize for construction of a landfill.

In the future, fly and bottom ash would continue to be trucked to the new landfill. Leachate treatment facilities are provided and were sized based on a 10-year, 24-hour rainfall event falling on half the area of one open cell. Internal cell diking will preclude contamination of all storm water runoff. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes could continue to be treated in the existing wastewater treatment plant.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities
2. Liner System	Use a single liner system as specified in the EPA guidance documents	Use a double liner system as specified in the EPA guidance documents

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed cells on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Figure 4.1 is a layout of the cells which are proposed for ash disposal under the hazardous waste scenario. Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

PROPOSED HAZARDOUS WASTE SCHEMATIC

SCALE 0 2000 4000 FEET

HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION ⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.2

HAZARDOUS MAXIMUM LANDFILL – TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.3

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 2

Design Mode: Hazardous Min

Date 11-29-1982

Power Plant Information (1980)

Generating capacity of plant	767 kw
Generating capacity of largest boiler	354 kw

Waste Production Information *

Fly ash	72786 dry ton/yr
Bottom Ash	31326 dry ton/yr
No FGI	--
Waste densities (as disposed)	
Fly ash	80 lb/cu ft
Bottom ash	80 lb/cu ft

General Disposal Site Information

Site area	220 acres
Percent heavily wooded	50 %
Percent lightly wooded	50 %
Site perimeter	13192 ft
Distance to plant	40 mi
Distance to main road	500 ft
Distance from disposal site to leachate treatment plant	2000 ft
Thickness of soils above bedrock	30 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	25 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	10 mi

Climatic Information

Maximum frost penetration	25 in
Total annual precipitation	43.73 in
10-yr, 24-hr rainfall event	5 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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HAZARDOUS MIN CELL GEOMETRY

Disposal Cell Cross-Section
Dry Landfill w/ Single Liner

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	220	[acres]	3,400	749,760
clear and grub	129	[acres]	1,494	192,823
heavy stump removal	65	[acres]	1,022	66,019
light stump removal	65	[acres]	613	39,612
final grading	132	[acres]	619	81,724
cut & fill non-compacted	586,233	[cy]	1.73	1,012,261
on-site structural cut/fill	859,153	[cy]	2.72	2,332,636
borrow material import	294,073	[cy]	6.71	2,472,892
topsoil removal & stockpile	285,117	[cy]	1.73	492,317
sand collection zone plant	296,395	[cy]	10.01	2,966,373
sand import	296,395	[cy]	7.21	-2,138,078
clay liner/cap placement	293,117	[cy]	5.34	1,565,009
synthetic membrane	6,529,283	[sf]	0.64	4,153,669
seeding and mulching -grass	638,880	[sy]	6.48	304,822
gravel stabilization	3,967	[sy]	0.80	3,155
plastic filter fabric	725,476	[sy]	0.82	593,381
light duty bituminous road	8,000	[lf]	14.40	115,200
heavy duty bituminous road	500	[lf]	18.90	9,450
perimeter fencing	13,192	[ft]	13.63	179,833
plastic pipe, pvc-4"	11,439	[lf]	11.30	129,257
plastic pipe, pvc-6"	17,666	[lf]	16.28	287,583
leachate collect sumps	1,050	[lf]	107	112,123
soil borings	1,980	[lf]	17.04	33,739
groundwater monitoring wells	643	[lf]	13.63	8,771

CELL CONSTRUCTION COST SUBTOTAL

\$20,041,130.

Leachate Treatment Plant Construction Cost
No Wet-to-Dry Conversion for Fly Ash or Bottom Ash

\$1,795,004.

CONSTRUCTION COST TOTAL

\$21,836,940.

Contractor Overhead 15%
Contractor Profit 10%
Engineering & Legal Costs 10%
Contingency 15%

50%

Other Capital Items = \$21,836,940. x 0.50 =

\$10,918,470.

Permitting Cost

\$250,000

TOTAL CAPITAL REQUIREMENT =

\$33,005,410.

* Site Cost Adjustment Factor (SCAF) = 1.136
Site Unit Cost = SCAF x National-Average Unit Cost

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TABLE 4.4

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	7,238,234	1.0000	7,238,234
1985	4,294,529	0.8925	3,832,867
1990	4,294,529	0.7966	3,421,022
1995	4,294,529	0.7110	3,053,410
2000	4,294,529	0.6346	2,725,308
2005	4,294,529	0.5664	2,432,421
2010	4,294,529	0.5055	2,170,884

Total Cap Exp \$33,005,408

Present Worth of all Capital Costs

\$24,874,147

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$1,840,687

[Plant # 2]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	72,786	3.98	289,397	Dry disposal
Bottom ash	31,326	3.98	124,552	Dry disposal
Total handling			413,949	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	72,786	8.63	628,176	open on road truck (16cy) 40 mi. hau
Bottom ash	31,326	8.63	270,338	open on road truck (16cy) 40 mi. hau
Total transportation			898,467	
<u>Landfill costs</u>				
Flyash	72,786	1.13	81,919	
Bottom ash	31,326	1.13	35,257	
Total landfill cost			117,176	
Leachate Treatment Plant O and M			\$209,597	
Total non-administrative O and M			<u>\$1,839,189</u>	

Administrative O&M Cost Items

Manifesting	\$11,639
Groundwater monitoring	\$19,321
Inspection	\$3,824
Personnel training	\$1,365
Non-sudden occurrence insurance	\$22,966
General administration	\$47,652
Total Annual Administration cost	<u>\$105,967</u>
Total annual operation and maintenance cost	\$1,745,158

Post closure O&M costs

Existing site (1980-2010)	\$0
New site	
Groundwater monitoring	\$38,647
Inspection	\$6,048
Maintenance	\$20,620
Administrative services	\$6,362
Total annual post closure cost (2014-2044)	<u>\$71,677</u>

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TABLE 4.6
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	1,745,158	1.0000	1,745,158	Begin post closure operation and maintenance of existing site
1981	1,745,158	0.9775	1,705,892	
1982	1,745,158	0.9555	1,667,498	
1983	1,745,158	0.9341	1,630,152	
1984	1,745,158	0.9131	1,593,504	
1985	1,745,158	0.8925	1,557,554	
1986	1,745,158	0.8725	1,522,650	
1987	1,745,158	0.8528	1,488,271	
1988	1,745,158	0.8337	1,454,938	
1989	1,745,158	0.8149	1,422,129	
1990	1,745,158	0.7966	1,390,193	
1991	1,745,158	0.7787	1,358,955	
1992	1,745,158	0.7612	1,328,414	
1993	1,745,158	0.7441	1,298,572	
1994	1,745,158	0.7273	1,269,253	
1995	1,745,158	0.7110	1,240,807	
1996	1,745,158	0.6950	1,212,885	
1997	1,745,158	0.6794	1,185,660	
1998	1,745,158	0.6641	1,158,959	
1999	1,745,158	0.6492	1,132,957	
2000	1,745,158	0.6346	1,107,477	
2001	1,745,158	0.6203	1,082,522	
2002	1,745,158	0.6064	1,058,264	
2003	1,745,158	0.5927	1,034,355	
2004	1,745,158	0.5794	1,011,145	
2005	1,745,158	0.5664	988,457	
2006	1,745,158	0.5536	966,119	
2007	1,745,158	0.5412	944,480	End post closure operation and maintenance of existing site
2008	1,745,158	0.5290	923,189	
2009	1,745,158	0.5171	902,421	
2010	1,745,158	0.5055	882,177	
2011	1,745,158	0.4941	862,283	Begin post closure operation and maintenance
2012	1,745,158	0.4830	842,911	
2013	1,745,158	0.4722	824,064	
2014	1,745,158	0.4616	805,565	
2015	71,676	0.4512	32,340	
2016	71,676	0.4410	31,609	
2017	71,676	0.4311	30,900	
2018	71,676	0.4214	30,204	
2019	71,676	0.4120	29,531	
2020	71,676	0.4027	28,864	
2021	71,676	0.3936	28,212	
2022	71,676	0.3848	27,581	
2023	71,676	0.3761	26,957	
2024	71,676	0.3677	26,355	
2025	71,676	0.3594	25,760	

(continued next page)

[Plant # 2]

TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	71,676	0.3513	25,180	
2027	71,676	0.3434	24,614	
2028	71,676	0.3357	24,062	
2029	71,676	0.3282	23,524	
2030	71,676	0.3208	22,994	
2031	71,676	0.3136	22,478	
2032	71,676	0.3065	21,969	
2033	71,676	0.2996	21,474	
2034	71,676	0.2929	20,994	
2035	71,676	0.2863	20,521	
2036	71,676	0.2799	20,062	
2037	71,676	0.2736	19,611	
2038	71,676	0.2674	19,166	
2039	71,676	0.2614	18,736	
2040	71,676	0.2555	18,313	
2041	71,676	0.2498	17,905	
2042	71,676	0.2442	17,503	
2043	71,676	0.2387	17,109	
2044	71,676	0.2333	16,722	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$43,311,078	
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			\$1,261,485	

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 2

Levelized Capital Cost

\$1,840,687

Levelized Operation and Maintenance Costs

\$1,261,485

Total Levelized Revenue Requirement

\$3,102,172

Levelized Revenue Requirement per Ton of Waste Disposed

\$29.80

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$32.18

TABLE 4.8

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 2

Design Mode: Hazardous Max

Date 11-29-1982

Power Plant Information (1980)

Generating capacity of plant	707 mw
Generating capacity of largest boiler	354 mw

Waste Production Information *

Fly ash	72786 dry ton/yr
Bottom Ash	31326 dry ton/yr
No FGI	--
Waste densities (as disposed):	
Fly ash	80 lb/cu ft
Bottom ash	80 lb/cu-ft

General Disposal Site Information

Site area	220 acres
Percent heavily wooded	50 %
Percent lightly wooded	50 %
Site perimeter	13192 ft
Distance to plant	40 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	2000 ft
Thickness of soils above bedrock	30 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	25 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	10 mi

Climatic Information

Maximum frost penetration	25 in
Total annual precipitation	43.73 in
10-yr, 24-hr rainfall event	5 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

[2011-29-1982010:51:33]

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TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	7
Cell volume	462554.1 cu yd
Depth of waste at edge of fill	48 ft
Cell dimensions	
length at top	1119 ft
width at top	373 ft
length at bottom	959 ft
width at bottom	213 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	9192 ft

Disposal Cell Cross-Section
Dry Landfill w/ Double Liner

NOTE: Datum is below existing ground surface an average of 20 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	220	[acres]	3,400	749,700
clear and grub	129	[acres]	1,494	192,823
heavy stump removal	65	[acres]	1,022	66,019
light stump removal	65	[acres]	613	39,612
final grading	132	[acres]	619	81,724
cut & fill non-compacted	897,183	[cy]	1.73	1,549,185
on-site structural cut/fill	560,657	[cy]	2.72	1,522,206
borrow material import	823,656	[cy]	-6.41	6,925,978
topsoil removal & stockpile	294,141	[cy]	1.73	507,899
sand collection zone placmt	367,721	[cy]	10.01	3,680,212
sand import	367,721	[cy]	7.21	2,652,593
clay liner/cap placement	593,238	[cy]	5.34	3,167,416
synthetic membrane	6,652,671	[sf]	0.64	4,232,163
seeding and mulching -grass	638,880	[sq]	0.40	255,552
gravel stabilization	3,967	[sq]	0.00	3,155
plastic filter fabric	739,166	[sq]	0.02	14,783
light duty bituminous road	8,023	[sf]	14.40	116,532
heavy duty bituminous road	500	[sf]	16.96	8,480
perimeter fencing	13,192	[ft]	13.63	179,833
plastic pipe, pvc-4"	22,876	[lf]	11.30	258,504
plastic pipe, pvc-6"	35,332	[lf]	16.28	575,163
leachate collect sumps	1,050	[lf]	107	112,350
soil borings	1,980	[lf]	17.04	33,739
groundwater monitoring wells	643	[lf]	13.63	8,771
CELL CONSTRUCTION COST SUBTOTAL				\$27,572,450.
Leachate Treatment Plant Construction Cost No Wet-to-Dry Conversion for Fly Ash or Bottom Ash				\$1,795,864.
CONSTRUCTION COST TOTAL				\$29,368,250.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items = \$29,368,250. x 0.50 =				\$14,684,130.
Permitting Cost				\$500,000
TOTAL CAPITAL REQUIREMENT =				\$44,552,380.

* Site Cost Adjustment Factor (SCAF) = 1.136
 Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.11

HAZARDOUS MAX 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	9,102,087	1.0000	9,102,087
1985	5,908,381	0.8925	5,273,230
1990	5,908,381	0.7966	4,706,616
1995	5,908,381	0.7110	4,200,859
2000	5,908,381	0.6346	3,749,459
2005	5,908,381	0.5664	3,346,507
2010	5,908,381	0.5055	2,986,687

Total Cap Exp \$44,552,373

Present Worth of all Capital Costs \$33,365,444

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST \$2,469,043

[Plant # 2]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	72,786	3.98	289,397	Dry disposal
Bottom ash	31,326	3.98	124,552	Dry disposal
Total handling			413,949	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	72,786	8.63	628,136	open on road truck (16cy) 40 mi. hau
Bottom ash	31,326	8.63	270,336	open on road truck (16cy) 40 mi. hau
Total transportation			898,467	
Landfill costs				
Flyash	72,786	1.13	81,919	
Bottom ash	31,326	1.13	35,257	
Total landfill cost			117,176	
Leachate Treatment Plant O and M			\$269,597	
Total non-administrative O and M			\$1,639,189	

Administrative O&M Cost Items

Manifesting	\$11,639
Groundwater monitoring	\$19,323
Inspection	\$3,824
Personnel training	\$1,363
Non-sudden occurrence insurance	\$22,966
General administration	\$47,652
Total Annual Administration cost	\$185,967
Total annual operation and maintenance cost	\$1,745,156

Post closure O&M costs

Existing site (1980-2010)	\$0
New site	
Groundwater monitoring	\$38,647
Inspection	\$6,846
Maintenance	\$20,620
Administrative services	\$6,362
Total annual post closure cost (2014-2044)	\$71,875

TABLE 4.13

HAZARDOUS MAX 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	1,745,158	1.0000	1,745,158	Begin post closure operation and maintenance of existing site
1981	1,745,158	0.9775	1,705,892	
1982	1,745,158	0.9555	1,667,498	
1983	1,745,158	0.9341	1,630,152	
1984	1,745,158	0.9131	1,593,504	
1985	1,745,158	0.8925	1,557,554	
1986	1,745,158	0.8725	1,522,650	
1987	1,745,158	0.8528	1,488,271	
1988	1,745,158	0.8337	1,454,938	
1989	1,745,158	0.8149	1,422,129	
1990	1,745,158	0.7966	1,390,193	
1991	1,745,158	0.7787	1,358,955	
1992	1,745,158	0.7612	1,328,414	
1993	1,745,158	0.7441	1,298,572	
1994	1,745,158	0.7273	1,269,253	
1995	1,745,158	0.7110	1,240,807	
1996	1,745,158	0.6950	1,212,885	
1997	1,745,158	0.6794	1,185,660	
1998	1,745,158	0.6641	1,158,959	
1999	1,745,158	0.6492	1,132,957	
2000	1,745,158	0.6346	1,107,477	
2001	1,745,158	0.6203	1,082,522	
2002	1,745,158	0.6064	1,058,264	
2003	1,745,158	0.5927	1,034,355	
2004	1,745,158	0.5794	1,011,145	
2005	1,745,158	0.5664	988,457	
2006	1,745,158	0.5536	966,119	
2007	1,745,158	0.5412	944,480	
2008	1,745,158	0.5290	923,189	
2009	1,745,158	0.5171	902,421	
2010	1,745,158	0.5055	882,177	
2011	1,745,158	0.4941	862,283	
2012	1,745,158	0.4830	842,911	End post closure operation and maintenance of existing site
2013	1,745,158	0.4722	824,064	
2014	1,745,158	0.4616	805,565	
2015	71,676	0.4512	32,340	
2016	71,676	0.4410	31,609	Begin post closure operation and maintenance
2017	71,676	0.4311	30,900	
2018	71,676	0.4214	30,204	
2019	71,676	0.4120	29,531	
2020	71,676	0.4027	28,864	
2021	71,676	0.3936	28,212	
2022	71,676	0.3848	27,581	
2023	71,676	0.3761	26,957	
2024	71,676	0.3677	26,355	
2025	71,676	0.3594	25,760	

(continued next page)

[Plant # 2]

TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	71,676	0.3513	25,180	
2027	71,676	0.3434	24,614	
2028	71,676	0.3357	24,062	
2029	71,676	0.3282	23,524	
2030	71,676	0.3208	22,994	
2031	71,676	0.3136	22,478	
2032	71,676	0.3065	21,969	
2033	71,676	0.2996	21,474	
2034	71,676	0.2929	20,994	
2035	71,676	0.2863	20,521	
2036	71,676	0.2799	20,062	
2037	71,676	0.2736	19,611	
2038	71,676	0.2674	19,166	
2039	71,676	0.2614	18,736	
2040	71,676	0.2555	18,313	
2041	71,676	0.2498	17,905	
2042	71,676	0.2442	17,503	
2043	71,676	0.2387	17,109	
2044	71,676	0.2333	16,722	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$43,311,078	
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			\$1,261,485	

[Plant # 2]

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 2

Levelized Capital Cost

\$2,469,043

Levelized Operation and Maintenance Costs

\$1,261,485

Total Levelized Revenue Requirement

\$3,730,528

Levelized Revenue Requirement per Ton of Waste Disposed

\$35.83

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$38.70

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 0	\$ 1,493,000	\$ 1,493,000	\$ 14.35	\$ 12.88
Non-Hazardous	400	1,499,000	1,500,000	14.42	12.94
Hazardous Minimum	1,841,000	1,261,000	3,102,000	29.80	32.18
Hazardous Maximum	2,469,000	1,261,000	3,730,000	35.83	38.70

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data 1980, Kingston, MA.

PLANT 2

RCRA Impact
Case Study of Plant 3

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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal in the utility industry. These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 3 is located in western Pennsylvania and has a current nameplate capacity of 1,800 MW. The plant has two pulverized coal-fired boilers. Fuel oil is used only for start-up and flame stabilization. Both boilers are dry-bottom tangentially-fired.

Bituminous coal for the plant is delivered by truck or conveyor from nearby mines. Normally a 60-day stockpile of coal is maintained on-site. Coal consumption for 1980 was 4,298,000 tons. The average analysis of the coal consumed during 1980 was 1.67 percent sulfur, 17.9 percent ash content, and 12,148 BTU's/lb. Projected 1985 and 2000 rates of coal consumption are 3,500,000 and 4,660,000 tons, respectively.

Each of the boilers is equipped with an electrostatic precipitator (ESP). Particulate removal for these units is estimated at 99.6 percent. The units presently meet the Federal and state emission limits. Table 1.1 summarizes plant characteristics including year of boiler start-up, 1980 availability factor, coal used, and air pollution control equipment.

EXISTING DISPOSAL

The schematic flow diagram of the existing disposal facilities for the plant is shown in Figure 1.2. The quantities of major waste materials generated are summarized in Table 1.2.

Fly ash from both units is pneumatically conveyed to dry storage silos. Any fly ash not sold is moisture conditioned and truck hauled to an on-site structural landfill. The bottom ash is hydraulically transported to hydrobins for dewatering before it is truck hauled to sales stockpiles or to the same on-site structural landfill. There are auxiliary ponds for the bottom ash sluicing. The ash disposal area is shown on Figure 1.3.

The coal pile runoff and other low volume wastes such as boiler and cooling tower blowdown, roof and floor drainage, water treatment plant effluent, and transport water are discharged into the treatment pond. Overflow from the treatment pond is discharged to a creek.

SCHEMATIC FLOW DIAGRAM

FIGURE 1.2

1-5

PLANT 3 75

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 3

Boiler	Stack	MW (Nameplate)	Year of Start-up	1980 Availability Factor	1980 Coal Used (tons)	1985 Coal Projections (tons)	2000 Coal Projections (tons)	Type of Control	
								Particulate	SO ₂
1	1	900	1965	86%	2,354,000	1,750,000	2,330,000	ESP	None
2	2	900	1965	73%	1,944,000	1,750,000	2,330,000	ESP	None
TOTAL		1,800			4,298,000	3,500,000	4,660,000		

Table 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 3

Waste Product	1980 Values	1985 Values	2000 Values	35-Year Average*
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	613,800	252,000	336,000	335,800
Tons Sold	<u>57,400</u>	<u>23,562</u>	<u>31,416</u>	<u>31,400</u>
Tons Disposed	556,400	228,438	304,584	304,400
<u>Bottom Ash (Dry Weight)</u>				
Tons Produced	153,400	63,000	84,000	419,950
Tons Sold	<u>70,600</u>	<u>28,980</u>	<u>38,640</u>	<u>38,620</u>
Tons Disposed	82,800	34,020	45,360	381,330
<u>Other Wastes</u>				
Coal Pile Runoff (MG/yr)	18.7	18.7	18.7	
Coal Cleaning Waste (tons)	0	315,000	420,000	**

** For the purpose of this study, the projected coal cleaning wastes (336,000 tons) were included in the 35-Year Average for bottom ash.

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates.

The additional current practice disposal capacity necessary to provide disposal until 2014 would be available by the construction of two landfills. The power company has completed a long range disposal program extending the plant disposal life to the year 2003 by proposing construction of one new landfill. A second structural landfill site adjacent to the plant would be necessary to give the additional 12 years of life to meet the project criteria of a 35 year disposal life (Figure 2.2).

In addition to clearing and grubbing to develop the proposed landfill sites it will require the construction of toe dikes, surface drainage controls, spring drains, and sedimentation basins. The two proposed landfill sites are shown on Figure 2.2.

The disposal and sales operations would continue as they now exist for the fly ash and bottom ash. In the mid 1980's when the on-site coal cleaning plant becomes operational the coal cleaning wastes would then

CURRENT PRACTICE HANDLING & DISPOSAL

Operation Activity
Construction Activity

PLANT 3

FIGURE 2.1

CURRENT PRACTICE WASTE DISPOSAL SITES

be codisposed with the ash in the structural landfill. Coal cleaning waste volumes would approximately equal the reduction in ash volumes. Coal cleaning wastes would not be expected to change the total waste quantities and are included with the bottom ash volumes for calculation of the 35-year average and disposal costs.

A water truck would be used to control dust at the landfill. A dozer would be required to spread the fly ash and bottom ash at the proposed landfill. A self-propelled compactor would be used to consolidate the waste material. This method of waste placement would minimize the waste volume, reduce the permeability of the waste fill, and increase landfill stability. At closure, a proposed 12-inch layer of topsoil would be placed and compacted on the disposal areas. These areas would be seeded to establish a vegetative cover to control erosion.

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies

to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 3

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	1800 MW
Generating capacity of largest boiler	900 MW

Waste Production Information*

Fly ash	304400 dry ton/yr
Bottom Ash	381330 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	66.4 lb/cu ft
Bottom ash	88.1 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 2.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1981

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

\$902,728

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$1,399,092.

* Site cost adjustment factor (SCAF) = 1.205

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 2.2 (continued)

Construction Cost Items for Period 2
1982 - 2000

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
clear and grub	91 [acres]		1,585	144,195
light stump removal	40 [acres]		651	26,028
final grading	115 [acres]		657	75,523
cut & fill non-compacted	2,286 [cy]		1.83	4,191
on-site structural cut/fill	15,073 [cy]		2.88	43,409
topsoil removal & stockpile	371,667 [cy]		1.83	679,646
seeding and mulching -grass	12,870 [sy]		0.51	6,514
riprap, hand placed	88 [sy]		20.82	1,832
concrete	931 [cy]		113	105,208
drainage cap-48"	121 [lf]		57.18	6,918
plastic pipe, pvc-6"	6,615 [lf]		17.27	114,226
soil borings	1,166 [lf]		18.08	20,967
groundwater monitoring wells	142 [lf]		14.46	2,024

CONSTRUCTION COST TOTAL**\$1,230,683.**

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%

Other Capital Items = \$1,230,683. x 0.50 =

\$615,342

CONSTRUCTION CAPITAL REQUIREMENT =**\$1,846,025.****Closure Cost****\$1,072,636.****CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)****\$1,608,954.**

* Site cost adjustment factor (SCAF)= 1.205

Site Unit cost= SCAF x National Average Unit Cost

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TABLE 2.2 (continued)

Construction Cost Items for Period 3
2001 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
clear and grub	69 [acres]		1,585	109,336
light stump removal	96 [acres]		651	62,467
final grading	75 [acres]		657	49,254
cut & fill non-compacted	2,288 [cy]		1.83	4,191
on-site structural cut/fill	11,898 [cy]		2.88	34,266
topsoil removal & stockpile	288,855 [cy]		1.83	366,421
seeding and mulching -grass	6,188 [sy]		0.51	3,091
riprap, hand placed	88 [sy]		20.82	1,832
concrete	1,558 [cy]		113	176,062
drainage cap-48"	119 [lf]		57.18	6,804
drainage pipe-48"	60 [lf]		72.84	4,371
plastic pipe, pvc-6"	6,615 [lf]		17.27	114,226
misc drainage structures	3,720 [ls]		1.21	4,483
soil borings	620 [lf]		18.88	11,287
groundwater monitoring wells	140 [lf]		14.46	2,024

CONSTRUCTION COST TOTAL

\$950,833

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

56%

Other Capital Items = $950,833 \times 0.50 =$

\$475,017

CONSTRUCTION CAPITAL REQUIREMENT =

\$1,425,850.

Closure Cost

\$578,290

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$867,436

* Site cost adjustment factor (SCAF) = 1.205

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 2.3
CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations
 Nominal Return : 8.4 %
 Inflation Rate : 6.0 %
 Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	1,846,025	0	0.9775	1,804,489
1982	0	1,399,092	0.9555	1,336,832
1983	0	0	0.9341	0
1984	0	0	0.9131	0
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	1,425,050	0	0.6346	904,337
2001	0	1,608,954	0.6203	998,034
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5411	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	867,436	0.4512	391,387

Total Present Worth of Future Capital Expenditures :

\$5,435,080

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$402,196

[Plant # 3]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1981

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	384,400	4.22	1,283,807	Dry disposal
Bottom ash	381,330	4.22	1,608,259	Dry disposal
Total handling			2,892,067	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	384,400	0.68	260,610	open off road truck (30cy) 1.6 mi. h
Bottom ash	381,330	0.68	260,678	open off road truck (30cy) 1.6 mi. h
Total transportation			467,688	
Landfill costs				
Flyash	384,400	1.44	437,872	
Bottom ash	381,330	1.02	413,392	
Total landfill cost			851,230	
Annual operation and maintenance cost			\$4,210,985	

[3:11-10-1982:14:23:23]

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TABLE 2.4 (continued)

O&M Costs for Period 2
1982 to 2000

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	304,400	4.22	1,283,807	Dry disposal
Bottom ash	381,330	4.22	1,608,259	Dry disposal
Total handling			2,892,067	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	304,400	0.68	207,610	open off road truck (30cy) 1.6 mi. h
Bottom ash	381,330	0.68	260,678	open off road truck (30cy) 1.6 mi. h
Total transportation			467,688	
Landfill costs				
Flyash	304,400	1.44	437,936	
Bottom ash	381,330	1.08	413,392	
Total landfill cost			851,230	
Annual operation and maintenance cost			\$4,210,985	

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TABLE 2.4 (continued)

O&M Costs for Period 3
2001 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	304,400	4.22	1,283,807	Dry disposal
Bottom ash	381,330	4.22	1,608,259	Dry disposal
Total handling			2,892,067	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	304,400	0.68	207,610	open off road truck (30cy) 1.6 mi. h
Bottom ash	381,330	0.68	260,078	open off road truck (30cy) 1.6 mi. h
Total transportation			467,688	
Landfill costs				
Flyash	304,400	1.44	437,830	
Bottom ash	381,330	1.08	413,392	
Total landfill cost			851,230	

Annual operation and maintenance cost \$4,210,985

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TABLE 2.5
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	4,210,985	1.0000	4,210,985
1981	4,210,985	0.9775	4,116,238
1982	4,210,985	0.9555	4,023,596
1983	4,210,985	0.9341	3,933,481
1984	4,210,985	0.9131	3,845,050
1985	4,210,985	0.8925	3,758,304
1986	4,210,985	0.8725	3,674,084
1987	4,210,985	0.8528	3,591,128
1988	4,210,985	0.8337	3,510,698
1989	4,210,985	0.8149	3,431,532
1990	4,210,985	0.7966	3,354,471
1991	4,210,985	0.7787	3,279,094
1992	4,210,985	0.7612	3,205,402
1993	4,210,985	0.7441	3,133,394
1994	4,210,985	0.7273	3,062,649
1995	4,210,985	0.7110	2,994,010
1996	4,210,985	0.6950	2,926,635
1997	4,210,985	0.6794	2,860,943
1998	4,210,985	0.6641	2,796,515
1999	4,210,985	0.6492	2,733,771
2000	4,210,985	0.6346	2,672,291
2001	4,210,985	0.6203	2,612,074
2002	4,210,985	0.6064	2,553,541
2003	4,210,985	0.5927	2,495,851
2004	4,210,985	0.5794	2,439,345
2005	4,210,985	0.5664	2,385,102
2006	4,210,985	0.5536	2,331,201
2007	4,210,985	0.5412	2,278,985
2008	4,210,985	0.5290	2,227,611
2009	4,210,985	0.5171	2,177,500
2010	4,210,985	0.5055	2,128,653
2011	4,210,985	0.4941	2,080,648
2012	4,210,985	0.4830	2,033,906
2013	4,210,985	0.4722	1,988,427
2014	4,210,985	0.4616	1,943,791
Total Present Worth of Future Costs :			\$102,791,407
Sum of Present Worth Factors :		24.4103	
Levelized O&M Cost = (Present Worth of all O&M Costs) / (Sum of Present Worth Factors)			
LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST			\$4,210,985

[Plant # 3]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 3

Levelized Capital Cost

\$402,196

Levelized Operation and Maintenance Costs

\$4,210,985

Total Levelized Revenue Requirement

\$4,613,181

Levelized Revenue Requirement per Ton of Waste Disposed

\$6.73

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$6.99

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of ground-water monitoring wells around the existing fly ash and bottom ash facilities. The new ash landfills (Figure 2.2) would be modified with a clay liner and cap to minimize leachate migration. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes, would continue to be treated and discharged to the creek.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge

NON-HAZARDOUS HANDLING & DISPOSAL

FIGURE 3.1

rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5.

A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

TABLE 3.1

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 3

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	1800 MW
Generating capacity of largest boiler	900 MW

Waste Production Information*

Fly ash	304400 dry ton/yr
Bottom Ash	381330 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	66.4 lb/cu ft
Bottom ash	88.1 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 3.2

NON-HAZARDOUS CAPITAL COSTSConstruction Cost Items for Period 1
1980 - 1981

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		\$2,798,513.		
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$4,197,769.
* Site cost adjustment factor (SCAF)= 1.205				
Site Unit cost= SCAF x National Average Unit Cost				
[3011-10-1982013:57:54]				PAGE 2

TABLE 3.2 (continued)

Construction Cost Items for Period 2
 1982 - 2000

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
clear and grub	91 [acres]		1,585	144,195
light stump removal	40 [acres]		651	26,020
final grading	115 [acres]		657	75,525
cut & fill non-compacted	224,928 [cy]		1.83	411,978
on-site structural cut/fill	15,073 [cy]		2.88	43,409
topsoil removal & stockpile	371,067 [cy]		1.83	679,646
clay liner/cap placement	222,640 [cy]		5.66	1,260,922
seeding and mulching -grass	12,876 [sy]		0.51	6,514
riprap, hand placed	88 [sy]		20.82	1,832
concrete	931 [cy]		113	105,200
drainage cap-48"	121 [lf]		57.18	6,918
plastic pipe, pvc-6"	6,615 [lf]		17.27	114,226
soil borings	1,160 [lf]		18.08	20,967
groundwater monitoring wells	770 [lf]		14.46	11,134

CONSTRUCTION COST TOTAL**\$2,988,502.**

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%

Other Capital Items = $\$2,988,502. \times 0.50 =$ **\$1,454,251.****CONSTRUCTION CAPITAL REQUIREMENT =****\$4,362,753.****Closure Cost****\$3,216,278.****CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)****\$4,827,417.**

* Site cost adjustment factor (SCAF) = 1.205

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 3.2 (continued)

Construction Cost Items for Period 3
2001 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
clear and grub	69	[acres]	1,585	109,336
light stump removal	56	[acres]	651	36,439
final grading	75	[acres]	657	49,254
cut & fill non-compacted	122,320	[cy]	1.83	224,041
on-site structural cut/fill	11,898	[cy]	2.88	34,266
topsoil removal & stockpile	200,055	[cy]	1.83	366,421
clay liner/cap placement	120,032	[cy]	5.66	679,801
seeding and mulching -grass	120,032	[sy]	0.51	60,748
riprap, hand placed	88	[sy]	20.82	1,832
concrete	1,558	[cy]	113	176,062
drainage cap-48"	119	[lf]	57.18	6,804
drainage rccp-48"	60	[lf]	72.64	4,371
plastic pipe, pvc-6"	6,615	[lf]	17.27	114,226
misc drainage structures	3,720	[ls]	1.21	4,483
soil borings	620	[lf]	18.08	11,207
groundwater monitoring wells	490	[lf]	14.46	7,085

CONSTRUCTION COST TOTAL

\$1,886,375.

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%

Other Capital Items = \$1,886,375. x 0.50 =

\$943,188

CONSTRUCTION CAPITAL REQUIREMENT =

\$2,829,563.

Closure Cost

\$1,695,675.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$2,543,512.

* Site cost adjustment factor (SCAF)= 1.205

Site Unit cost= SCAF x National Average Unit Cost

[3011-10-1982013:57:54]

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TABLE 3.3
NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	4,362,753	0	0.9775	4,264,591
1982	0	4,197,769	0.9555	4,010,968
1983	0	0	0.9341	0
1984	0	0	0.9131	0
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	2,829,563	0	0.6346	1,795,641
2001	0	4,827,417	0.6203	2,994,447
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	2,543,512	0.4512	1,147,633

Total Present Worth of Future Capital Expenditures :

\$14,213,279

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$1,051,783

[Plant # 3]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1981

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	304,400	4.22	1,283,807	Dry disposal
Bottom ash	381,330	4.22	1,608,259	Dry disposal
Total handling			2,892,067	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	304,400	0.68	207,610	open off road truck (30cy) 1.6 mi. h
Bottom ash	381,330	0.68	260,078	open off road truck (30cy) 1.6 mi. h
Total transportation			467,688	
Landfill costs				
Flyash	304,400	1.44	437,838	
Bottom ash	381,330	1.05	413,392	
Total landfill cost			851,230	
Annual operation and maintenance cost			\$4,210,985	

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TABLE 3.4 (continued)

O&M Costs for Period 2
1982 to 2000

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	304,400	4.22	1,283,807	Dry disposal
Bottom ash	381,330	4.22	1,608,259	Dry disposal
Total handling			2,892,067	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	304,400	0.69	207,610	open off road truck (30cy) 1.6 mi. h
Bottom ash	381,330	0.68	260,076	open off road truck (30cy) 1.6 mi. h
Total transportation			467,688	
Landfill costs				
Flyash	304,400	1.44	437,858	
Bottom ash	381,330	1.08	413,392	
Total landfill cost			851,250	
Groundwater monitoring			15,319	
Annual operation and maintenance cost			\$4,226,304	

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TABLE 3.4 (continued)

O&M Costs for Period 3
2001 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	304,400	4.22	1,283,807	Dry disposal
Bottom ash	381,330	4.22	1,606,259	Dry disposal
Total handling			2,892,067	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	304,400	0.68	207,610	open off road truck (30cy) 1.6 mi. h
Bottom ash	381,330	0.68	260,078	open off road truck (30cy) 1.6 mi. h
Total transportation			467,688	
Landfill costs				
Flyash	304,400	1.44	437,838	
Bottom ash	381,330	1.08	413,392	
Total landfill cost			851,230	
Groundwater monitoring			22,522	
Annual operation and maintenance cost			\$4,233,507	

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TABLE 3.5
NON-HAZARDOUS 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	4,210,985	1.0000	4,210,985
1981	4,210,985	0.9775	4,116,238
1982	4,226,304	0.9555	4,038,233
1983	4,226,304	0.9341	3,947,791
1984	4,226,304	0.9131	3,859,038
1985	4,226,304	0.8925	3,771,976
1986	4,226,304	0.8725	3,687,450
1987	4,226,304	0.8528	3,604,192
1988	4,226,304	0.8337	3,523,470
1989	4,226,304	0.8149	3,444,015
1990	4,226,304	0.7966	3,366,674
1991	4,226,304	0.7787	3,291,023
1992	4,226,304	0.7612	3,217,063
1993	4,226,304	0.7441	3,144,793
1994	4,226,304	0.7273	3,073,791
1995	4,226,304	0.7110	3,004,902
1996	4,226,304	0.6950	2,937,281
1997	4,226,304	0.6794	2,871,351
1998	4,226,304	0.6641	2,806,688
1999	4,226,304	0.6492	2,743,717
2000	4,226,304	0.6346	2,682,013
2001	4,233,507	0.6203	2,626,044
2002	4,233,507	0.6064	2,567,199
2003	4,233,507	0.5927	2,509,200
2004	4,233,507	0.5794	2,452,894
2005	4,233,507	0.5664	2,397,858
2006	4,233,507	0.5536	2,343,669
2007	4,233,507	0.5412	2,291,174
2008	4,233,507	0.5290	2,239,525
2009	4,233,507	0.5171	2,189,146
2010	4,233,507	0.5055	2,140,038
2011	4,233,507	0.4941	2,091,776
2012	4,233,507	0.4830	2,044,784
2013	4,233,507	0.4722	1,999,062
2014	4,233,507	0.4616	1,954,187

Total Present Worth of Future Costs :

\$103,189,240

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$4,227,283

[Plant # 3]

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 3

Levelized Capital Cost

\$1,051,783

Levelized Operation and Maintenance Costs

\$4,227,283

Total Levelized Revenue Requirement

\$5,279,066

Levelized Revenue Requirement per Ton of Waste Disposed

\$7.70

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$8.00

SECTION 4

HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

The proposed design consists of acquiring a tract of land adjacent to the active landfill. For the purpose of this analysis, it has been determined that it will be most cost effective in the future if dry handling systems are utilized for the disposal of the fly ash and bottom ash. In the future, all fly ash and bottom ash will be trucked to the new landfill. Leachate treatment facilities are provided and were sized based on a 10-year, 24-hour rainfall event falling on half the area of one open cell. Internal cell diking will preclude contamination of all storm water runoff. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes could be used to moisture condition the ash before placement in the landfill.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities

Design FactorHazardous MinimumHazardous Maximum

2. Liner System	Use a single liner system as specified in the EPA guidance documents	Use a double liner system as specified in the EPA guidance documents
-----------------	--	--

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. It was assumed that because of RCRA restrictions ash would no longer be able to be sold for other uses. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed cells on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Figure 4.1 is a layout of the cells which are proposed for ash disposal under the hazardous waste scenario. Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the

HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION ⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.2

HAZARDOUS MAXIMUM LANDFILL – TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 3

Design Mode: Hazardous Min

Date 11-11-1982

Power Plant Information (1980)

Generating capacity of plant	1800 MW
Generating capacity of largest boiler	900 MW

Waste Production Information *

Fly ash	335800 dry ton/yr
Bottom Ash	419950 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	80 lb/cu ft
Bottom ash	106 lb/cu ft

General Disposal Site Information

Site area	978 acres
Percent heavily wooded	12.5 %
Percent lightly wooded	12.5 %
Site perimeter	29750 ft
Distance to plant	1.6 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	3200 ft
Thickness of soils above bedrock	30 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	25 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	20 mi

Climatic Information

Maximum frost penetration	40 in
Total annual precipitation	43.73 in
10-yr, 24-hr rainfall event	3.8 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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TABLE 4.2

HAZARDOUS MIN CELL GEOMETRY

Number of cells	18
Cell volume	2122016 cu yd
Depth of waste at edge of fill	40 ft
Cell dimensions	
length at top	2133 ft
width at top	711 ft
length at bottom	1973 ft
width at bottom	551 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	49068 ft

Disposal Cell Cross-Section
Dry Landfill w/ Single Liner

----- Grass -----	
----- Cover Soil 2.333333 ft -----	
..... Sand Drainage w/ Synthetic Filter 1 ft	
----- Membrane -----	
///// Clay Cap 2 ft ///// -----	
----- Waste -----	
..... Leachate Collection Sand w/ Synthetic Filter 1 ft	
----- Membrane Liner -----	
Bedding Soil .5 ft -----	
----- Undisturbed Soil -----	datum

NOTE: Datum is below existing ground surface an average of 18 feet at this site

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT+ COST	EXTENSION
real estate	978	[acres]	0.00	0.
clear and grub	780	[acres]	1,585	1,235,964
heavy stump removal	97	[acres]	1,085	105,738
light stump removal	97	[acres]	651	63,440
final grading	782	[acres]	657	513,822
cut & fill non-compacted	3,162,953	[cy]	1.83	5,793,265
on-site structural cut/fill	5,055,045	[cy]	2.93	14,595,719
topsoil removal & stockpile	1,460,255	[cy]	1.83	2,674,683
sand collection zone placmt	1,454,839	[cy]	10.62	15,363,819
sand import	1,454,825	[cy]	7.65	11,161,540
clay liner/cap placement	1,459,825	[cy]	5.66	8,267,719
synthetic membrane	32,424,440	[sf]	0.67	21,880,012
seeding and mulching -grass	3,780,815	[sy]	0.51	1,916,508
gravel stabilization	3,967	[sy]	0.84	3,346
plastic filter fabric	3,602,715	[sy]	0.37	1,323,118
light duty bituminous road	30,578	[lf]	15.26	467,213
heavy duty bituminous road	300	[lf]	20.05	6,015
perimeter fencing	28,750	[ft]	14.46	415,725
plastic pipe, pvc-4"	86,970	[lf]	11.99	1,042,747
plastic pipe, pvc-6"	45,600	[lf]	17.27	791,894
leachate collect sumps	2,500	[lf]	113	283,175
jacking & boring 36" casing	100	[lf]	355	35,548
soil borings	11,736	[lf]	18.08	212,125
groundwater monitoring wells	3,435	[lf]	14.46	49,667

CELL CONSTRUCTION COST SUBTOTAL

\$90,604,520.

Leachate Treatment Plant Construction Cost

\$2,909,316.

No Wet-to-Dry Conversion for Fly Ash or Bottom Ash

Construction Cost for Closure of Existing Disposal Site(s)

\$2,608,855

CONSTRUCTION COST TOTAL

\$96,322,690.

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%

Other Capital Items = \$96,322,690. x 0.50 =

\$48,161,350.

Permitting Cost

\$250,000

TOTAL CAPITAL REQUIREMENT =

\$144,734,100.

* Site Cost Adjustment Factor (SCAF) = 1.205

Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.4

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

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YEAR OF EXPENDITURE	EXPENDITURE IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH EXPRESSED IN 1980 \$
1980	22,417,930	1.0000	22,417,930
1984	13,590,680	0.9131	12,409,650
1987	13,590,680	0.8528	11,590,132
1991	13,590,680	0.7787	10,583,063
1994	13,590,680	0.7273	9,884,502
1998	13,590,680	0.6641	9,025,571
2001	13,590,680	0.6203	8,430,299
2005	13,590,680	0.5664	7,697,761
2008	13,590,680	0.5290	7,189,470
2012	13,590,680	0.4830	6,564,298

Total Cap Exp \$144,734,050

Present Worth of all Capital Costs

\$105,792,675

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$7,828,638

[Plant # 3]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	335,800	4.22	1,416,237	Dry disposal
Bottom ash	419,950	4.22	1,771,139	Dry disposal
Total handling			3,187,376	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	335,800	0.68	229,025	open off road truck (30cy) 1.6 mi. h
Bottom ash	419,950	0.68	286,419	open off road truck (30cy) 1.6 mi. h
Total transportation			515,444	
Landfill costs				
Flyash	335,800	1.19	400,892	
Bottom ash	419,950	0.90	378,380	
Total landfill cost			779,273	
Leachate Treatment Plant O and M			\$276,194	
Total non-administrative O and M			\$4,758,286	

Administrative O&M Cost Items

Manifesting	\$33,548
Groundwater monitoring	\$111,595
Inspection	\$14,260
Personnel training	\$1,446
Non-sudden occurrence insurance	\$50,922
General administration	\$96,875
Total Annual Administration cost	\$308,645
Total annual operation and maintenance cost	\$5,066,931

Post closure O&M costs

Existing site (1980-2010)	\$69,378
New site	
Groundwater monitoring	\$223,190
Inspection	\$28,519
Maintenance	\$98,885
Administrative services	\$6,748
Total annual post closure cost (2014-2044)	\$357,342

TABLE 4.6
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	5,136,309	1.0000	5,136,309	Begin post closure operation and maintenance of existing site
1981	5,136,309	0.9775	5,020,742	
1982	5,136,309	0.9555	4,907,743	
1983	5,136,309	0.9341	4,797,826	
1984	5,136,309	0.9131	4,689,964	
1985	5,136,309	0.8925	4,584,156	
1986	5,136,309	0.8725	4,481,430	
1987	5,136,309	0.8528	4,380,244	
1988	5,136,309	0.8337	4,282,141	
1989	5,136,309	0.8149	4,185,578	
1990	5,136,309	0.7966	4,091,584	
1991	5,136,309	0.7787	3,999,644	
1992	5,136,309	0.7612	3,909,758	
1993	5,136,309	0.7441	3,821,928	
1994	5,136,309	0.7273	3,735,638	
1995	5,136,309	0.7110	3,651,916	
1996	5,136,309	0.6950	3,569,735	
1997	5,136,309	0.6794	3,489,608	
1998	5,136,309	0.6641	3,411,023	
1999	5,136,309	0.6492	3,334,492	
2000	5,136,309	0.6346	3,259,502	
2001	5,136,309	0.6203	3,186,052	
2002	5,136,309	0.6064	3,114,658	
2003	5,136,309	0.5927	3,044,290	
2004	5,136,309	0.5794	2,975,977	
2005	5,136,309	0.5664	2,909,205	
2006	5,136,309	0.5536	2,843,461	
2007	5,136,309	0.5412	2,779,770	
2008	5,136,309	0.5290	2,717,107	
2009	5,136,309	0.5171	2,655,985	
2010	5,136,309	0.5055	2,596,404	
2011	5,066,931	0.4941	2,503,571	
2012	5,066,931	0.4830	2,447,328	End post closure operation and maintenance of existing site
2013	5,066,931	0.4722	2,392,605	
2014	5,066,931	0.4616	2,338,895	
2015	357,342	0.4512	161,233	
2016	357,342	0.4410	157,588	Begin post closure operation and maintenance
2017	357,342	0.4311	154,050	
2018	357,342	0.4214	150,584	
2019	357,342	0.4120	147,225	
2020	357,342	0.4027	143,902	
2021	357,342	0.3936	140,650	
2022	357,342	0.3848	137,505	
2023	357,342	0.3761	134,396	
2024	357,342	0.3677	131,395	
2025	357,342	0.3594	128,429	

(continued next page)

[Plant # 3]

TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	357,342	0.3513	125,534	
2027	357,342	0.3434	122,711	
2028	357,342	0.3357	119,960	
2029	357,342	0.3282	117,280	
2030	357,342	0.3208	114,635	
2031	357,342	0.3136	112,062	
2032	357,342	0.3065	109,525	
2033	357,342	0.2996	107,060	
2034	357,342	0.2929	104,665	
2035	357,342	0.2863	102,307	
2036	357,342	0.2799	100,020	
2037	357,342	0.2736	97,769	
2038	357,342	0.2674	95,553	
2039	357,342	0.2614	93,409	
2040	357,342	0.2555	91,301	
2041	357,342	0.2498	89,264	
2042	357,342	0.2442	87,263	
2043	357,342	0.2387	85,298	
2044	357,342	0.2333	83,368	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$128,792,210	
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			\$3,751,222	

[Plant # 3]

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 3

Levelized Capital Cost

\$7,828,658

Levelized Operation and Maintenance Costs

\$3,751,222

Total Levelized Revenue Requirement

\$11,579,880

Levelized Revenue Requirement per Ton of Waste Disposed

\$15.32

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$19.16

TABLE 4.8

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 3

Design Mode: Hazardous Max

Date 11-11-1982

Power Plant Information (1980)

Generating capacity of plant	1800 MW
Generating capacity of largest boiler	900 MW

Waste Production Information *

Fly ash	335800 dry ton/yr
Bottom Ash	419950 dry ton/yr

No FGD

Waste densities (as disposed)

Fly ash	80 lb/cu ft
Bottom ash	106 lb/cu ft

General Disposal Site Information

Site area	978 acres
Percent heavily wooded	12.5 %
Percent lightly wooded	12.5 %
Site perimeter	28750 ft
Distance to plant	1.6 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	3200 ft
Thickness of soils above bedrock	30 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	25 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	20 mi

Climatic Information

Maximum frost penetration	40 in
Total annual precipitation	43.73 in
10-yr, 24-hr rainfall event	3.8 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

[3011-11-1982#15:53:04]

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TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	10
Cell volume	2122016 cu yd
Depth of waste at edge of fill	40 ft
Cell dimensions	
length at top	2133 ft
width at top	711 ft
length at bottom	1973 ft
width at bottom	551 ft
Cell dike information	
Dike side slopes	
exterior	3 horiz : 1 vert
interior	2 horiz : 1 vert
Average width at top of dike	25 ft
Total length of exterior dike	49056 ft

Disposal Cell Cross-Section
Dry Landfill w/ Double Liner

-----	Grass	
-----		Cover Soil
		2.333333 ft

.....		Sand Drainage w/ Synthetic Filter
.....		1 ft
-----		Membrane
////		Clay Cap
////		2 ft

-----		Waste

.....		Leachate Collection Sand w/ Synthetic Filter
.....		1 ft
-----		Membrane Liner
.....		Leachate Detection Sand
.....		1 ft

////		Secondary Clay Liner
////		2 ft

-----	Undisturbed Soil	datum

NOTE: Datum is below existing ground surface an average of 20 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	978	[acres]	0.00	0.
clear and grub	780	[acres]	1,585	1,235,964
heavy stump removal	97	[acres]	1,085	105,738
light stump removal	97	[acres]	651	63,443
final grading	782	[acres]	657	513,822
cut & fill non-compacted	4,656,427	[cy]	1.83	8,528,712
on-site structural cut/fill	4,683,420	[cy]	2.88	13,488,015
borrow material import	453,815	[cy]	8.92	4,046,667
topsoil removal & stockpile	1,458,697	[cy]	1.83	2,671,731
sand collection zone placmt	1,812,675	[cy]	10.62	19,243,448
sand import	1,812,675	[cy]	7.65	13,870,136
clay liner/cap placement	2,919,575	[cy]	5.66	16,535,013
synthetic membrane	32,751,870	[sf]	0.67	22,100,962
seeding and mulching -grass	3,786,816	[sq]	0.51	1,916,508
gravel stabilization	3,967	[sf]	0.84	3,334
plastic filter fabric	3,639,097	[sq]	0.67	2,440,201
light duty bituminous road	30,573	[lf]	15.28	467,213
heavy duty bituminous road	300	[lf]	20.05	6,015
perimeter fencing	28,750	[ft]	14.46	415,725
plastic pipe, pvc-4"	173,940	[lf]	11.99	2,085,494
plastic pipe, pvc-6"	91,720	[lf]	17.27	1,583,789
leachate collect sumps	2,560	[lf]	113	283,175
jacking & boring 36" casing	100	[lf]	355	35,548
soil borings	11,736	[lf]	18.66	212,128
groundwater monitoring wells	3,435	[lf]	14.46	49,667

CELL CONSTRUCTION COST SUBTOTAL

\$112,619,500.

Leachate Treatment Plant Construction Cost

\$2,909,310.

No Wet-to-Dry Conversion for Fly Ash or Bottom Ash

Construction Cost for Closure of Existing Disposal Sites) \$10,559,420

CONSTRUCTION COST TOTAL

\$126,088,300.

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%

Other Capital Items = \$126,088,300. x 0.50 =

\$63,044,150.

Permitting Cost

\$500,000

TOTAL CAPITAL REQUIREMENT =

\$189,632,400.

* Site Cost Adjustment Factor (SCAF) = 1.205

Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.11

HAZARDOUS MAX 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

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YEAR OF EXPENDITURE	EXPENDITURE IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH EXPRESSED IN 1980 \$
1980	37,596,020	1.0000	37,596,020
1984	16,892,930	0.9131	15,424,934
1987	16,892,930	0.8528	14,406,291
1991	16,892,930	0.7787	13,154,525
1994	16,892,930	0.7273	12,286,228
1998	16,892,930	0.6641	11,218,595
2001	16,892,930	0.6203	10,478,684
2005	16,892,930	0.5664	9,568,156
2008	16,892,930	0.5290	8,936,360
2012	16,892,930	0.4830	8,159,285
Total Cap Exp	\$189,632,390		
Present Worth of all Capital Costs			\$141,229,078
Total Levelizing Factor (LF) =		0.0740	
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$10,450,952

[Plant # 3]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	335,800	4.22	1,416,237	Dry disposal
Bottom ash	419,950	4.22	1,771,139	Dry disposal
Total handling			3,187,376	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	335,800	0.68	229,023	open off road truck (30cy) 1.6 mi. h
Bottom ash	419,950	0.68	286,415	open off road truck (30cy) 1.6 mi. h
Total transportation			515,444	
Landfill costs				
Flyash	335,800	1.19	400,002	
Bottom ash	419,950	0.90	378,380	
Total landfill cost			779,273	
Leachate Treatment Plant O and M			\$276,194	
Total non-administrative O and M			\$4,758,266	

Administrative O&M Cost Items

Manifesting	\$33,548
Groundwater monitoring	\$111,593
Inspection	\$14,260
Personnel training	\$1,445
Non-sudden occurrence insurance	\$50,922
General administration	\$95,875
Total Annual Administration cost	\$308,645
Total annual operation and maintenance cost	\$5,066,931

Post closure O&M costs

Existing site (1980-2010)	\$69,378
New site	
Groundwater monitoring	\$223,190
Inspection	\$28,519
Maintenance	\$98,895
Administrative services	\$6,748
Total annual post closure cost (2014-2044)	\$357,342

[3#11-11-1982#15:53:04]

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TABLE 4.13
HAZARDOUS MAX 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	5,136,309	1.0000	5,136,309	Begin post closure operation and maintenance of existing site
1981	5,136,309	0.9775	5,020,742	
1982	5,136,309	0.9555	4,907,743	
1983	5,136,309	0.9341	4,797,826	
1984	5,136,309	0.9131	4,689,964	
1985	5,136,309	0.8925	4,584,156	
1986	5,136,309	0.8725	4,481,430	
1987	5,136,309	0.8528	4,380,244	
1988	5,136,309	0.8337	4,282,141	
1989	5,136,309	0.8149	4,185,578	
1990	5,136,309	0.7966	4,091,584	
1991	5,136,309	0.7787	3,999,644	
1992	5,136,309	0.7612	3,909,758	
1993	5,136,309	0.7441	3,821,928	
1994	5,136,309	0.7273	3,735,638	
1995	5,136,309	0.7110	3,651,916	
1996	5,136,309	0.6950	3,569,735	
1997	5,136,309	0.6794	3,489,608	
1998	5,136,309	0.6641	3,411,023	
1999	5,136,309	0.6492	3,334,492	
2000	5,136,309	0.6346	3,259,502	
2001	5,136,309	0.6203	3,186,052	
2002	5,136,309	0.6064	3,114,658	
2003	5,136,309	0.5927	3,044,290	
2004	5,136,309	0.5794	2,975,977	
2005	5,136,309	0.5664	2,909,205	
2006	5,136,309	0.5536	2,843,461	
2007	5,136,309	0.5412	2,779,770	
2008	5,136,309	0.5290	2,717,107	
2009	5,136,309	0.5171	2,655,985	
2010	5,136,309	0.5055	2,596,404	
2011	5,066,931	0.4941	2,503,571	End post closure operation and maintenance of existing site
2012	5,066,931	0.4830	2,447,328	
2013	5,066,931	0.4722	2,392,605	
2014	5,066,931	0.4616	2,338,895	
2015	357,342	0.4512	161,233	Begin post closure operation and maintenance
2016	357,342	0.4410	157,588	
2017	357,342	0.4311	154,050	
2018	357,342	0.4214	150,584	
2019	357,342	0.4120	147,225	
2020	357,342	0.4027	143,902	
2021	357,342	0.3936	140,650	
2022	357,342	0.3848	137,505	
2023	357,342	0.3761	134,396	
2024	357,342	0.3677	131,395	
2025	357,342	0.3594	128,429	

(continued next page)

[Plant # 3]

TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$
2026	357,342	0.3513	125,534
2027	357,342	0.3434	122,711
2028	357,342	0.3357	119,960
2029	357,342	0.3282	117,280
2030	357,342	0.3208	114,635
2031	357,342	0.3136	112,062
2032	357,342	0.3065	109,525
2033	357,342	0.2996	107,060
2034	357,342	0.2929	104,665
2035	357,342	0.2863	102,307
2036	357,342	0.2799	100,020
2037	357,342	0.2736	97,769
2038	357,342	0.2674	95,553
2039	357,342	0.2614	93,409
2040	357,342	0.2555	91,301
2041	357,342	0.2498	89,264
2042	357,342	0.2442	87,263
2043	357,342	0.2387	85,298
2044	357,342	0.2333	83,368
			End post closure operation and maintenance
Total Present Worth of Future Costs :			\$128,792,210
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			\$3,751,222

[Plant # 3]

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 3

Levelized Capital Cost

\$10,450,952

Levelized Operation and Maintenance Costs

\$3,751,222

Total Levelized Revenue Requirement

\$14,202,174

Levelized Revenue Requirement per Ton of Waste Disposed

\$18.79

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$23.50

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 402,000	\$ 4,211,000	\$ 4,613,000	\$ 6.73	\$ 6.99
Non-Hazardous	1,052,000	4,227,000	5,279,000	7.70	8.00
Hazardous Minimum	7,829,000	3,751,000	11,580,000	15.32	19.16
Hazardous Maximum	10,451,000	3,751,000	14,202,000	18.79	23.50

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

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REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data 1980,
Kingston, MA.

RCRA Impact
Case Study of Plant 4

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SECTION 1
INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal in the utility industry. These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 4 is located on the Illinois side of the Mississippi River 90 miles south of St. Louis. As shown in Table 1.1 the plant has a current nameplate rating of 184.7 MW. The plant has three (3) boilers with two generation units. One unit is serviced by one boiler and the other unit is serviced by the other two boilers. All of the boilers are pulverized coal-fired with dry bottoms.

Bituminous coal for the plant is obtained from Illinois by truck. Normally a 90 day stockpile of coal is maintained on-site. Coal consumption for 1980 was 419,400 tons. The average analysis of the coal consumed during 1980 was 3.4 percent sulfur, 12.8 percent ash, and 11,000 BTU's/lb. The projected 1985 coal consumption is 393,000 tons,

but due to removal of boilers 7 and 8 from service, the coal consumption in 2000 will be 282,000 tons.

Each of the boilers is equipped with an electrostatic precipitator (ESP). Particulate removal meets the Federal and State emission limits. Table 1.1 summarizes plant characteristics including year of boiler start-up, 1980 availability factor, coal used, and air pollution control equipment.

EXISTING DISPOSAL

The schematic flow diagram of the existing disposal facilities for this plant is shown in Figure 1.2. The quantities of major waste materials generated are summarized in Table 1.2.

Fly ash from both units is pneumatically conveyed by mechanical vacuum producers to collectors for transfer to dry fly ash storage bins. The original wet ash handling system for sluicing to the ash pond has been left in place as a backup system to the dry ash system. Bottom ash is sluiced to the ash basin for deposition (Figure 1.3).

The fly ash is loaded into bulk pneumatic trailers and is used as a raw feedstock material by a cement producer. The bottom ash is excavated and donated to local customers for road base, deicing aggregates, or fill material.

In addition to the fly ash and bottom ash, the ash pond receives direct discharge from the coal pile runoff, floor drains, yard drains, and boiler blowdown. The decant water from the ash pond is treated with carbon dioxide and discharged into the Mississippi River.

SCHEMATIC FLOW DIAGRAM

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PLANT 4 147

FIGURE 1.2

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 4

Boiler	Stack	MW (Nameplate)	Year of Start-up	1980 Availability Factor	1980 Coal Used (tons)	1985 Coal Projections (tons)	2000 Coal Projections (tons)	Type of Control Particulate SO ₂	
7	7	75.0 ¹	1957	85.9 ¹	166,200 ¹	103,000 ¹	OUT OF SERVICE	ESP	NONE
8	8	(1)	1957	(1)	(1)	(1)	OUT OF SERVICE	ESP	NONE
9	9	<u>109.7</u>	1958	78.2	<u>253,200</u>	<u>290,000</u>	<u>282,000</u>	ESP	NONE
TOTALS		184.7			419,400	393,000	282,000		

¹ Number provided is the combined value for both generating Units 7 & 8.

TABLE 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 4

Waste Product	1980 Values	1985 Values	2000 Values	35-Year Average*
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	41,600	40,200	28,900	31,844
Tons Sold	<u>39,600</u>	<u>38,270</u>	<u>27,500</u>	<u>30,252</u>
Tons Disposed	2,000	1,930	1,400	1,592
<u>Bottom Ash (Dry Weight)</u>				
Tons Produced	10,600	10,100	7,200	7,960
Tons Donated	<u>9,600</u>	<u>9,150</u>	<u>6,500</u>	<u>7,164</u>
Tons Disposed	1,000	950	700	796
<u>Other Wastes</u>				
Coal Pile Runoff (MG/yr)	4.0	4.0	4.0	
Boiler Cleaning Waste (MG/yr)	0.2	0.2	0.2	

* Average is for 1980-2014, assuming that the 2000 values remain constant through 2014.

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates.

The additional current practice disposal capacity necessary to provide disposal until 2014 is available within the existing ash pond. This assumes that the present levels of sales of fly ash and bottom ash continue and the shutdown of Units 7 & 8 proceeds as planned. The current practice design for this plant would be a continuation of the existing disposal practices.

The present dry collection of fly ash and sale as cement raw feedstock would continue with the occasional use of the backup wet sluicing system. The bottom ash sluicing to holding pond and subsequent excavation and sale would be the standard practice through 2014. At the end of this active life the present pond would be covered with six (6) inches of topsoil and seeded to establish a vegetative cover as a final closure.

CURRENT PRACTICE HANDLING & DISPOSAL

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 4

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	184.7 MW
Generating capacity of largest boiler	109.7 MW

Waste Production Information*

Fly ash	1592 dry ton/yr
Bottom Ash	796 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	82.7 lb/cu ft
Bottom ash	71.9 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 2.2

CURRENT PRACTICE CAPITAL COSTSConstruction Cost Items for Period 1
1980 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
<hr/>				
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 \$162,687

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items) \$244,031

* Site cost adjustment factor (SCAF) = 1.019

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 2.3
CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	0	0	0.9131	0
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	244,031	0.4512	110,107

Total Present Worth of Future Capital Expenditures :

\$110,107

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$8,148

[Plant # 4]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	1,592	2.55	4,056	Wet disposal
Bottom ash	796	2.55	2,026	Wet disposal
Total handling			6,083	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Annual operation and maintenance cost			\$6,083	

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TABLE 2.5
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	6,083	1.0000	6,083
1981	6,083	0.9775	5,946
1982	6,083	0.9555	5,812
1983	6,083	0.9341	5,682
1984	6,083	0.9131	5,554
1985	6,083	0.8925	5,429
1986	6,083	0.8725	5,307
1987	6,083	0.8528	5,188
1988	6,083	0.8337	5,071
1989	6,083	0.8149	4,957
1990	6,083	0.7966	4,846
1991	6,083	0.7787	4,737
1992	6,083	0.7612	4,630
1993	6,083	0.7441	4,526
1994	6,083	0.7273	4,424
1995	6,083	0.7110	4,325
1996	6,083	0.6950	4,228
1997	6,083	0.6794	4,133
1998	6,083	0.6641	4,040
1999	6,083	0.6492	3,949
2000	6,083	0.6346	3,860
2001	6,083	0.6203	3,773
2002	6,083	0.6064	3,689
2003	6,083	0.5927	3,605
2004	6,083	0.5794	3,524
2005	6,083	0.5664	3,445
2006	6,083	0.5536	3,368
2007	6,083	0.5412	3,292
2008	6,083	0.5290	3,218
2009	6,083	0.5171	3,146
2010	6,083	0.5055	3,075
2011	6,083	0.4941	3,006
2012	6,083	0.4830	2,938
2013	6,083	0.4722	2,872
2014	6,083	0.4616	2,808

Total Present Worth of Future Costs :			\$148,488
Sum of Present Worth Factors :			24.4103
Levelized O&M Cost = (Present Worth of all O&M Costs) / (Sum of Present Worth Factors)			
LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST			\$6,083

[Plant # 4]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 4

Levelized Capital Cost

\$8,148

Levelized Operation and Maintenance Costs

\$6,083

Total Levelized Revenue Requirement

\$14,231

Levelized Revenue Requirement per Ton of Waste Disposed

\$5.96

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$6.34

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of ground-water monitoring wells around the existing ash facilities. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes, would continue to be discharged to the bottom ash pond. Since the ash pond will be in continuous use until the year 2014 and represents a large ash volume, it was decided that a clay cap would be a reasonable safeguard against possible future leachate generation.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge

NON-HAZARDOUS HANDLING & DISPOSAL

FIGURE 3.1

rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5.

A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

TABLE 3.1

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 4

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	184.7 MW
Generating capacity of largest boiler	109.7 MW

Waste Production Information*

Fly ash	1592 dry ton/yr
Bottom Ash	796 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	82.7 lb/cu ft
Bottom ash	71.9 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 3.2

NON-HAZARDOUS CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1984

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				\$0.
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
* Site cost adjustment factor (SCAF)= 1.019				
Site Unit cost= SCAF x National Average Unit Cost				

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TABLE 3.2 (continued)

Construction Cost Items for Period 2
 1985 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
<hr/>				
groundwater monitoring wells	450 [1f]		12.23	\$,503
CONSTRUCTION COST TOTAL				\$,503
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
<hr/>				
	50%			
Other Capital Items =	\$5,503 x 0.50 =			\$2,751
CONSTRUCTION CAPITAL REQUIREMENT =				\$8,254
<hr/>				
Closure Cost	\$966,295			
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$1,359,442.
<hr/>				
* Site cost adjustment factor (SCAF)= 1.019				
Site Unit cost= SCAF x National Average Unit Cost				

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TABLE 3.3
NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	8,254	0	0.9131	7,537
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	1,359,442	0.4512	613,380

Total Present Worth of Future Capital Expenditures :

\$620,917

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$45,948

[Plant # 4]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1984

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	1,592	2.55	4,056	Wet disposal
Bottom ash	796	2.55	2,028	Wet disposal
Total handling			6,083	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Annual operation and maintenance cost			\$6,083	

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TABLE 3.4 (continued)

O&M Costs for Period 2
1985 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	1,592	2.55	4,056	Wet disposal
Bottom ash	796	2.55	2,028	Wet disposal
Total handling			6,083	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Groundwater monitoring			10,615	
Annual operation and maintenance cost			\$16,698	

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TABLE 3.5
NON-HAZARDOUS 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	6,083	1.0000	6,083
1981	6,083	0.9775	5,946
1982	6,083	0.9555	5,812
1983	6,083	0.9341	5,682
1984	6,083	0.9131	5,554
1985	16,698	0.8925	14,903
1986	16,698	0.8725	14,569
1987	16,698	0.8528	14,240
1988	16,698	0.8337	13,921
1989	16,698	0.8149	13,607
1990	16,698	0.7966	13,302
1991	16,698	0.7787	13,003
1992	16,698	0.7612	12,711
1993	16,698	0.7441	12,425
1994	16,698	0.7273	12,144
1995	16,698	0.7110	11,872
1996	16,698	0.6950	11,605
1997	16,698	0.6794	11,345
1998	16,698	0.6641	11,089
1999	16,698	0.6492	10,840
2000	16,698	0.6346	10,597
2001	16,698	0.6203	10,358
2002	16,698	0.6064	10,126
2003	16,698	0.5927	9,897
2004	16,698	0.5794	9,675
2005	16,698	0.5664	9,458
2006	16,698	0.5536	9,244
2007	16,698	0.5412	9,037
2008	16,698	0.5290	8,833
2009	16,698	0.5171	8,635
2010	16,698	0.5055	8,441
2011	16,698	0.4941	8,250
2012	16,698	0.4830	8,065
2013	16,698	0.4722	7,885
2014	16,698	0.4616	7,708

Total Present Worth of Future Costs :

\$356,861

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$14,619

[Plant # 4]

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 4

Levelized Capital Cost

\$45,948

Levelized Operation and Maintenance Costs

\$14,619

Total Levelized Revenue Requirement

\$60,567

Levelized Revenue Requirement per Ton of Waste Disposed

\$25.36

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$26.97

SECTION 4

HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

The proposed design consists of acquiring a tract of land located 7.5 miles north of the plant site, since the plant site and adjacent lands are within flood plains and national forest lands. For the purpose of this analysis, it has been determined that it will be most cost effective in the future if dry handling systems are utilized for the disposal of the fly ash and bottom ash. In the future, all fly ash and bottom ash will be trucked to the new landfill. Leachate treatment facilities are provided and were sized based on a 10-year, 24-hour rainfall event falling on half the area of one open cell. Internal cell diking will preclude contamination of all storm water runoff. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes could be used to moisture condition the ash before placement in the landfill.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities
2. Liner System	Use a single liner system as specified in the EPA guidance documents	Use a double liner system as specified in the EPA guidance documents

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. It was assumed that because of RCRA restrictions ash would no longer be able to be sold for other uses. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed cells on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Figure 4.1 is a layout of the seven cells which are proposed for ash disposal under the hazardous waste scenario. Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980

FIGURE 4.1

HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION ⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.2

HAZARDOUS MAXIMUM LANDFILL – TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.3

dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 4

Design Mode: Hazardous Min

Date 11-10-1982

Power Plant Information (1980)

Generating capacity of plant	184.7 MW
Generating capacity of largest boiler	109.7 MW

Waste Production Information *

Fly ash	31844 dry ton/yr
Bottom Ash	7960 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	99.2 lb/cu ft
Bottom ash	86.3 lb/cu ft

General Disposal Site Information

Site area	220 acres
Percent heavily wooded	0 %
Percent lightly wooded	0 %
Site perimeter	12470 ft
Distance to plant	7.5 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	1500 ft
Thickness of soils above bedrock	120 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	40 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	10 mi

Climatic Information

Maximum frost penetration	20 in
Total annual precipitation	43.14 in
10-yr, 24-hr rainfall event	5 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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TABLE 4.2

HAZARDOUS MIN CELL GEOMETRY

Number of cells	7
Cell volume	153855.6 cu yd
Depth of waste at edge of fill	25 ft
Cell dimensions	
length at top	783 ft
width at top	261 ft
length at bottom	683 ft
width at bottom	161 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	4496 ft

Disposal Cell Cross-Section
Dry Landfill w/ Single Liner

NOTE: Datum is below existing ground surface an average of 15 feet at this site

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	220	[acres]	3,057	672,540
clear and grub	134	[acres]	1,340	179,717
final grading	165	[acres]	555	91,634
cut & fill non-compacted	297,898	[cy]	1.55	461,409
on-site structural cut/fill	286,542	[cy]	2.44	697,848
topsoil removal & stockpile	134,074	[cy]	1.55	207,665
sand collection zone plant	147,385	[cy]	8.98	1,323,132
sand import	147,385	[cy]	6.47	953,676
clay liner/cap placement	148,947	[cy]	4.79	713,362
synthetic membrane	3,277,387	[sf]	0.57	1,874,208
seeding and mulching -grass	798,600	[sy]	0.43	341,785
gravel stabilization	3,967	[sy]	0.71	2,830
plastic filter fabric	364,154	[sy]	0.73	267,173
light duty bituminous road	4,792	[lf]	12.92	61,917
heavy duty bituminous road	300	[lf]	16.96	5,087
perimeter fencing	12,476	[ft]	12.23	152,483
drainage cap-48"	400	[lf]	48.35	19,341
plastic pipe, pvc-4"	6,158	[lf]	10.14	62,436
plastic pipe, pvc-6"	12,462	[lf]	14.60	181,973
leachate collect sumps	490	[lf]	95.79	46,935
soil borings	4,950	[lf]	15.29	75,601
groundwater monitoring wells	450	[lf]	12.23	5,496

CELL CONSTRUCTION COST SUBTOTAL

\$8,394,307.

Leachate Treatment Plant Construction Cost

\$1,414,386.

Wet-to-dry conversion cost of Bottom ash \$680,257

Construction Cost for Closure of Existing Disposal Site(s)

\$874,302

CONSTRUCTION COST TOTAL

\$11,363,250.

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%

Other Capital Items = \$11,363,250. x 0.50 =

\$5,681,626.

Permitting Cost

\$250,000

TOTAL CAPITAL REQUIREMENT =

\$17,294,880.

* Site Cost Adjustment Factor (SCAF) = 1.019

Site Unit Cost = SCAF x National-Average Unit Cost

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TABLE 4.4

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	6,502,198	1.0000	6,502,198
1985	1,798,780	0.8925	1,605,411
1990	1,798,780	0.7966	1,432,908
1995	1,798,780	0.7110	1,278,933
2000	1,798,780	0.6346	1,141,506
2005	1,798,780	0.5664	1,018,829
2010	1,798,780	0.5055	909,283
Total Cap Exp	\$17,294,878		
Present Worth of all Capital Costs			\$13,889,068
Total Levelizing Factor (LF) = 0.0740			
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$1,027,791

[Plant # 4]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	31,844	3.57	113,572	Dry disposal
Bottom ash	7,960	3.57	28,389	-- Dry disposal
Total handling			141,961	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	31,844	1.71	54,334	open on road truck (16cy) 7.5 mi. ha
Bottom ash	7,960	1.71	13,562	open on road truck (16cy) 7.5 mi. ha
Total transportation			67,915	
Landfill costs				
Flyash	31,844	0.81	25,926	
Bottom ash	7,960	0.94	7,449	
Total landfill cost			33,376	
Leachate Treatment Plant O and M			\$178,517	
Total non-administrative O and M			\$421,769	

Administrative O&M Cost Items

Manifesting	\$8,671
Groundwater monitoring	\$8,667
Inspection	\$2,713
Personnel training	\$1,223
Non-sudden occurrence insurance	\$20,208
General administration	\$38,878
Total Annual Administration cost	\$80,359
Total annual operation and maintenance cost	\$502,129

Post closure O&M costs

Existing site (1980-2010)	\$28,950
New site	
Groundwater monitoring	\$17,333
Inspection	\$5,425
Maintenance	\$17,529
Administrative services	\$5,706
Total annual post closure cost (2014-2044)	\$45,994

[4011-10-1982012:53:24]

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TABLE 4.6

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	531,079	1.0000	531,079	Begin post closure operation and maintenance of existing site
1981	531,079	0.9775	519,130	
1982	531,079	0.9555	507,446	
1983	531,079	0.9341	496,081	
1984	531,079	0.9131	484,928	
1985	531,079	0.8925	473,988	
1986	531,079	0.8725	463,366	
1987	531,079	0.8528	452,904	
1988	531,079	0.8337	442,761	
1989	531,079	0.8149	432,776	
1990	531,079	0.7966	423,058	
1991	531,079	0.7787	413,551	
1992	531,079	0.7612	404,257	
1993	531,079	0.7441	395,176	
1994	531,079	0.7273	386,254	
1995	531,079	0.7110	377,597	
1996	531,079	0.6950	369,100	
1997	531,079	0.6794	360,815	
1998	531,079	0.6641	352,690	
1999	531,079	0.6492	344,776	
2000	531,079	0.6346	337,023	
2001	531,079	0.6203	329,428	
2002	531,079	0.6064	322,046	
2003	531,079	0.5927	314,771	
2004	531,079	0.5794	307,707	
2005	531,079	0.5664	300,803	
2006	531,079	0.5536	294,005	
2007	531,079	0.5412	287,420	
2008	531,079	0.5290	280,941	
2009	531,079	0.5171	274,621	
2010	531,079	0.5055	268,460	
2011	502,129	0.4941	248,102	
2012	502,129	0.4830	242,528	End post closure operation and maintenance of existing site
2013	502,129	0.4722	237,105	
2014	502,129	0.4616	231,783	
2015	45,994	0.4512	20,752	
2016	45,994	0.4410	20,283	Begin post closure operation and maintenance
2017	45,994	0.4311	19,828	
2018	45,994	0.4214	19,382	
2019	45,994	0.4120	18,950	
2020	45,994	0.4027	18,522	
2021	45,994	0.3936	18,103	
2022	45,994	0.3848	17,698	
2023	45,994	0.3761	17,298	
2024	45,994	0.3677	16,912	
2025	45,994	0.3594	16,530	

(continued next page)

[Plant # 4]

TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$
2026	45,994	0.3513	16,158
2027	45,994	0.3434	15,794
2028	45,994	0.3357	15,440
2029	45,994	0.3282	15,095
2030	45,994	0.3208	14,755
2031	45,994	0.3136	14,424
2032	45,994	0.3065	14,097
2033	45,994	0.2996	13,780
2034	45,994	0.2929	13,472
2035	45,994	0.2863	13,168
2036	45,994	0.2799	12,874
2037	45,994	0.2736	12,584
2038	45,994	0.2674	12,299
2039	45,994	0.2614	12,023
2040	45,994	0.2555	11,751
2041	45,994	0.2498	11,489
2042	45,994	0.2442	11,232
2043	45,994	0.2387	10,979
2044	45,994	0.2333	10,730

End post closure operation
and maintenance

Total Present Worth of Future Costs :

\$13,364,880

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

\$389,268

[Plant # 4]

Page 2

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 4

Levelized Capital Cost

\$1,027,791

Levelized Operation and Maintenance Costs

\$389,268

Total Levelized Revenue Requirement

\$1,417,059

Levelized Revenue Requirement per Ton of Waste Disposed

\$35.60

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$46.29

TABLE 4.8

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 4

Design Mode: Hazardous Max

Date 11-10-1982

Power Plant Information (1980)

Generating capacity of plant	184.7 MW
Generating capacity of largest boiler	109.7 MW

Waste Production Information *

Fly ash	31844 dry ton/yr
Bottom Ash	7960 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	99.2 lb/cu ft
Bottom ash	86.3 lb/cu ft

General Disposal Site Information

Site area	220 acres
Percent heavily wooded	0 %
Percent lightly wooded	0 %
Site perimeter	12470 ft
Distance to plant	7.5 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	1500 ft
Thickness of soils above bedrock	120 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	40 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	10 mi

Climatic Information

Maximum frost penetration	20 in
Total annual precipitation	43.14 in
10-yr, 24-hr rainfall event	5 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	7
Cell volume	153855.6 cu yd
Depth of waste at edge of fill	25 ft
Cell dimensions	
length at top	783 ft
width at top	261 ft
length at bottom	683 ft
width at bottom	161 ft
Cell dike information	
Dike side slopes	
exterior	3 horiz : 1 vert
interior	2 horiz : 1 vert
Average width at top of dike	28 ft
Total length of exterior dike	4496 ft

Disposal Cell Cross-Section
Dry Landfill w/ Double Liner

NOTE: Datum is below existing ground surface an average of 18 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	220 [acres]		3,057	672,540
clear and grub	134 [acres]		1,340	179,717
final grading	165 [acres]		555	91,634
cut & fill non-compacted	457,201 [cy]		1.55	708,149
on-site structural cut/fill	267,771 [cy]		2.44	652,131
topsoil removal & stockpile	137,312 [cy]		1.55	212,679
sand collection zone plant	185,174 [cy]		8.98	1,662,380
sand import	185,174 [cy]		6.47	1,198,197
clay liner/cap placement	300,540 [cy]		4.79	1,439,374
synthetic membrane	3,365,714 [sf]		0.57	1,920,611
seeding and mulching -grass	798,600 [sy]		0.43	341,785
gravel stabilization	3,967 [sy]		0.71	2,830
plastic filter fabric	373,968 [sy]		0.73	274,373
light duty bituminous road	4,792 [lf]		12.92	61,917
heavy duty bituminous road	300 [lf]		16.96	5,087
perimeter fencing	12,470 [ft]		12.23	152,463
drainage cap-48"	400 [lf]		48.35	19,341
plastic pipe, pvc-4"	12,316 [lf]		10.14	124,871
plastic pipe, pvc-6"	24,924 [lf]		14.60	363,947
leachate collect sumps	490 [lf]		95.79	46,935
soil borings	4,950 [lf]		15.29	75,661
groundwater monitoring wells	450 [lf]		12.23	5,498

CELL CONSTRUCTION COST SUBTOTAL

\$10,212,140.

Leachate Treatment Plant Construction Cost

\$1,414,386.

Wet-to-dry conversion cost of Bottom ash

\$680,257

Construction Cost for Closure of Existing Disposal Site(s)

\$1,956,851

CONSTRUCTION COST TOTAL

\$14,263,630.

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%

Other Capital Items = \$14,263,630. x 0.50 =

\$7,131,817.

Permitting Cost

\$500,000

TOTAL CAPITAL REQUIREMENT =

\$21,895,450.

* Site Cost Adjustment Factor (SCAF) = 1.019

Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.11

HAZARDOUS MAX 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

4-19

YEAR OF EXPENDITURE	EXPENDITURE IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH EXPRESSED IN 1980 \$
1980	8,765,557	1.0000	8,765,557
1985	2,188,316	0.8925	1,953,072
1990	2,188,316	0.7966	1,743,213
1995	2,188,316	0.7110	1,555,893
2000	2,188,316	0.6346	1,388,705
2005	2,188,316	0.5664	1,239,462
2010	2,188,316	0.5055	1,106,194
Total Cap Exp	\$21,895,453		
Present Worth of all Capital Costs			\$17,752,095
Total Levelizing Factor (LF) =		0.0740	
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$1,313,655

[Plant # 4]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	31,844	3.57	113,572	Dry disposal
Bottom ash	7,960	3.57	28,389	Dry disposal
Total handling			141,961	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	31,844	1.71	54,334	open on road truck (16cy) 7.5 mi. ha
Bottom ash	7,960	1.71	13,582	open on road truck (16cy) 7.5 mi. ha
Total transportation			67,916	
Landfill costs				
Flyash	31,844	0.81	25,926	
Bottom ash	7,960	0.94	7,449	
Total landfill cost			33,376	
Leachate Treatment Plant O and M			\$178,517	
Total non-administrative O and M			-----\$421,769-----	

Administrative O&M Cost Items

Manifesting	\$8,671
Groundwater monitoring	\$8,667
Inspection	\$2,713
Personnel training	\$1,223
Non-sudden occurrence insurance	\$20,200
General administration	\$38,878
Total Annual Administration cost	-----\$80,359-----
Total annual operation and maintenance cost	\$502,129

Post closure O&M costs

Existing site (1980-2010)	\$28,950
New site	
Groundwater monitoring	\$17,333
Inspection	\$5,425
Maintenance	\$17,529
Administrative services	\$5,706
Total annual post closure cost (2014-2044)	-----\$45,994-----

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TABLE 4.13
HAZARDOUS MAX 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	531,079	1.0000	531,079	Begin post closure operation and maintenance of existing site
1981	531,079	0.9775	519,130	
1982	531,079	0.9555	507,446	
1983	531,079	0.9341	496,081	
1984	531,079	0.9131	484,928	
1985	531,079	0.8925	473,988	
1986	531,079	0.8725	463,366	
1987	531,079	0.8528	452,904	
1988	531,079	0.8337	442,761	
1989	531,079	0.8149	432,776	
1990	531,079	0.7966	423,058	
1991	531,079	0.7787	413,551	
1992	531,079	0.7612	404,257	
1993	531,079	0.7441	395,176	
1994	531,079	0.7273	386,254	
1995	531,079	0.7110	377,597	
1996	531,079	0.6950	369,100	
1997	531,079	0.6794	360,815	
1998	531,079	0.6641	352,690	
1999	531,079	0.6492	344,776	
2000	531,079	0.6346	337,023	
2001	531,079	0.6203	329,428	
2002	531,079	0.6064	322,046	
2003	531,079	0.5927	314,771	
2004	531,079	0.5794	307,707	
2005	531,079	0.5664	300,803	
2006	531,079	0.5536	294,005	End post closure operation and maintenance of existing site
2007	531,079	0.5412	287,420	
2008	531,079	0.5290	280,941	
2009	531,079	0.5171	274,621	
2010	531,079	0.5055	268,460	
2011	502,129	0.4941	248,102	Begin post closure operation and maintenance
2012	502,129	0.4830	242,528	
2013	502,129	0.4722	237,105	
2014	502,129	0.4616	231,783	
2015	45,994	0.4512	20,752	
2016	45,994	0.4410	20,283	
2017	45,994	0.4311	19,828	
2018	45,994	0.4214	19,382	
2019	45,994	0.4120	18,950	
2020	45,994	0.4027	18,522	
2021	45,994	0.3936	18,103	
2022	45,994	0.3848	17,698	
2023	45,994	0.3761	17,298	
2024	45,994	0.3677	16,912	
2025	45,994	0.3594	16,530	

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[Plant # 4]

TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	45,994	0.3513	16,158	
2027	45,994	0.3434	15,794	
2028	45,994	0.3357	15,440	
2029	45,994	0.3282	15,095	
2030	45,994	0.3208	14,755	
2031	45,994	0.3136	14,424	
2032	45,994	0.3065	14,097	
2033	45,994	0.2996	13,780	
2034	45,994	0.2929	13,472	
2035	45,994	0.2863	13,168	
2036	45,994	0.2799	12,874	
2037	45,994	0.2736	12,584	
2038	45,994	0.2674	12,299	
2039	45,994	0.2614	12,023	
2040	45,994	0.2555	11,751	
2041	45,994	0.2498	11,489	
2042	45,994	0.2442	11,232	
2043	45,994	0.2387	10,979	
2044	45,994	0.2333	10,730	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$13,364,880	
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			\$389,268	

[Plant # 4]

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 4

Levelized Capital Cost

\$1,313,655

Levelized Operation and Maintenance Costs

\$389,268

Total Levelized Revenue Requirement

\$1,702,923

Levelized Revenue Requirement per Ton of Waste Disposed

\$42.78

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$55.63

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 8,000	\$ 6,000	\$ 14,000	\$ 5.86	\$ 6.34
Non-Hazardous	46,000	15,000	61,000	25.36	26.97
Hazardous Minimum	1,028,000	389,000	1,417,000	35.60	46.29
Hazardous Maximum	1,314,000	389,000	1,703,000	42.78	55.63

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data 1980, Kingston, MA.

RCRA Impact
Case Study of Plant 5

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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal in the utility industry. These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 5 is located in the midwest and has a current nameplate generating capacity of 1,181 MW. The plant has three boilers, each pulverized coal-fired. Fuel oil is used only for start-up and combustion stabilization. All boilers are dry-bottom, tangentially-fired units. An expansion of the facility consists of a fourth boiler (532 MW) scheduled for operation in mid-1986. With the new boiler, the total generating capacity will be 1,713 MW as shown in Table 1.1.

Bituminous coal for the plant is obtained primarily from Indiana. Coal is transported to the facility by truck and rail with the majority arriving by rail. Normally a 90-day stockpile of coal is maintained on-site. Coal consumption for 1980 was 3,440,700 tons. The average analysis of the coal consumed during 1980 was 2.54 percent sulfur, 9.9 percent ash, and 10,939 BTU's/lb. Projected 1985 and 1990 rates of coal consumption are 3,708,000 and 4,773,000 tons, respectively.

Each of the boilers is equipped with an electrostatic precipitator (ESP). Unit 3 has, in addition, SO₂ scrubber equipment which utilizes a limestone slurry. Particulate removal for these units is estimated to fall between 99.2 and 99.6 percent. The units presently meet the Federal and State emission limits. The new unit (Unit 4) will be equipped with an ESP and scrubbing system similar to Unit 3. Table 1.1 summarizes plant characteristics including year of boiler start-up, 1980 availability factor, coal used, and air pollution control equipment.

EXISTING DISPOSAL

The schematic flow diagram of the existing disposal facilities for the plant is shown in Figure 1.2. The quantities of major waste materials generated are summarized in Table 1.2.

Fly ash and bottom ash from Units 1 and 2 are sluiced to an on-site disposal pond. FGD sludge and dry silo stored fly ash from Unit 3 are mixed with lime in the sludge treatment process and then placed in a structural landfill (See Figure 1.3). The bottom ash from Unit 3 is sluiced to the bottom ash dewatering bins. There are also emergency lines provided to allow the fly ash and bottom ash to flow to the ash pond serving Units 1 & 2 (Figure 1.3).

Fly ash and bottom ash have not been sold for commercial purposes. However, dewatered bottom ash from Unit 3 has been used internally as fill material to improve the drainage in the FGD stabilized landfill.

In addition to the fly ash and bottom ash, the ash pond receives direct discharge from the coal pile runoff collection system, chemical boiler cleaning wastes, cooling tower blowdown, demineralizer wastes, and water treatment plant sludge. The decant water from the ash pond is recycled.

SCHEMATIC FLOW DIAGRAM

FIGURE 1.2

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 5

Boiler	Stack	MW (Nameplate)	Year of Start-up	1980 Availability Factor	1980 Coal Used (tons)	1985 Coal Projections (tons)	1990 Coal Projections (tons)	<u>Type of Control</u> Particulate SO ₂	
1	1	220	1967	88%	3,440,700 ¹	3,708,000 ¹	4,773,000 ¹	ESP	None
2	2	430	1969	90%	(1)	(1)	(1)	ESP	None
3	3	531	1977	91%	(1)	(1)	(1)	ESP	Wet & Throw Away
4	4	532	1986	N/A	N/A	N/A	(1)	ESP	Wet &
Totals		1,713			3,440,700	3,708,000	4,773,000		Throw Away

¹ Generating units are fed by a common conveyor. Coal consumption is for all units.
N/A - Not applicable

TABLE 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 5

Waste Product	1980 Values	1985 Values	1990 Values	35-Year Average*
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	285,800	312,028	401,648	378,953
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	285,800	312,028	401,648	378,953
<u>Bottom Ash (Dry Weight)</u>				
Tons Produced	43,200	55,064	70,879	66,874
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	43,200	55,064	70,879	66,874
<u>Scrubber Sludge (Dry Weight)</u>				
Tons Produced**	246,900	311,900	493,800	447,060
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	246,900	311,900	493,800	447,060
<u>Other Wastes</u>				
Coal Pile Runoff (MG/yr)	19.7	19.7	19.7	

* Average is for 1980-2014, assuming that the 1990 values remain constant through 2014.

** Includes lime used for fixation.

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates.

The additional current practice disposal capacity necessary to provide disposal until 2014 would be achieved by modifying the disposal pond for Units 1 and 2, and developing a new structural landfill. Both sites are identified in Figure 2.2.

Modifications of the ash pond include constructing a higher dike on top of the foundation dike as shown in Figure 2.3 and partitioning the resulting pond into two areas by constructing a dividing dike through the center for additional ash deposition capacity. A typical section of the dividing dike is shown in Figure 2.4. Modifications to the second site include acquiring a tract of land adjacent to the active FGD stabilized sludge landfill, clearing and regrading the area as necessary prior to waste materials deposition, and providing a surface water drainage system. Diversion channels would be constructed to collect water from the area and transport it to the existing retention pond.

CURRENT PRACTICE HANDLING & DISPOSAL

FIGURE 2.2

PERIMETER DIKE - TYPICAL SECTION

DIVIDING DIKE - TYPICAL SECTION

FIGURE 2.4

Together, these two sites provide an additional capacity of 20,952,000 tons. This quantity combined with 10,080,000 tons of existing remaining capacity provide a total of 31,032,000 tons, which is the estimated waste production during the period of 1980 to 2014.

The fixed scrubber sludge, fly ash and bottom ash from Units 3 & 4 would continue to be trucked by a contractor to the landfill area. A water truck would be used to control dust at the landfill. Both fly ash and bottom ash from Units 1 and 2 would normally be sluiced to the divided ash pond. While one is being filled, the other could be excavated. The dewatered ash would be trucked and then placed in the structural landfill with FGD stabilized sludge. A dozer would be required to spread the scrubber sludge, fly ash, and bottom ash at the proposed landfill. A self-propelled compactor would be used to consolidate the waste material. This method of waste placement would minimize the waste volume, reduce the permeability of the waste fill, and increase landfill stability. At closure, a proposed 12-inch layer of topsoil would be placed and compacted on the disposal areas. These areas would be seeded to establish a vegetative cover to control erosion.

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items,

quantity take-off information, regional unit costs (1980 dollars), and extensions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 5

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	1181 mw
Generating capacity of largest boiler	531.5 mw

Waste Production Information*

Fly ash	266363 dry ton/yr
Bottom Ash	179464 dry ton/yr
FGD sludge	448789 dry ton/yr
Waste densities (as disposed)	
Fly ash	74.5 lb/cu ft
Bottom ash	74.5 lb/cu ft
FGD sludge	98 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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Notes for Plant 5

The Fly Ash quantity indicated includes the dry-disposed fly ash and bottom ash in the following quantities:

Fly ash	226,409 ton/yr. at 73.4 lb/cu.ft.
Bottom ash	39,954 ton/yr. at 80.8 lb/cu.ft.

The Bottom Ash quantity indicated includes the wet-disposed fly and and bottom ash in the following quantities:

Fly ash	152,544 ton/yr. at 73.4 lb/cu.ft.
Bottom ash	26,920 ton/yr. at 80.8 lb/cu.ft.

The waste density was calculated as a weighted average of the values for the ashes.

TABLE 2.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1981

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				\$0.
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
* Site cost adjustment factor (SCAF)= 1.033				
Site Unit cost= SCAF x National Average Unit Cost				

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TABLE 2.2 (continued)

Construction Cost Items for Period 2
 1982 - 1984

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
on-site structural cut/fill	38,836	[cy]	2.47	95,881
topsoil placement & grading	7,210	[cy]	1.75	12,587
topsoil removal & stockpile	7,210	[cy]	1.57	11,321
seeding and mulching -grass	21,623	[sy]	0.43	9,381

CONSTRUCTION COST TOTAL

\$129,170

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%

Other Capital Items = \$129,170 x 0.50 =

\$64,585

CONSTRUCTION CAPITAL REQUIREMENT =

\$193,755

Closure Cost

\$0.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$0.

* Site cost adjustment factor (SCAF)= 1.033

Site Unit cost= SCAF x National Average Unit Cost

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TABLE 2.2 (continued)

Construction Cost Items for Period 3
1985 - 1987

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
on-site structural cut/fill	37,022 [cy]		2.47	91,403
topsoil placement & grading	12,844 [cy]		1.75	22,423
topsoil removal & stockpile	12,844 [cy]		1.57	20,167
seeding and mulching -grass	38,535 [sy]		0.43	16,719
gravel roadways	1,700 [lf]		3.12	5,303
drainage cap-48"	90 [lf]		49.02	4,411

CONSTRUCTION COST TOTAL**\$160,426**

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%Other Capital Items = $\$160,426 \times 0.50 =$ **\$80,213****CONSTRUCTION CAPITAL REQUIREMENT =****\$240,639****Closure Cost****\$452,996****CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)****\$679,495**

* Site cost adjustment factor (SCAF) = 1.033

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 2.2 (continued)

Construction Cost Items for Period 4
1988 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	200	[acres]	3,099	619,800
clear and grub	200	[acres]	1,358	271,679
final grading	165	[acres]	563	92,893
cut & fill non-compacted	39,585	[cy]	1.57	62,155
on-site structural cut/fill	4,980	[cy]	2.47	12,295
topsoil placement & grading	2,800	[cy]	1.75	4,880
topsoil removal & stockpile	532,400	[cy]	1.57	835,953
seeding and mulching -grass	45,800	[sy]	0.43	19,871
gravel roadways	2,334	[lf]	3.12	7,281
riprap, grouted	2,270	[sy]	79.21	179,800
concrete	840	[cy]	96.87	81,375
drainage cap-48"	100	[lf]	49.02	4,902
drainage rccp-48"	60	[lf]	62.44	3,747
misc drainage structures	8,280	[ls]	1.03	8,553
soil borings	840	[lf]	15.50	13,016

CONSTRUCTION COST TOTAL**\$2,218,214.**

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%Other Capital Items = $\$2,218,214. \times 0.50 =$ **\$1,109,107.****CONSTRUCTION CAPITAL REQUIREMENT =****\$3,327,322.****Closure Cost****\$1,187,179.****CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)****\$1,780,769.**

* Site cost adjustment factor (SCAF) = 1.033

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 2.3

CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
 Inflation Rate : 6.0 %
 Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	193,755	0	0.9775	189,396
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	240,639	0	0.9131	219,727
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	3,327,322	0	0.8528	2,837,540
1988	0	679,495	0.8337	566,495
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	1,780,769	0.4512	803,483

Total Present Worth of Future Capital Expenditures :

\$4,616,641

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$341,631

[Plant # 5]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1981

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	266,363	3.62	963,035	Dry disposal
Bottom ash	179,464	2.58	463,466	Wet disposal
FGD	440,789	6.49	2,860,050	Dry disposal
Total handling			4,286,551	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	266,363	0.51	134,825	open on road truck (16cy) 1 mi. haul
FGD	440,789	0.51	223,114	open on road truck (16cy) 1 mi. haul
Total transportation			357,939	
Landfill costs				
Flyash	266,363	1.10	292,730	
FGD	440,789	0.91	400,995	
Total landfill cost			693,725	

Annual operation and maintenance cost \$5,338,216

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TABLE 2.4 (continued)

O&M Costs for Period 2
1982 to 1984

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	266,363	3.62	963,035	Dry disposal
Bottom ash	179,464	2.58	463,466	Wet disposal
FGD	440,789	6.49	2,860,050	Dry disposal
Total handling			4,286,551	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	266,363	0.51	134,825	open on road truck (16cy) 1 mi. haul
FGD	440,789	0.51	223,114	open on road truck (16cy) 1 mi. haul
Total transportation			357,939	
<u>Landfill costs</u>				
Flyash	266,363	1.10	292,730	
FGD	440,789	0.91	400,995	
Total landfill cost			693,725	

Annual operation and maintenance cost \$5,338,216
 Non-annual ash excavation cost 1484630 c.y. @ \$ 3.2023 /c.y = \$ 4754231 in year 1984

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TABLE 2.4 (continued)

O&M Costs for Period 3
1985 to 1987

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	266,363	3.62	963,035	Dry disposal
Bottom ash	179,464	2.58	463,466	Wet disposal
FGD	440,789	6.49	2,860,050	Dry disposal
Total handling			4,286,551	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	266,363	0.51	134,825	open on road truck (16cy) 1 mi. haul
FGD	440,789	0.51	223,114	open on road truck (16cy) 1 mi. haul
Total transportation			357,939	
<u>Landfill costs</u>				
Flyash	266,363	1.10	292,730	
FGD	440,789	0.91	400,995	
Total landfill cost			693,725	
Annual operation and maintenance cost			\$5,338,216	

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TABLE 2.4 (continued)

O&M Costs for Period 4
1988 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	266,363	3.62	963,035	Dry disposal
Bottom ash	179,464	2.58	463,466	Wet disposal
FGD	440,789	6.49	2,860,050	Dry disposal
Total handling			4,286,551	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	266,363	0.51	134,825	open on road truck (16cy) 1 mi. haul
FGD	440,789	0.51	223,114	open on road truck (16cy) 1 mi. haul
Total transportation			357,939	
<u>Landfill costs</u>				
Flyash	266,363	1.10	292,730	
FGD	440,789	0.91	400,995	
Total landfill cost			693,725	

Annual operation and maintenance cost \$5,338,216
 Non-annual ash excavation cost 888900 c.y. @ \$ 2.39656 /c.y. = \$ 2130302 in year 1990
 Non-annual ash excavation cost 1484630 c.y. @ \$ 2.39656 /c.y. = \$ 3558005 in year 1995
 Non-annual ash excavation cost 888900 c.y. @ \$ 2.39656 /c.y. = \$ 2130302 in year 2003
 Non-annual ash excavation cost 952880 c.y. @ \$ 2.39656 /c.y. = \$ 2283634 in year 2008

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TABLE 2.5
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	5,338,216	1.0000	5,338,216
1981	5,338,216	0.9775	5,218,106
1982	5,338,216	0.9555	5,100,865
1983	5,338,216	0.9341	4,986,428
1984	10,092,450	0.9131	9,215,416
1985	5,338,216	0.8925	4,764,358
1986	5,338,216	0.8725	4,657,593
1987	5,338,216	0.8528	4,552,431
1988	5,338,216	0.8337	4,450,471
1989	5,338,216	0.8149	4,350,112
1990	7,468,518	0.7966	5,949,421
1991	5,338,216	0.7787	4,156,869
1992	5,338,216	0.7612	4,063,450
1993	5,338,216	0.7441	3,972,167
1994	5,338,216	0.7273	3,882,484
1995	8,895,220	0.7110	6,325,212
1996	5,338,216	0.6950	3,710,060
1997	5,338,216	0.6794	3,626,784
1998	5,338,216	0.6641	3,545,109
1999	5,338,216	0.6492	3,465,570
2000	5,338,216	0.6346	3,387,632
2001	5,338,216	0.6203	3,311,295
2002	5,338,216	0.6064	3,237,094
2003	7,468,518	0.5927	4,426,591
2004	5,338,216	0.5794	3,092,962
2005	5,338,216	0.5664	3,023,566
2006	5,338,216	0.5536	2,955,236
2007	5,338,216	0.5412	2,889,042
2008	7,621,950	0.5290	4,031,959
2009	5,338,216	0.5171	2,760,391
2010	5,338,216	0.5055	2,698,468
2011	5,338,216	0.4941	2,637,613
2012	5,338,216	0.4830	2,578,358
2013	5,338,216	0.4722	2,520,706
2014	5,338,216	0.4616	2,464,121
Total Present Worth of Future Costs :			\$141,345,957
Sum of Present Worth Factors :		24.4103	
Levelized O&M Cost = (Present Worth of all O&M Costs) / (Sum of Present Worth Factors)			
LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST			\$5,790,423

[Plant # 5]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 5

Levelized Capital Cost

\$341,631

Levelized Operation and Maintenance Costs

\$5,790,423

Total Levelized Revenue Requirement

\$6,132,054

Levelized Revenue Requirement per Ton of Waste Disposed

\$6.92

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$7.61

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of ground-water monitoring wells around the existing ash pond and structural landfill. The new sludge and ash landfill (Figure 2.2) would be constructed with ground-water monitoring wells and a clay liner and cap to minimize leachate migration. Since the ash pond will be in continuous use until the year 2014 and represents a large ash volume, it was decided that a clay liner and cap would be a reasonable safeguard against possible future leachate generation. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes, would continue to be discharged to the ash pond.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge

NON-HAZARDOUS HANDLING & DISPOSAL

rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5.

A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

TABLE 3.1

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 5

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	1181 mw
Generating capacity of largest boiler	531.5 mw

Waste Production Information*

Fly ash	266363 dry ton/yr
Bottom Ash	179464 dry ton/yr
FGD sludge	440789 dry ton/yr
Waste densities (as disposed)	
Fly ash	74.5 lb/cu ft
Bottom ash	74.5 lb/cu ft
FGD sludge	99 lb/cu ft

 * Average for design period, 1980-2014.
 Does not include wastes being sold
 or reused (if applicable).

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Notes for Plant 5

The Fly Ash quantity indicated includes the
 dry-disposed fly ash and bottom ash in the
 following quantities:

Fly ash	226,409 ton/yr. at 73.4 lb/cu.ft.
Bottom ash	39,954 ton/yr. at 80.8 lb/cu.ft.

The Bottom Ash quantity indicated includes the
 wet-disposed fly and bottom ash in the
 following quantities:

Fly ash	152,544 ton/yr. at 73.4 lb/cu.ft.
Bottom ash	26,920 ton/yr. at 80.8 lb/cu.ft.

The waste density was calculated as a weighted
 average of the values for the ashes.

TABLE 3.2

NON-HAZARDOUS CAPITAL COSTSConstruction Cost Items for Period 1
1980 - 1981

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			\$0.	
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
* Site cost adjustment factor (SCAF) = 1.033				
Site Unit cost = SCAF x National Average Unit Cost				
[5001-18-1983#10:10:37]				PAGE 2

TABLE 3.2 (continued)

Construction Cost Items for Period 2
1982 - 1984

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
on-site structural cut/fill	38,836	[cy]	2.47	95,881
topsoil placement & grading	7,210	[cy]	1.75	12,587
topsoil removal & stockpile	7,210	[cy]	1.57	11,321
seeding and mulching -grass	21,623	[sy]	0.43	9,381

CONSTRUCTION COST TOTAL

\$129,170

Contractor Overhead 15%
Contractor Profit 10%
Engineering & Legal Costs 10%
Contingency 15%

50%

Other Capital Items = \$129,170 x 0.50 =

\$64,585

CONSTRUCTION CAPITAL REQUIREMENT =

\$193,755

Closure Cost

\$0.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$0.

Site cost adjustment factor (SCAF)= 1.033

The Unit cost= SCAF x National Average Unit Cost

[5001-10-1983010:10:37]

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TABLE 3.2 (continued)

Construction Cost Items for Period 3
1985 - 1987

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
cut & fill non-compacted	89,856 [cy]		1.57	139,832
on-site structural cut/fill	126,878 [cy]		2.47	311,270
topsoil placement & grading	12,844 [cy]		1.75	22,423
topsoil removal & stockpile	12,844 [cy]		1.57	20,167
clay liner/cap placement	89,856 [cy]		4.86	432,376
seeding and mulching -grass	38,535 [sy]		0.43	16,719
gravel roadways	1,700 [lf]		3.12	5,303
drainage cap-48"	90 [lf]		49.02	4,411
groundwater monitoring wells	750 [lf]		12.40	9,297

CONSTRUCTION COST TOTAL**\$961,799**

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%Other Capital Items = $961,799 \times 0.50 =$ **\$480,899****CONSTRUCTION CAPITAL REQUIREMENT =****\$1,442,698.****Closure Cost****\$1,057,792.****CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)****\$1,586,688.**

* Site cost adjustment factor (SCAF) = 1.033

Site Unit cost = SCAF x National Average Unit Cost

[5001-18-1983010:10:37]**PAGE 4**

TABLE 3.2 (continued)

Construction Cost Items for Period 4
1988 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	200	[acres]	3,099	619,800
clear and grub	200	[acres]	1,358	271,679
final grading	165	[acres]	563	92,893
cut & fill non-compacted	1,046,305	[cy]	1.57	1,642,866
on-site structural cut/fill	53,300	[cy]	2.47	131,788
topsoil placement & grading	2,800	[cy]	1.75	4,880
topsoil removal & stockpile	532,400	[cy]	1.57	835,953
clay liner/cap placement	1,006,720	[cy]	4.86	4,887,726
seeding and mulching -grass	45,800	[sy]	0.43	19,871
gravel roadways	2,334	[lf]	3.12	7,281
riprap, grouted	2,270	[sy]	79.21	179,888
concrete	840	[cy]	96.87	81,375
drainage cap-48"	100	[lf]	49.02	4,902
drainage rccp-48"	60	[lf]	62.44	3,747
misc drainage structures	8,280	[ls]	1.03	8,553
soil borings	1,660	[lf]	15.50	25,722
groundwater monitoring wells	530	[lf]	12.40	6,570

CONSTRUCTION COST TOTAL**\$8,825,423.**

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%Other Capital Items = $\$8,825,423. \times 0.50 =$ **\$4,412,712.****CONSTRUCTION CAPITAL REQUIREMENT =****\$13,238,130.****Closure Cost****\$4,845,803.****CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)****\$7,268,705.**

* Site cost adjustment factor (SCAF)= 1.033

Site Unit cost= SCAF x National Average Unit Cost

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TABLE 3.3
NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations
 Nominal Return : 8.4 %
 Inflation Rate : 6.0 %
 Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	193,755	0	0.9775	189,396
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	1,442,698	0	0.9131	1,317,328
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	13,238,130	0	0.8528	11,289,477
1988	0	1,586,688	0.8337	1,322,822
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	7,268,705	0.4512	3,279,640

Total Present Worth of Future Capital Expenditures :

\$17,398,662

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$1,287,501

[Plant # 5]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTSO&M Costs for Period 1
1980 to 1981

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	266,363	3.62	963,035	Dry disposal
Bottom ash	179,464	2.58	463,466	Wet disposal
FGD	440,789	6.49	2,860,050	Dry disposal
Total handling			4,286,551	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	266,363	0.51	134,825	open on road truck (16cy) 1 mi. haul
FGD	440,789	0.51	223,114	open on road truck (16cy) 1 mi. haul
Total transportation			357,939	
<u>Landfill costs</u>				
Flyash	266,363	1.10	292,730	
FGD	440,789	0.91	400,995	
Total landfill cost			693,725	

Annual operation and maintenance cost \$5,338,216

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TABLE 3.4 (continued)

O&M Costs for Period 2
1982 to 1984

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	266,363	3.62	963,835	Dry disposal
Bottom ash	179,464	2.58	463,466	Wet disposal
F6D	440,789	6.49	2,860,850	Dry disposal
Total handling			4,286,551	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	266,363	0.51	134,825	open on road truck (16cy) 1 mi. haul
F6D	440,789	0.51	223,114	open on road truck (16cy) 1 mi. haul
Total transportation			357,939	
<u>Landfill costs</u>				
Flyash	266,363	1.10	292,730	
F6D	440,789	0.91	400,995	
Total landfill cost			693,725	

Annual operation and maintenance cost \$5,338,216
 Non-annual ash excavation cost 1484630 c.y. @ \$ 3.2023 /c.y = \$ 4754231 in year 1984

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TABLE 3.4 (continued)

O&M Costs for Period 3
1985 to 1987

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	266,363	3.62	963,835	Dry disposal
Bottom ash	179,464	2.58	463,466	Wet disposal
FGD	448,789	6.49	2,860,850	Dry disposal
Total handling			4,286,551	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	266,363	0.51	134,825	open on road truck (16cy) 1 mi. haul
FGD	448,789	0.51	223,114	open on road truck (16cy) 1 mi. haul
Total transportation			357,939	
<u>Landfill costs</u>				
Flyash	266,363	1.10	292,730	
FGD	448,789	0.91	408,995	
Total landfill cost			693,725	
Groundwater monitoring			15,025	

Annual operation and maintenance cost \$5,353,241
 Non-annual ash excavation cost 888900 c.y. @ \$ 2.39656 /c.y = \$ 2130302 in year 1987

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TABLE 3.4 (continued)

O&M Costs for Period 4
1988 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	266,363	3.62	963,035	Dry disposal
Bottom ash	179,464	2.58	463,466	Wet disposal
FGD	440,789	6.49	2,860,050	Dry disposal
Total handling			4,286,551	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	266,363	0.51	134,825	open on road truck (16cy) 1 mi. haul
FGD	440,789	0.51	223,114	open on road truck (16cy) 1 mi. haul
Total transportation			357,939	
<u>Landfill costs</u>				
Flyash	266,363	1.10	292,730	
FGD	440,789	0.91	400,995	
Total landfill cost			693,725	
Groundwater monitoring			22,816	

Annual operation and maintenance cost \$5,361,032
 Non-annual ash excavation cost 1484630 c.y. @ \$ 2.39656 /c.y = \$ 3558005 in year 1995
 Non-annual ash excavation cost 888700 c.y. @ \$ 2.39656 /c.y = \$ 2130302 in year 2003
 Non-annual ash excavation cost 952880 c.y. @ \$ 2.39656 /c.y = \$ 2283634 in year 2008

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TABLE 3.5
NON-HAZARDOUS 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	5,338,216	1.0000	5,338,216
1981	5,338,216	0.9775	5,218,106
1982	5,338,216	0.9555	5,100,665
1983	5,338,216	0.9341	4,986,428
1984	10,092,450	0.9131	9,215,416
1985	5,353,241	0.8925	4,777,768
1986	5,353,241	0.8725	4,670,703
1987	7,483,543	0.8528	6,381,965
1988	5,361,032	0.8337	4,469,492
1989	5,361,032	0.8149	4,368,705
1990	5,361,032	0.7966	4,270,598
1991	5,361,032	0.7787	4,174,836
1992	5,361,032	0.7612	4,080,818
1993	5,361,032	0.7441	3,989,144
1994	5,361,032	0.7273	3,899,079
1995	8,919,036	0.7110	6,341,435
1996	5,361,032	0.6950	3,725,917
1997	5,361,032	0.6794	3,642,285
1998	5,361,032	0.6641	3,560,261
1999	5,361,032	0.6492	3,480,382
2000	5,361,032	0.6346	3,402,111
2001	5,361,032	0.6203	3,325,448
2002	5,361,032	0.6064	3,250,930
2003	7,491,334	0.5927	4,440,114
2004	5,361,032	0.5794	3,106,182
2005	5,361,032	0.5664	3,036,489
2006	5,361,032	0.5536	2,967,867
2007	5,361,032	0.5412	2,901,391
2008	7,644,666	0.5290	4,044,028
2009	5,361,032	0.5171	2,772,190
2010	5,361,032	0.5055	2,710,002
2011	5,361,032	0.4941	2,648,886
2012	5,361,032	0.4830	2,589,378
2013	5,361,032	0.4722	2,531,479
2014	5,361,032	0.4616	2,474,652

Total Present Worth of Future Costs :

\$141,893,165

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$5,812,840

Plant # 5 J

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 5

Levelized Capital Cost

\$1,287,501

Levelized Operation and Maintenance Costs

\$5,812,840

Total Levelized Revenue Requirement

\$7,100,341

Levelized Revenue Requirement per Ton of Waste Disposed

\$8.01

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$8.81

SECTION 4
HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

The proposed design consists of acquiring a tract of land located 5 miles east of the plant site. For the purpose of this analysis, it has been determined that it will be most cost effective in the future if dry handling systems are utilized for the disposal of the fly ash, bottom ash and scrubber sludge. In the future, all ash and sludge will be trucked to the new landfill. Leachate treatment facilities are provided and were sized based on a 10-year, 24-hour rainfall event falling on half the area of one open cell. Internal cell diking will preclude contamination of all storm water runoff. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes could be used to moisture condition the ash before placement in the landfill.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities

Design FactorHazardous MinimumHazardous Maximum

2. Liner System

Use a single liner system as specified in the EPA guidance documents

Use a double liner system as specified in the EPA guidance documents

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed cells on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Figure 4.1 is a layout of the cells which are proposed for ash disposal under the hazardous waste scenario. Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the

FIGURE 4.1

HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION ⁽¹⁾

SYMMETRICAL

24" COVER SOIL ⁽²⁾

SYNTHETIC FIBER FILTER

12" SAND DRAINAGE LAYER

20 MIL MEMBRANE

24" CLAY LAYER

SLOPE BETWEEN 3% AND 5%

COVER VEGETATION

WASTE

2%

DIKE

DRAINAGE SWALE

3

1

2

1

SYNTHETIC FIBER FILTER

12" SAND LEACHATE COLLECTION ZONE

30 MIL MEMBRANE LINER

6" BEDDING SAND

PVC LEACHATE DRAINS
(4" Dia. Laterals/
6" Dia. Mains)

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

**PVC LEACHATE DRAINS-
(4" Dia. Laterals/
6" Dia. Mains)**

FIGURE 4.2

HAZARDOUS MAXIMUM LANDFILL – TYPICAL CELL HALF SECTION ⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 5

Design Mode: Hazardous Min

Date 101-19-1982

Power Plant Information (1980)

Generating capacity of plant	1181 MW
Generating capacity of largest boiler	531.5 MW

Waste Production Information *

Fly ash	378953 dry ton/yr
Bottom Ash	66874 dry ton/yr
FGD sludge	447060 dry ton/yr
Waste densities (as disposed)	
Fly ash	88 lb/cu ft
Bottom ash	97 lb/cu ft
FGD sludge	90 lb/cu ft

General Disposal Site Information

Site area	1000 acres
Percent heavily wooded	2.5 %
Percent lightly wooded	2.5 %
Site perimeter	30600 ft
Distance to plant	5 mi
Distance to main road	750 ft
Distance from disposal site to leachate treatment plant	4000 ft
Thickness of soils above bedrock	50 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	15 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	yes

Climatic Information

Maximum frost penetration	20 in
Total annual precipitation	42.5 in
10-yr, 24-hr rainfall event	4.5 in

* note: Average for period 1980- 2014 . If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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TABLE 4.2

HAZARDOUS MIN CELL GEOMETRY

Number of cells	14
Cell volume	1832857 cu yd
Depth of waste at edge of fill	35 ft
Cell dimensions	
length at top	2891 ft
width at top	697 ft
length at bottom	1951 ft
width at bottom	557 ft
Cell dike information	
Dike side slopes	
exterior	3 horiz : 1 vert
interior	2 horiz : 1 vert
Average width at top of dike	28 ft
Total length of exterior dike	32628 ft

**Disposal Cell Cross-Section
Dry Landfill w/ Single Liner**

NOTE: Datum is below existing ground surface an average of 10 feet at this site

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980- 2014)

ITEM	QUANTITY	UNIT	UNIT+ COST	EXTENSION
real estate	1,000	[acres]	3,099	3,099,000
clear and grub	789	[acres]	1,358	1,072,122
heavy stump removal	20	[acres]	930	18,344
light stump removal	20	[acres]	558	11,007
final grading	790	[acres]	563	444,750
cut & fill non-compacted	5,854,903	[cy]	1.57	9,193,134
on-site structural cut/fill	619,392	[cy]	2.47	1,529,198
borrow material import	5,316,173	[cy]	7.64	40,637,890
topsoil removal & stockpile	1,794,801	[cy]	1.57	2,818,125
sand collection zone plant	1,962,419	[cy]	9.10	18,041,460
clay liner/cap placement	1,936,242	[cy]	4.86	9,400,649
synthetic membrane	43,242,330	[sf]	0.58	25,011,823
seeding and mulching -grass	3,823,600	[sy]	0.43	1,650,907
gravel stabilization	3,967	[sy]	0.72	2,869
plastic filter fabric	4,804,703	[sy]	0.74	3,573,546
light duty bituminous road	23,102	[lf]	13.10	302,600
heavy duty bituminous road	750	[lf]	17.19	12,892
perimeter fencing	30,600	[ft]	12.40	379,310
plastic pipe, pvc-4"	121,711	[lf]	10.28	1,250,990
plastic pipe, pvc-6"	62,548	[lf]	14.80	925,891
leachate collect sumps	3,150	[lf]	97.10	305,871
soil borings	13,825	[lf]	15.50	214,210
groundwater monitoring wells	1,631	[lf]	12.40	20,223
CELL CONSTRUCTION COST SUBTOTAL				\$119,927,800.
Leachate Treatment Plant Construction Cost				\$2,455,004.
** Wet-to-dry conversion cost of Bottom ash				\$2,376,498.
No Wet-to-Dry Conversion for FGD				
Construction Cost for Closure of Existing Disposal Site(s)				\$1,824,278.
CONSTRUCTION COST TOTAL				\$126,563,600.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
50%				
Other Capital Items = \$126,563,600. x 0.50 =				\$63,291,810.
Permitting Cost				\$250,000
TOTAL CAPITAL REQUIREMENT =				\$190,125,400.
* Site Cost Adjustment Factor (SCAF) = 1.033				
Site Unit Cost = SCAF x National-Average Unit Cost				

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** This figure has been adjusted for the wet-handled fly ash and dry-handled bottom ash.

TABLE 4.4

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	23,083,080	1.0000	23,083,080
1983	12,849,410	0.9341	12,002,634
1985	12,849,410	0.8925	11,468,098
1988	12,849,410	0.8337	10,712,553
1990	12,849,410	0.7966	10,235,840
1993	12,849,410	0.7441	9,561,246
1995	12,849,410	0.7110	9,135,931
1998	12,849,410	0.6641	8,533,293
2000	12,849,410	0.6346	8,154,236
2003	12,849,410	0.5927	7,615,845
2005	12,849,410	0.5664	7,277,906
2008	12,849,410	0.5290	6,797,338
2010	12,849,410	0.5055	6,495,377
2013	12,849,410	0.4722	6,067,491

Total Cap Exp \$190,125,410

Present Worth of all Capital Costs

\$137,140,868

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$10,148,424

[Plant # 5]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flvash	378,953	3.62	1,378,185	Dry disposal
Bottom ash	66,874	3.62	241,783	Dry disposal
FGD	447,860	6.45	2,885,176	Dry disposal
Total handling			4,497,863	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flvash	378,953	1.26	477,144	open on road truck (16cy) 5 mi. haul
Bottom ash	66,874	1.26	84,282	open on road truck (16cy) 5 mi. haul
FGD	447,860	1.26	562,899	open on road truck (16cy) 5 mi. haul
Total transportation			1,124,245	
<u>Landfill costs</u>				
Flvash	378,953	0.93	352,576	
Bottom ash	66,874	0.84	56,446	
FGD	447,860	0.91	406,699	
Total landfill cost			815,722	
Leachate Treatment Plant O and M			\$234,387	
Total non-administrative O and M			-----\$6,671,337-----	

Administrative O&M Cost Items

Manifesting	\$32,584
Groundwater monitoring	\$63,452
Inspection	\$12,499
Personnel training	\$1,240
Non-sudden occurrence insurance	\$56,885
General administration	\$91,405
Total Annual Administration cost	-----\$257,985-----
Total annual operation and maintenance cost	\$6,929,322

Post closure O&M costs

Existing site (1988-2010)	\$85,335
New site	
Groundwater monitoring	\$126,984
Inspection	\$24,999
Maintenance	\$89,990
Administrative services	\$5,785
Total annual post closure cost (2014 - 2044)	-----\$247,678-----

[5901-19-1982017:35:56]

TABLE 4.6

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	7,014,657	1.0000	7,014,657	Begin post closure operation and maintenance of existing site
1981	7,014,657	0.9775	6,856,827	
1982	7,014,657	0.9555	6,702,505	
1983	7,014,657	0.9341	6,552,391	
1984	7,014,657	0.9131	6,405,083	Begin post closure operation and maintenance of existing site
1985	7,014,657	0.8925	6,260,581	
1986	7,014,657	0.8725	6,120,288	
1987	7,014,657	0.8528	5,982,099	
1988	7,014,657	0.8337	5,848,120	
1989	7,014,657	0.8149	5,716,244	
1990	7,014,657	0.7966	5,587,876	
1991	7,014,657	0.7787	5,462,313	
1992	7,014,657	0.7612	5,339,557	
1993	7,014,657	0.7441	5,219,606	
1994	7,014,657	0.7273	5,101,760	
1995	7,014,657	0.7110	4,987,421	
1996	7,014,657	0.6950	4,875,187	
1997	7,014,657	0.6794	4,765,758	
1998	7,014,657	0.6641	4,658,434	
1999	7,014,657	0.6492	4,553,915	End post closure operation and maintenance of existing site
2000	7,014,657	0.6346	4,451,501	
2001	7,014,657	0.6203	4,351,192	
2002	7,014,657	0.6064	4,253,688	
2003	7,014,657	0.5927	4,157,587	
2004	7,014,657	0.5794	4,064,292	
2005	7,014,657	0.5664	3,973,102	
2006	7,014,657	0.5536	3,883,314	
2007	7,014,657	0.5412	3,796,332	
2008	7,014,657	0.5290	3,710,754	
2009	7,014,657	0.5171	3,627,279	
2010	7,014,657	0.5055	3,545,909	
2011	6,929,322	0.4941	3,423,778	
2012	6,929,322	0.4830	3,346,863	
2013	6,929,322	0.4722	3,272,026	
2014	6,929,322	0.4616	3,198,575	Begin post closure operation and maintenance
2015	247,678	0.4512	111,752	
2016	247,678	0.4410	109,226	
2017	247,678	0.4311	106,774	
2018	247,678	0.4214	104,372	
2019	247,678	0.4120	102,043	
2020	247,678	0.4027	99,740	
2021	247,678	0.3936	97,486	
2022	247,678	0.3848	95,306	
2023	247,678	0.3761	93,152	
2024	247,678	0.3677	91,071	
2025	247,678	0.3594	89,015	

(continued next page)

[Plant # 5]

TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	247,678	0.3513	87,009	
2027	247,678	0.3434	85,053	
2028	247,678	0.3357	83,146	
2029	247,678	0.3282	81,288	
2030	247,678	0.3208	79,455	
2031	247,678	0.3136	77,672	
2032	247,678	0.3065	75,913	
2033	247,678	0.2996	74,204	
2034	247,678	0.2929	72,545	
2035	247,678	0.2863	70,910	
2036	247,678	0.2799	69,325	
2037	247,678	0.2736	67,765	
2038	247,678	0.2674	66,229	
2039	247,678	0.2614	64,743	
2040	247,678	0.2555	63,282	
2041	247,678	0.2498	61,870	
2042	247,678	0.2442	60,483	
2043	247,678	0.2387	59,121	
2044	247,678	0.2333	57,783	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$173,524,549	
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			\$5,054,103	

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 5

Levelized Capital Cost

\$10,148,424

Levelized Operation and Maintenance Costs

\$5,054,103

Total Levelized Revenue Requirement

\$15,202,527

Levelized Revenue Requirement per Ton of Waste Disposed

\$17.03

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$20.60

TABLE 4.8

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 5

Design Mode: Hazardous Max

Date 101-19-1982

Power Plant Information (1980)

Generating capacity of plant	1181 MW
Generating capacity of largest boiler	531.5 MW

Waste Production Information *

Fly ash	378953 dry ton/yr
Bottom Ash	66874 dry ton/yr
FGD sludge	447060 dry ton/yr
Waste densities (as disposed)	
Fly ash	88 lb/cu ft
Bottom ash	97 lb/cu ft
FGD sludge	90 lb/cu ft

General Disposal Site Information

Site area	1000 acres
Percent heavily wooded	2.5 %
Percent lightly wooded	2.5 %
Site perimeter	30600 ft
Distance to plant	5 mi
Distance to main road	750 ft
Distance from disposal site to leachate treatment plant	4000 ft
Thickness of soils above bedrock	50 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	15 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	yes

Climatic Information

Maximum frost penetration	20 in
Total annual precipitation	42.5 in
10-yr, 24-hr rainfall event	4.5 in

* note: Average for period 1980- 2014 . If dry disposal is utilized, densities reflect a 1.2 compaction factor.

[5001-19-1982017:28:40]

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TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	14
Cell volume	1832857 cu yd
Depth of waste at edge of fill	35 ft
Cell dimensions	
length at top	2091 ft
width at top	697 ft
length at bottom	1951 ft
width at bottom	557 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	32628 ft

Disposal Cell Cross-Section
Dry Landfill w/ Double Liner

NOTE: Datum is below existing ground surface an average of 10 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS

Construction Cost Items (1980- 2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	1,000	[acres]	3,099	3,099,000
clear and grub	789	[acres]	1,358	1,072,122
heavy stump removal	20	[acres]	930	18,344
light stump removal	20	[acres]	558	11,007
final grading	790	[acres]	563	444,758
cut & fill non-compacted	6,295,036	[cy]	1.57	13,024,534
borrow material import	6,915,054	[cy]	7.64	52,860,056
topsoil removal & stockpile	1,827,875	[cy]	1.57	2,870,056
sand collection zone plant	2,423,245	[cy]	9.10	22,053,298
clay liner/cap placement	3,895,860	[cy]	4.86	18,914,790
synthetic membrane	43,691,960	[sf]	0.58	25,274,925
seeding and mulching -grass	3,823,600	[sy]	0.43	1,658,907
gravel stabilization	3,967	[sy]	0.72	2,869
plastic filter fabric	4,854,662	[sy]	0.74	3,610,703
light duty bituminous road	23,102	[lf]	13.10	302,600
heavy duty bituminous road	750	[lf]	17.19	12,892
perimeter fencing	30,600	[ft]	12.40	379,318
plastic pipe, pvc-4"	243,422	[lf]	10.28	2,501,981
plastic pipe, pvc-6"	125,096	[lf]	14.80	1,851,782
leachate collect sumps	3,150	[lf]	97.10	305,871
soil borings	13,825	[lf]	15.50	214,218
groundwater monitoring wells	1,631	[lf]	12.40	20,223
CELL CONSTRUCTION COST SUBTOTAL				\$150,504,300.
Leachate Treatment Plant Construction Cost				\$2,455,004.
** Wet-to-dry conversion cost of Bottom ash				\$2,376,498.
No Wet-to-Dry Conversion for FGD				
Construction Cost for Closure of Existing Disposal Site(s)				\$6,940,727.
CONSTRUCTION COST TOTAL				\$162,276,500.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
50%				
Other Capital Items = \$162,276,500. x 0.50 =				98,138,240.
Permitting Cost				\$500,000
TOTAL CAPITAL REQUIREMENT =				\$243,914,700.

* Site Cost Adjustment Factor (SCAF) = 1.033
 Site Unit Cost = SCAF x National-Average Unit Cost

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** This figure has been adjusted for the wet-handled fly ash
 and dry-handled bottom ash.

TABLE 4.11

HAZARDOUS MAX 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

4-19

YEAR OF EXPENDITURE	EXPENDITURE IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH EXPRESSED IN 1980 \$
1980	34,283,800	1.0000	34,283,800
1983	16,125,460	0.9341	15,062,792
1985	16,125,460	0.8925	14,391,973
1988	16,125,460	0.8337	13,443,796
1990	16,125,460	0.7966	12,845,541
1993	16,125,460	0.7441	11,998,955
1995	16,125,460	0.7110	11,465,202
1998	16,125,460	0.6641	10,708,918
2000	16,125,460	0.6346	10,233,217
2003	16,125,460	0.5927	9,557,560
2005	16,125,460	0.5664	9,133,461
2008	16,125,460	0.5290	8,530,368
2010	16,125,460	0.5055	8,151,420
2013	16,125,460	0.4722	7,614,442
Total Cap Exp	\$243,914,780		
Present Worth of all Capital Costs			\$177,421,446
Total Levelizing Factor (LF) =		0.0740	
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$13,129,187

[Plant # 5]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	378,953	3.62	1,378,185	Dry disposal
Bottom ash	66,874	3.62	241,783	Dry disposal
FGD	447,868	6.45	2,885,176	Dry disposal
Total handling			4,497,863	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	378,953	1.26	477,144	open on road truck (16cy) 5 mi. haul
Bottom ash	66,874	1.26	84,282	open on road truck (16cy) 5 mi. haul
FGD	447,868	1.26	562,899	open on road truck (16cy) 5 mi. haul
Total transportation			1,124,245	
<u>Landfill costs</u>				
Flyash	378,953	0.93	352,576	
Bottom ash	66,874	0.84	56,446	
FGD	447,868	0.91	406,699	
Total landfill cost			815,722	
Leachate Treatment Plant O and M			\$234,387	
Total non-administrative O and M			-----\$6,671,337-----	

Administrative O&M Cost Items

Manifesting	\$32,584
Groundwater monitoring	\$63,452
Inspection	\$12,499
Personnel training	\$1,248
Non-sudden occurrence insurance	\$56,885
General administration	\$91,485
Total Annual Administration cost	-----\$257,985-----
Total annual operation and maintenance cost	\$6,929,322

Post closure O&M costs

Existing site (1988-2010)	\$85,335
New site	
Groundwater monitoring	\$126,984
Inspection	\$24,999
Maintenance	\$89,998
Administrative services	\$5,785
Total annual post closure cost (2014 - 2044)	-----\$247,778-----

[5881-19-1982#17:28:40]

TABLE 4.13
HAZARDOUS MAX 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	7,014,657	1.0000	7,014,657	Begin post closure operation and maintenance of existing site
1981	7,014,657	0.9775	6,856,827	
1982	7,014,657	0.9555	6,702,505	
1983	7,014,657	0.9341	6,552,391	
1984	7,014,657	0.9131	6,405,083	End post closure operation and maintenance of existing site
1985	7,014,657	0.8925	6,260,581	
1986	7,014,657	0.8725	6,120,288	
1987	7,014,657	0.8528	5,982,099	
1988	7,014,657	0.8337	5,848,120	
1989	7,014,657	0.8149	5,716,244	
1990	7,014,657	0.7966	5,587,876	
1991	7,014,657	0.7787	5,462,313	
1992	7,014,657	0.7612	5,339,557	
1993	7,014,657	0.7441	5,219,606	
1994	7,014,657	0.7273	5,101,760	
1995	7,014,657	0.7110	4,987,421	
1996	7,014,657	0.6950	4,875,187	
1997	7,014,657	0.6794	4,765,758	
1998	7,014,657	0.6641	4,658,434	
1999	7,014,657	0.6492	4,553,915	Begin post closure operation and maintenance
2000	7,014,657	0.6346	4,451,501	
2001	7,014,657	0.6203	4,351,192	
2002	7,014,657	0.6064	4,253,688	
2003	7,014,657	0.5927	4,157,587	End post closure operation and maintenance of existing site
2004	7,014,657	0.5794	4,064,292	
2005	7,014,657	0.5664	3,973,102	
2006	7,014,657	0.5536	3,883,314	
2007	7,014,657	0.5412	3,796,332	Begin post closure operation and maintenance
2008	7,014,657	0.5290	3,710,754	
2009	7,014,657	0.5171	3,627,279	
2010	7,014,657	0.5055	3,545,909	
2011	6,929,322	0.4941	3,423,778	End post closure operation and maintenance of existing site
2012	6,929,322	0.4830	3,346,863	
2013	6,929,322	0.4722	3,272,026	
2014	6,929,322	0.4616	3,198,575	
2015	247,678	0.4512	111,752	Begin post closure operation and maintenance
2016	247,678	0.4410	109,226	
2017	247,678	0.4311	106,774	
2018	247,678	0.4214	104,372	
2019	247,678	0.4120	102,043	End post closure operation and maintenance of existing site
2020	247,678	0.4027	99,740	
2021	247,678	0.3936	97,486	
2022	247,678	0.3848	95,306	
2023	247,678	0.3761	93,152	Begin post closure operation and maintenance
2024	247,678	0.3677	91,071	
2025	247,678	0.3594	89,015	

(continued next page)

[Plant # 5]

TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	247,678	0.3513	87,009	
2027	247,678	0.3434	85,053	
2028	247,678	0.3357	83,146	
2029	247,678	0.3282	81,288	
2030	247,678	0.3208	79,455	
2031	247,678	0.3136	77,672	
2032	247,678	0.3065	75,913	
2033	247,678	0.2996	74,204	
2034	247,678	0.2929	72,545	
2035	247,678	0.2863	70,910	
2036	247,678	0.2799	69,325	
2037	247,678	0.2736	67,765	
2038	247,678	0.2674	66,229	
2039	247,678	0.2614	64,743	
2040	247,678	0.2555	63,282	
2041	247,678	0.2498	61,870	
2042	247,678	0.2442	60,483	
2043	247,678	0.2387	59,121	
2044	247,678	0.2333	57,783	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$173,524,549	
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			\$5,054,103	

[Plant # 5]

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 5

Levelized Capital Cost

\$13,129,187

Levelized Operation and Maintenance Costs

\$5,054,103

Total Levelized Revenue Requirement

\$18,183,290

Levelized Revenue Requirement per Ton of Waste Disposed

\$20.36

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$24.64

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 342,000	\$ 5,790,000	\$ 6,132,000	\$ 6.92	\$ 7.61
Non-Hazardous	1,288,000	5,813,000	7,100,000	8.01	8.81
Hazardous Minimum	10,148,000	5,054,000	15,202,000	17.03	20.60
Hazardous Maximum	13,129,000	5,054,000	18,183,000	20.36	24.64

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data 1980, Kingston, MA.

RCRA Impact
Case Study of Plant 6

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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal in the utility industry. These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 6 is located in Ohio and has a current nameplate generating capacity of 1,981 MW. The plant has six pulverized coal-fired boilers. Fuel oil is used only for start-up and combustion stabilization. Boilers 1 and 2 are wet-bottoms and 3 through 6 are dry-bottoms.

Bituminous coal for the plant is obtained from the local Ohio area. Coal is transported to the facility by conveyor belt and trucks. Normally 1 90-day stock pile is maintained on-site. Coal consumption for 1981 was 3,954,732 tons. The average analysis of the coal consumed during 1981 was 4.59 percent sulfur, 13.86 percent ash, and 11,038 BTU's/lb. Projected 1985 and 1990 rates of coal consumption are 3,864,000 and 4,699,000 tons, respectively.

Each of the boilers is equipped with an electrostatic precipitator (ESP). Units 5 and 6 have, in addition, SO₂ scrubber equipment which utilizes a lime slurry. Particulate removal for these units is estimated to be 99.0 percent. The Unit 5 and 6 scrubber system was designed remove 89.6 percent of sulfur dioxide emission. Table 1.1 summarizes plant characteristics including year of boiler start-up, 1981 capacity factor, coal used, and air pollution control equipment.

EXISTING DISPOSAL

The schematic flow diagram of the existing disposal facilities for the plant is shown in Figure 1.2. The quantities of waste materials generated are summarized in Table 1.2.

Fly ash, bottom ash, and boiler slag from boilers 1, 2, 3, and 4 and bottom ash from boilers 5 and 6 are sluiced to an on-site disposal pond (Figure 1.3). Scrubber bleed slurry from boilers 5 and 6 is thickened and vacuum filtered. Fly ash from boilers 5 and 6 and a cementing agent are mixed with the dewatered sludge; the resulting product is cured for a short period of time prior to placement in an on-site landfill.

Fly ash, bottom ash, and boiler slag have not been sold for commercial purposes. However, boiler slag is donated to local townships for ice control and bottom ash has been used internally as a base material.

The overflow from the ash pond is discharged to a sedimentation basin. The sedimentation basin receives direct discharges from coal pile runoff collection system, neutralization basin, and cooling tower blowdown. The decant water from the sedimentation pond is discharged to the river. Boiler cleaning wastes are injected into the boilers and evaporated.

FIGURE 1.2

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 6

Boiler	Stack	MW (Nameplate)	Year of Start-up	1981 Capacity Factor	1981 Coal Used (tons)	1985 Coal Projections (tons)	1990 Coal Projections (tons)	Type of Control	
								Particulate	SO ₂
1	1	125	1959	55%	299,560	3,864,000 ¹	4,699,000 ¹	ESP	None
2	1	125	1957	61%	330,528	(1)	(1)	ESP	None
3	2	125	1962	56%	382,210	(1)	(1)	ESP	None
4	3	800	1973	47%	1,504,347	(1)	(1)	ESP	None
5	4	403	1976	50%	687,574	(1)	(1)	ESP	Scrubber
6	4	403	1978	55%	749,513	(1)	(1)	ESP	Scrubber
TOTALS		1,981			3,953,732	3,864,000 ¹	4,699,000 ¹		

¹ Coal consumption is for all units

TABLE 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 6

Waste Product	1981 Values	1985 Values	1990 Values	35-Year Average*
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	382,132	306,600	293,500	301,750
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	382,132	306,600	293,500	301,750
<u>Bottom Ash (Dry Weight)</u>				
Tons Produced**	161,996	76,700	73,400	78,055
Tons Sold	<u>0</u>	<u>38,000</u>	<u>73,400</u>	<u>63,320</u>
Tons Disposed	161,996	38,700	0	14,735
<u>Scrubber Sludge (Dry Weight)</u>				
Tons Produced***	522,249	525,000	525,000	524,800
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	522,249	525,000	525,000	524,800

* Average is for 1980-2014, assuming that the 1990 values remain constant through 2014.

** Bottom slag on Units 1 and 2 included with bottom ash.

*** Does not include fly ash used for stabilization of sludge.

Note: The volume of ash decreases after 1981 because of burning cleaned coal in units 1, 2, 3, and 4.

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates.

In 1980, the existing landfill had a remaining life of 3 years while the ash pond had a projected life of 6 years. To provide sufficient ash disposal capacity over the 35 year design period, it was necessary to construct a new ash landfill and to modify the existing ash pond by constructing a dividing dike.

Construction modifications were made to the existing ash pond as shown in Figure 2.2. A dividing dike was constructed between the bottom ash and fly ash ponds as shown in Figure 2.3. The excavated fly ash would be hauled to the landfill. Bottom ash will be sold. Miscellaneous low volume wastes, e.g. coal pile runoff, etc., currently generated by the plant would continue to be sent to the sedimentation basin.

The proposed design consists of developing a tract of strip-mined land located 3 miles from the plant, clearing and regrading the area as necessary before waste materials deposition, and providing a

CURRENT PRACTICE HANDLING & DISPOSAL

FIGURE 2.2

DIVIDING DIKE - TYPICAL SECTION

surface water drainage system. Figure 2.4 illustrates the locations of the disposal sites.

FGD sludge and ash would be transported by a contractor to the new landfill area. A water truck would be used to control dust at the landfill. A dozer would be required to spread the ash and FGD sludge at the landfill. A self-propelled compactor could be used to consolidate the waste material. This method of waste placement would minimize the waste volume, reduce the permeability of the waste fill, and increase landfill stability. At closure, a proposed 12-inch layer of topsoil would be placed and compacted on the disposal areas. These areas would be seeded to establish a vegetative cover to control erosion.

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed

levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 6

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	1981 mw
Generating capacity of largest boiler	800 mw

Waste Production Information*

Fly ash	175015 dry ton/yr
Bottom Ash	14735 dry ton/yr
FGD sludge	651535 dry ton/yr
Waste densities (as disposed)	
Fly ash	55 lb/cu ft
Bottom ash	65 lb/cu ft
FGD sludge	95 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

[6001-18-1983#10:46:58]

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FGD sludge includes the fly ash
(160,840 tons) from units 5 and 6
since it is mixed with the sludge.

TABLE 2.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1981

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				\$0.
--------------	--	--	--	------

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
---	--	--	--	------

* Site cost adjustment factor (SCAF)= .933

Site Unit cost= SCAF x National Average Unit Cost

[6001-18-1983010:46:58]

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TABLE 2.2 (continued)

Construction Cost Items for Period 2
1982 - 1983

ITEM	QUANTITY	UNIT	UNIT+ COST	EXTENSION
on-site structural cut/fill	83,350	[cy]	2.23	185,860
seeding and mulching -grass	22,225	[sy]	0.39	8,709
gravel roadways	2,500	[lf]	2.82	7,044
CONSTRUCTION COST TOTAL				\$201,613
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items =	$\$201,613 \times 0.50 =$			\$100,806
CONSTRUCTION CAPITAL REQUIREMENT =				\$302,419
Closure Cost			\$0.	
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
* Site cost adjustment factor (SCAF)= .933				
Site Unit cost= SCAF x National Average Unit Cost				

[6001-18-1903#10:46:58]

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TABLE 2.2 (continued)

Construction Cost Items for Period 3
 1984 - 1985

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	960 [acres]		500	480,000
clear and grub	300 [acres]		1,227	368,069
final grading	300 [acres]		508	152,546
cut & fill non-compacted	11,000 [cy]		1.42	15,600
seeding and mulching -grass	32,935 [sy]		0.39	12,906
gravel roadways	2,500 [lf]		2.82	7,044
jacking & boring 36" casing	200 [lf]		275	55,047

CONSTRUCTION COST TOTAL

\$1,091,211.

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%

Other Capital Items = \$1,091,211. x 0.50 =

\$545,605

CONSTRUCTION CAPITAL REQUIREMENT =

\$1,636,816.

Closure Cost

\$0.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$0.

* Site cost adjustment factor (SCAF) = .933

Site Unit cost = SCAF x National Average Unit Cost

[6001-18-1983010:46:58]

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TABLE 2.2 (continued)

Construction Cost Items for Period 4
1986 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
clear and grub	145	[acres]	1,227	177,900
final grading	145	[acres]	508	73,730
cut & fill non-compacted	7,825	[cy]	1.42	11,097
seeding and mulching -grass	23,467	[sy]	0.39	9,196
gravel roadways	1,760	[lf]	2.82	4,959

CONSTRUCTION COST TOTAL \$276,882

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%

Other Capital Items = $\$276,882 \times 0.50 =$ \$138,441

CONSTRUCTION CAPITAL REQUIREMENT = \$415,323

Closure Cost \$2,653,452.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items) \$3,980,178.

* Site cost adjustment factor (SCAF) = .933
 Site Unit cost = SCAF x National Average Unit Cost

[6001-18-1983010:46:50]

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TABLE 2.3
CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	302,419	0	0.9775	295,615
1982	0	0	0.9555	0
1983	1,636,816	0	0.9341	1,528,950
1984	0	0	0.9131	0
1985	415,323	0	0.8925	370,676
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	3,980,178	0.4512	1,795,856

Total Present Worth of Future Capital Expenditures :

\$3,991,096

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$295,341

[Plant # 6]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTSO&M Costs for Period 1
1980 to 1981

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	175,015	2.33	408,223	Wet disposal
Bottom ash	14,735	2.33	34,369	Wet disposal
F6D	651,535	4.85	3,160,987	Dry disposal
Total handling			3,603,579	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
F6D	651,535	0.46	297,862	open on road truck (16cy) 1 mi. haul
Total transportation			297,862	
<u>Landfill costs</u>				
F6D	651,535	0.78	507,161	
Total landfill cost			507,161	
Annual operation and maintenance cost			94,408,603	

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TABLE 2.4 (continued)

O&M Costs for Period 2
1982 to 1983

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	175,015	2.33	408,223	Wet disposal
Bottom ash	14,735	2.33	34,369	Wet disposal
FGD	651,535	4.85	3,160,987	Dry disposal
Total handling			3,603,579	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
FGD	651,535	0.46	297,862	open on road truck (16cy) 1 mi. haul
Total transportation			297,862	
<u>Landfill costs</u>				
FGD	651,535	0.78	507,161	
Total landfill cost			507,161	

Annual operation and maintenance cost \$4,408,603

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TABLE 2.4 (continued)

O&M Costs for Period 3
1984 to 1985

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	175,015	2.33	408,223	Wet disposal
Bottom ash	14,735	2.33	34,369	Wet disposal
FGD	651,535	4.85	3,160,987	Dry disposal
Total handling			3,603,579	
Ash excavation				
Total excavation			none	
Ash transportation				
FGD	651,535	0.80	519,401	open on road truck (16cy) 3 mi. haul
Total transportation			519,401	
Landfill costs				
FGD	651,535	0.78	507,161	
Total landfill cost			507,161	

Annual operation and maintenance cost 94,630,142

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TABLE 2.4 (continued)

O&M Costs for Period 4
1986 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	175,015	2.33	408,223	Wet disposal
Bottom ash	14,735	2.33	34,369	Wet disposal
FGD	651,535	4.85	3,160,987	Dry disposal
Total handling			3,603,579	
<u>Ash excavation</u>				
Flyash	175,015	1.94	338,673	
Total excavation			338,673	
<u>Ash transportation</u>				
Flyash	175,015	0.80	139,521	open on road truck (16cy) 3 mi. haul
FGD	651,535	0.80	519,401	open on road truck (16cy) 3 mi. haul
Total transportation			658,923	
<u>Landfill costs</u>				
Flyash	175,015	1.34	235,312	
FGD	651,535	0.78	507,161	
Total landfill cost			742,473	

Annual operation and maintenance cost \$5,343,649

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TABLE 2.5
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	4,408,603	1.0000	4,408,603
1981	4,408,603	0.9775	4,309,409
1982	4,408,603	0.9555	4,212,420
1983	4,408,603	0.9341	4,118,076
1984	4,630,142	0.9131	4,227,783
1985	4,630,142	0.8925	4,132,402
1986	5,343,649	0.8725	4,662,334
1987	5,343,649	0.8528	4,557,064
1988	5,343,649	0.8337	4,455,000
1989	5,343,649	0.8149	4,354,540
1990	5,343,649	0.7966	4,256,751
1991	5,343,649	0.7787	4,161,099
1992	5,343,649	0.7612	4,067,586
1993	5,343,649	0.7441	3,976,209
1994	5,343,649	0.7273	3,886,436
1995	5,343,649	0.7110	3,799,334
1996	5,343,649	0.6950	3,713,836
1997	5,343,649	0.6794	3,630,475
1998	5,343,649	0.6641	3,548,717
1999	5,343,649	0.6492	3,469,097
2000	5,343,649	0.6346	3,391,080
2001	5,343,649	0.6203	3,314,665
2002	5,343,649	0.6064	3,240,389
2003	5,343,649	0.5927	3,167,181
2004	5,343,649	0.5794	3,096,110
2005	5,343,649	0.5664	3,026,645
2006	5,343,649	0.5536	2,958,244
2007	5,343,649	0.5412	2,891,983
2008	5,343,649	0.5290	2,826,790
2009	5,343,649	0.5171	2,763,201
2010	5,343,649	0.5055	2,701,215
2011	5,343,649	0.4941	2,640,297
2012	5,343,649	0.4830	2,580,982
2013	5,343,649	0.4722	2,523,271
2014	5,343,649	0.4616	2,466,628
Total Present Worth of Future Costs :			\$125,535,851
Sum of Present Worth Factors :		24.4103	
Levelized O&M Cost = (Present Worth of all O&M Costs) / (Sum of Present Worth Factors)			
LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST			\$5,142,741

[Plant # 6]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 6

Levelized Capital Cost

\$295,341

Levelized Operation and Maintenance Costs

\$5,142,741

Total Levelized Revenue Requirement

\$5,438,082

Levelized Revenue Requirement per Ton of Waste Disposed

\$6.46

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$7.15

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of groundwater monitoring wells around the existing ash and sludge disposal facilities. The new ash and sludge landfill (Figure 2.2) would be modified with a clay liner and cap to minimize leachate migration. Since the ash pond will be in continuous use until the year 2014 and represents a large ash volume, it was decided that a clay liner and cap would be a reasonable safeguard against possible future leachate generation. Miscellaneous wastes, eg. coal pile runoff, would continue to be discharged to the sedimentation pond.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge

NON-HAZARDOUS HANDLING & DISPOSAL

Operation Activity
Construction Activity

PLANT 6

rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5.

A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

TABLE 3.1

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 6

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	1981 MW
Generating capacity of largest boiler	800 MW

Waste Production Information*

Fly ash	175015 dry ton/yr
Bottom Ash	14735 dry ton/yr
FGD sludge	651535 dry ton/yr
Waste densities (as disposed)	
Fly ash	55 lb/cu ft
Bottom ash	65 lb/cu ft
FGD sludge	95 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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FGD sludge includes the fly ash
(160,840 tons) from units 5 and 6
since it is mixed with the sludge.

TABLE 3.2

NON-HAZARDOUS CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1981

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
<hr/>				
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.
<hr/>				
Closure Cost			\$0.	
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
<hr/>				
* Site cost adjustment factor (SCAF) = .933				
Site Unit cost = SCAF x National Average Unit Cost				
<hr/>				PAGE 2
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TABLE 3.2 (continued)

Construction Cost Items for Period 2
 1982 - 1983

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
on-site structural cut/fill	83,350	[cy]	2.23	185,860
seeding and mulching -grass	22,225	[sy]	0.39	8,709
gravel roadways	2,500	[lf]	2.82	7,044

CONSTRUCTION COST TOTAL \$201,613

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%

Other Capital Items = $\$201,613 \times 0.50 =$ \$100,806

CONSTRUCTION CAPITAL REQUIREMENT = \$302,419

Closure Cost \$0.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items) \$0.

* Site cost adjustment factor (SCAF) = .933

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 3.2 (continued)

Construction Cost Items for Period 3
 1984 - 1985

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	960 [acres]		500	480,000
clear and grub	300 [acres]		1,227	368,069
final grading	300 [acres]		500	152,546
cut & fill non-compacted	11,000 [cy]		1.42	15,600
on-site structural cut/fill	542,000 [cy]		2.23	1,208,760
topsoil removal & stockpile	451,735 [cy]		1.42	640,633
clay liner/cap placement	542,000 [cy]		4.39	2,377,075
clay import	542,000 [cy]		4.67	2,528,803
seeding and mulching -grass	32,935 [sq]		0.39	12,906
gravel roadways	2,500 [lf]		2.82	7,044
jacking & boring 36" casing	200 [lf]		275	55,047
groundwater monitoring wells	885 [lf]		11.20	9,908

CONSTRUCTION COST TOTAL

\$7,856,398.

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%

Other Capital Items = \$7,856,398. x 0.50 =

\$3,928,199.

CONSTRUCTION CAPITAL REQUIREMENT =

\$11,784,600.

Closure Cost

\$0.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$0.

* Site cost adjustment factor (SCAF) = .933

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 3.2 (continued)

Construction Cost Items for Period 4
1986 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
clear and grub	145 [acres]		1,227	177,900
final grading	145 [acres]		508	73,730
cut & fill non-compacted	7,825 [cy]		1.42	11,097
on-site structural cut/fill	280,720 [cy]		2.23	625,969
topsoil removal & stockpile	233,935 [cy]		1.42	331,757
clay liner/cap placement	280,720 [cy]		4.39	1,230,985
clay import	280,720 [cy]		4.67	1,309,559
seeding and mulching -grass	23,467 [sy]		0.39	9,196
gravel roadways	1,760 [lf]		2.82	4,959

groundwater monitoring wells 210 [lf] 11.20 2,351

CONSTRUCTION COST TOTAL \$3,777,504.

Contractor Overhead 15%
Contractor Profit 10%
Engineering & Legal Costs 10%
Contingency 15%

50%

Other Capital Items = \$3,777,504. x 0.50 = \$1,888,752.

CONSTRUCTION CAPITAL REQUIREMENT = \$5,666,256.

Closure Cost \$13,585,410.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items) \$20,378,120.

* Site cost adjustment factor (SCAF) = .933
Site Unit cost = SCAF x National Average Unit Cost

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TABLE 3.3
NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations
 Nominal Return : 8.4 %
 Inflation Rate : 6.0 %
 Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	302,419	0	0.9775	295,615
1982	0	0	0.9555	0
1983	11,784,600	0	0.9341	11,007,995
1984	0	0	0.9131	0
1985	5,666,256	0	0.8925	5,057,133
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	20,378,120	0.4512	9,194,608

Total Present Worth of Future Capital Expenditures :

\$25,555,351

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$1,891,096

[Plant # 6]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1981

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	175,815	2.33	408,223	Wet disposal
Bottom ash	14,735	2.33	34,369	Wet disposal
FGD	651,535	4.85	3,160,987	Dry disposal
Total handling			3,603,579	
Ash excavation				
Total excavation			none	
Ash transportation				
FGD	651,535	0.46	297,862	open on road truck (16cy) 1 mi. haul
Total transportation			297,862	
Landfill costs				
FGD	651,535	0.78	507,161	
Total landfill cost			507,161	

Annual operation and maintenance cost \$4,408,603

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TABLE 3.4 (continued)

O&M Costs for Period 2
1982 to 1983

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	175,015	2.33	408,223	Wet disposal
Bottom ash	14,735	2.33	34,369	Wet disposal
FGD	651,535	4.85	3,160,987	Dry disposal
Total handling			3,603,579	
Ash excavation				
Total excavation			none	
Ash transportation				
FGD	651,535	0.46	297,862	open on road truck (16cy) 1 mi. haul
Total transportation			297,862	
Landfill costs				
FGD	651,535	0.78	507,161	
Total landfill cost			507,161	
Annual operation and maintenance cost			\$4,408,603	

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TABLE 3.4 (continued)

O&M Costs for Period 3
1984 to 1985

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	175,015	2.33	408,223	Wet disposal
Bottom ash	14,735	2.33	34,369	Wet disposal
FBD	651,535	4.85	3,160,987	Dry disposal
Total handling			3,603,579	
Ash excavation				
Total excavation			none	
Ash transportation				
FBD	651,535	0.00	519,401	open on road truck (16cy) 3 mi. haul
Total transportation			519,401	
Landfill costs				
FBD	651,535	0.78	507,161	
Total landfill cost			507,161	
Groundwater monitoring			17,010	
Annual operation and maintenance cost			\$4,647,152	

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TABLE 3.4 (continued)

O&M Costs for Period 4
1986 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	175,015	2.33	408,223	Wet disposal
Bottom ash	14,735	2.33	34,369	Wet disposal
FGD	651,535	4.85	3,160,987	Dry disposal
Total handling			3,603,579	
<u>Ash excavation</u>				
Flyash	175,015	1.94	338,673	
Total excavation			338,673	
<u>Ash transportation</u>				
Flyash	175,015	0.80	139,521	open on road truck (16cy) 3 mi. haul
FGD	651,535	0.80	519,401	open on road truck (16cy) 3 mi. haul
Total transportation			658,923	
<u>Landfill costs</u>				
Flyash	175,015	1.34	235,312	
FGD	651,535	0.78	507,161	
Total landfill cost			742,473	
Groundwater monitoring			28,897	

Annual operation and maintenance cost \$5,363,746

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TABLE 3.5
NON-HAZARDOUS 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	4,408,603	1.0000	4,408,603
1981	4,408,603	0.9775	4,309,409
1982	4,408,603	0.9555	4,212,420
1983	4,408,603	0.9341	4,118,076
1984	4,647,152	0.9131	4,243,314
1985	4,647,152	0.8925	4,147,583
1986	5,363,746	0.8725	4,679,868
1987	5,363,746	0.8528	4,574,203
1988	5,363,746	0.8337	4,471,755
1989	5,363,746	0.8149	4,370,917
1990	5,363,746	0.7966	4,272,760
1991	5,363,746	0.7787	4,176,749
1992	5,363,746	0.7612	4,082,883
1993	5,363,746	0.7441	3,991,163
1994	5,363,746	0.7273	3,901,052
1995	5,363,746	0.7110	3,813,623
1996	5,363,746	0.6950	3,727,803
1997	5,363,746	0.6794	3,644,129
1998	5,363,746	0.6641	3,562,064
1999	5,363,746	0.6492	3,482,144
2000	5,363,746	0.6346	3,403,833
2001	5,363,746	0.6203	3,327,132
2002	5,363,746	0.6064	3,252,576
2003	5,363,746	0.5927	3,179,092
2004	5,363,746	0.5794	3,107,754
2005	5,363,746	0.5664	3,038,026
2006	5,363,746	0.5536	2,969,370
2007	5,363,746	0.5412	2,902,859
2008	5,363,746	0.5290	2,837,422
2009	5,363,746	0.5171	2,773,593
2010	5,363,746	0.5055	2,711,374
2011	5,363,746	0.4941	2,650,227
2012	5,363,746	0.4830	2,590,689
2013	5,363,746	0.4722	2,532,761
2014	5,363,746	0.4616	2,475,905

Total Present Worth of Future Costs :

\$125,943,133

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$5,159,426

[Plant # 6]

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 6

Levelized Capital Cost

\$1,891,096

Levelized Operation and Maintenance Costs

\$5,159,426

Total Levelized Revenue Requirement

\$7,050,522

Levelized Revenue Requirement per Ton of Waste Disposed

\$8.38

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$9.27

SECTION 4

HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

The proposed design consists of acquiring a tract of land 3 miles east of the power plant. For the purpose of this analysis, it has been determined that it will be most cost effective in the future if dry handling systems are utilized for the disposal of the ash and sludge. In the future, all ash and sludge will be trucked to the new landfill. Leachate treatment facilities are provided and were sized based on a 10-year, 24-hour rainfall event falling on half the area of one open cell. Internal cell diking will preclude contamination of all storm water runoff. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes could be used to moisture condition the ash before placement in the landfill.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities

Design FactorHazardous MinimumHazardous Maximum

2. Liner System

Use a single liner system
as specified in the EPA
guidance documents

Use a double liner
system as specified in
the EPA guidance
documents

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. It was assumed that because of RCRA restrictions ash would no longer be able to be used for commercial purposes. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed cells on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Figure 4.1 is a layout of the cells which are proposed for ash disposal under the hazardous waste scenario. Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

FIGURE 4.1

HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION ⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.2

HAZARDOUS MAXIMUM LANDFILL - TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 6

Design Mode: Hazardous Min

Date 101-19-1982

Power Plant Information (1980)

Generating capacity of plant	1981 mw
Generating capacity of largest boiler	800 mw

Waste Production Information *

Fly ash	175015 dry ton/yr
Bottom Ash	78035 dry ton/yr
FGD sludge	651335 dry ton/yr
Waste densities (as disposed)	
Fly ash	66 lb/cu ft
Bottom ash	78 lb/cu ft
FGD sludge	95 lb/cu ft

General Disposal Site Information

Site area	1420 acres
Percent heavily wooded	0 %
Percent lightly wooded	0 %
Site perimeter	30000 ft
Distance to plant	3 mi
Distance to main road	500 ft
Distance from disposal site to leachate treatment plant	4000 ft
Thickness of soils above bedrock	150 ft
Thickness of topsoil at site	1 ft
Groundwater table depth	5 ft

Construction Materials

Clay availability on-site	no
Clay import distance	25 mi
Sand availability on-site	no
Sand import distance	4 mi

Climatic Information

Maximum frost penetration	15 in
Total annual precipitation	43.64 in
10-yr, 24-hr rainfall event	3.75 in

* note: Average for period 1980- 2014 . If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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FGD sludge includes the fly ash
(160,840 tons) from units 5 and 6
since it is mixed with the sludge.

TABLE 4.2

HAZARDOUS MIN CELL GEOMETRY

Number of cells	15
Cell volume	1820036 cu yd
Depth of waste at edge of fill	40 ft
Cell dimensions	
length at top	1992 ft
width at top	664 ft
length at bottom	1832 ft
width at bottom	584 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	18912 ft

Disposal Cell Cross-Section
Dry Landfill w/ Single Liner

NOTE: Datum is below existing ground surface an average of 0 feet at this site

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980- 2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	1,420	[acres]	500	710,000
clear and grub	1,200	[acres]	1,227	1,481,941
final grading	1,207	[acres]	508	613,741
cut & fill non-compacted	1,875,920	[cy]	1.42	2,660,366
borrow material import	10,314,400	[cy]	6.90	71,212,680
topsoil removal & stockpile	865,690	[cy]	1.42	1,227,687
sand collection zone plant	1,931,390	[cy]	8.22	15,875,504
sand import	1,931,390	[cy]	5.92	11,442,617
clay liner/cap placement	1,875,920	[cy]	4.39	8,226,132
clay import	1,875,920	[cy]	4.67	8,751,204
synthetic membrane	42,113,170	[sf]	0.52	22,003,289
seeding and mulching -grass	5,841,880	[sy]	0.39	2,289,199
gravel stabilization	3,967	[sy]	0.65	2,591
plastic filter fabric	4,679,241	[sy]	0.67	3,143,327
light duty bituminous road	16,112	[lf]	11.83	190,612
heavy duty bituminous road	500	[lf]	15.53	7,763
perimeter fencing	30,800	[ft]	11.20	344,837
plastic pipe, pvc-4"	110,799	[lf]	9.28	1,028,590
plastic pipe, pvc-6"	63,760	[lf]	13.37	852,464
leachate collect sumps	3,750	[lf]	87.70	328,883
jacking & boring 36" casing	100	[lf]	275	27,524
soil borings	15,000	[lf]	14.00	211,150
groundwater monitoring wells	567	[lf]	11.20	6,352
CELL CONSTRUCTION COST SUBTOTAL				\$152,630,500.
Leachate Treatment Plant Construction Cost				\$2,120,272.
Wet-to-dry conversion cost of Bottom ash				\$3,772,054.
No Wet-to-Dry Conversion for FGD				
Construction Cost for Closure of Existing Disposal Site(s)				\$3,348,537.
CONSTRUCTION COST TOTAL				\$161,879,300.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items = \$161,879,300. x 0.50 =				\$80,939,650.
Permitting Cost				\$250,000
TOTAL CAPITAL REQUIREMENT =				\$243,069,000.
* Site Cost Adjustment Factor (SCAF) = .933				
Site Unit Cost = SCAF x National-Average Unit Cost				

TABLE 4.4

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	29,375,140	1.0000	29,375,140
1982	15,263,840	0.9555	14,584,599
1985	15,263,840	0.8925	13,622,977
1987	15,263,840	0.8528	13,017,003
1989	15,263,840	0.8149	12,438,503
1992	15,263,840	0.7612	11,618,835
1994	15,263,840	0.7273	11,101,391
1996	15,263,840	0.6950	10,608,369
1999	15,263,840	0.6492	9,909,285
2001	15,263,840	0.6203	9,468,160
2003	15,263,840	0.5927	9,046,878
2006	15,263,840	0.5536	8,450,062
2008	15,263,840	0.5290	8,074,571
2010	15,263,840	0.5055	7,715,871
2013	15,263,840	0.4722	7,207,585
Total Cap Exp	\$243,068,900		
Present Worth of all Capital Costs			\$176,239,229
Total Levelizing Factor (LF) =	0.0740		
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$13,041,703

[Plant # 6]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	175,015	3.27	571,512	Dry disposal
Bottom ash	78,055	3.27	254,889	Dry disposal
FGD	651,535	4.85	3,160,987	Dry disposal
Total handling			3,987,388	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	175,015	0.80	139,521	open on road truck (16cy) 3 mi. haul
Bottom ash	78,055	0.80	62,225	open on road truck (16cy) 3 mi. haul
FGD	651,535	0.80	519,401	open on road truck (16cy) 3 mi. haul
Total transportation			721,148	
Landfill costs				
Flyash	175,015	1.12	196,093	
Bottom ash	78,055	0.95	74,001	
FGD	651,535	0.78	507,161	
Total landfill cost			777,255	
Leachate Treatment Plant O and M			\$206,378	
Total non-administrative O and M			\$5,692,169	

Administrative O&M Cost Items

Manifesting	\$29,725
Groundwater monitoring	\$33,504
Inspection	\$16,031
Personnel training	\$1,120
Non-sudden occurrence insurance	\$57,308
General administration	\$83,202
Total Annual Administration cost	\$220,889
Total annual operation and maintenance cost	\$5,913,058

Post closure O&M costs

Existing site (1980-2010)	\$73,878
New site	
Groundwater monitoring	\$67,000
Inspection	\$32,062
Maintenance	\$109,865
Administrative services	\$5,225
Total annual post closure cost (2014 - 2044)	\$214,159

TABLE 4.6
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	5,986,936	1.0000	5,986,936	Begin post closure operation and maintenance of existing site
1981	5,986,936	0.9775	5,852,230	
1982	5,986,936	0.9555	5,720,517	
1983	5,986,936	0.9341	5,592,397	
1984	5,986,936	0.9131	5,466,671	Begin post closure operation and maintenance of existing site
1985	5,986,936	0.8925	5,343,340	
1986	5,986,936	0.8725	5,223,602	
1987	5,986,936	0.8528	5,105,659	
1988	5,986,936	0.8337	4,991,309	
1989	5,986,936	0.8149	4,878,754	
1990	5,986,936	0.7966	4,769,193	
1991	5,986,936	0.7787	4,662,027	
1992	5,986,936	0.7612	4,557,256	
1993	5,986,936	0.7441	4,454,879	
1994	5,986,936	0.7273	4,354,299	
1995	5,986,936	0.7110	4,256,711	
1996	5,986,936	0.6950	4,160,921	
1997	5,986,936	0.6794	4,067,524	
1998	5,986,936	0.6641	3,975,924	
1999	5,986,936	0.6492	3,886,719	End post closure operation and maintenance of existing site
2000	5,986,936	0.6346	3,799,310	
2001	5,986,936	0.6203	3,713,696	
2002	5,986,936	0.6064	3,630,478	
2003	5,986,936	0.5927	3,548,457	
2004	5,986,936	0.5794	3,468,831	
2005	5,986,936	0.5664	3,391,001	
2006	5,986,936	0.5536	3,314,368	
2007	5,986,936	0.5412	3,240,130	
2008	5,986,936	0.5290	3,167,089	
2009	5,986,936	0.5171	3,095,845	
2010	5,986,936	0.5055	3,026,396	
2011	5,913,058	0.4941	2,921,642	
2012	5,913,058	0.4830	2,856,007	
2013	5,913,058	0.4722	2,792,146	
2014	5,913,058	0.4616	2,729,468	Begin post closure operation and maintenance
2015	214,159	0.4512	96,629	
2016	214,159	0.4410	94,644	
2017	214,159	0.4311	92,324	
2018	214,159	0.4214	90,247	
2019	214,159	0.4120	88,234	
2020	214,159	0.4027	86,242	
2021	214,159	0.3936	84,293	
2022	214,159	0.3848	82,408	
2023	214,159	0.3761	80,545	
2024	214,159	0.3677	78,746	
2025	214,159	0.3594	76,969	

(continued next page)

[Plant # 6]

TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	214,159	0.3513	75,234	
2027	214,159	0.3434	73,542	
2028	214,159	0.3357	71,893	
2029	214,159	0.3282	70,287	
2030	214,159	0.3208	68,702	
2031	214,159	0.3136	67,160	
2032	214,159	0.3065	65,640	
2033	214,159	0.2996	64,162	
2034	214,159	0.2929	62,727	
2035	214,159	0.2863	61,314	
2036	214,159	0.2799	59,943	
2037	214,159	0.2736	58,594	
2038	214,159	0.2674	57,266	
2039	214,159	0.2614	55,981	
2040	214,159	0.2555	54,718	
2041	214,159	0.2498	53,497	
2042	214,159	0.2442	52,298	
2043	214,159	0.2387	51,120	
2044	214,159	0.2333	49,963	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$148,126,852	
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			\$4,314,366	

[Plant # 6]

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 6

Levelized Capital Cost

\$13,041,703

Levelized Operation and Maintenance Costs

\$4,314,366

Total Levelized Revenue Requirement

\$17,356,069

Levelized Revenue Requirement per Ton of Waste Disposed

\$19.19

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$22.29

TABLE 4.8

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 6

Design Mode: Hazardous Max

Date 101-19-1982

Power Plant Information (1980)

Generating capacity of plant	1981 mw
Generating capacity of largest boiler	800 mw

Waste Production Information *

Fly ash	175015 dry ton/yr
Bottom Ash	78055 dry ton/yr
FGD sludge	651535 dry ton/yr
Waste densities (as disposed)	
Fly ash	66 lb/cu ft
Bottom ash	78 lb/cu ft
FGD sludge	95 lb/cu ft

General Disposal Site Information

Site area	1420 acres
Percent heavily wooded	0 %
Percent lightly wooded	0 %
Site perimeter	30800 ft
Distance to plant	3 mi
Distance to main road	500 ft
Distance from disposal site to leachate treatment plant	4000 ft
Thickness of soils above bedrock	150 ft
Thickness of topsoil at site	1 ft
Groundwater table depth	5 ft

Construction Materials

Clay availability on-site	no
Clay import distance	25 mi
Sand availability on-site	no
Sand import distance	4 mi

Climatic Information

Maximum frost penetration	15 in
Total annual precipitation	43.64 in
10-yr, 24-hr rainfall event	3.75 in

* note: Average for period 1980-2014 . If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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FGD sludge includes the fly ash
(160,840 tons) from units 5 and 6
since it is mixed with the sludge.

TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	15
Cell volume	1820036 cu yd
Depth of waste at edge of fill	40 ft
Cell dimensions	
length at top	1992 ft
width at top	664 ft
length at bottom	1832 ft
width at bottom	504 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	18912 ft

Disposal Cell Cross-Section
Dry Landfill w/ Double Liner

NOTE: Datum is below existing ground surface an average of 6 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS

Construction Cost Items (1980- 2014)

ITEM	QUANTITY	UNIT	UNIT+ COST	EXTENSION
real estate	1,420	[acres]	500	710,000
clear and grub	1,200	[acres]	1,227	1,481,941
final grading	1,207	[acres]	500	613,741
cut & fill non-compacted	1,916,485	[cy]	1.42	2,717,882
borrow material import	11,502,180	[cy]	6.90	79,413,351
topsoil removal & stockpile	882,588	[cy]	1.42	1,251,652
sand collection zone plant	2,364,633	[cy]	8.22	19,436,645
sand import	2,364,633	[cy]	5.92	14,009,386
clay liner/cap placement	3,795,802	[cy]	4.39	16,644,971
clay import	3,795,802	[cy]	4.67	17,707,416
synthetic membrane	42,572,780	[sf]	0.52	22,243,426
seeding and mulching -grass	5,841,800	[sy]	0.39	2,289,199
gravel stabilization	3,967	[sy]	0.65	2,591
plastic filter fabric	4,730,309	[sy]	0.67	3,177,632
light duty bituminous road	16,112	[lf]	11.83	190,612
heavy duty bituminous road	500	[lf]	15.53	7,763
perimeter fencing	30,800	[ft]	11.20	344,837
plastic pipe, pvc-4"	221,599	[lf]	9.28	2,057,178
plastic pipe, pvc-6"	127,520	[lf]	13.37	1,704,928
leachate collect suaps	3,750	[lf]	87.70	328,883
jacking & boring 36" casing	100	[lf]	275	27,524
soil borings	15,088	[lf]	14.00	211,150
groundwater monitoring wells	567	[lf]	11.20	6,352
CELL CONSTRUCTION COST SUBTOTAL				\$186,579,100.
Leachate Treatment Plant Construction Cost				\$2,120,272.
Wet-to-dry conversion cost of Bottom ash				\$3,772,054.
No Wet-to-Dry Conversion for FGD				
Construction Cost for Closure of Existing Disposal Site(s)				\$10,561,560.
CONSTRUCTION COST TOTAL				\$203,032,900.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items = \$203,032,900. x 0.50 =				\$101,516,500.
Permitting Cost				\$500,000
TOTAL CAPITAL REQUIREMENT =				\$305,049,400.

* Site Cost Adjustment Factor (SCAF) = .933
 Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.11

HAZARDOUS MAX 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	43,838,730	1.0000	43,838,730
1982	18,657,900	0.9555	17,827,623
1985	18,657,900	0.8925	16,652,176
1987	18,657,900	0.8528	15,911,457
1989	18,657,900	0.8149	15,204,323
1992	18,657,900	0.7612	14,202,393
1994	18,657,900	0.7273	13,569,891
1996	18,657,900	0.6950	12,967,241
1999	18,657,900	0.6492	12,112,709
2001	18,657,900	0.6203	11,573,495
2003	18,657,900	0.5927	11,058,537
2006	18,657,900	0.5536	10,329,013
2008	18,657,900	0.5290	9,870,029
2010	18,657,900	0.5055	9,431,568
2013	18,657,900	0.4722	8,810,260
Total Cap Exp	\$305,049,330		
Present Worth of all Capital Costs			\$223,359,446
Total Levelizing Factor (LF) =		0.0740	
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$16,528,599

[Plant # 6]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	175,015	3.27	571,512	Dry disposal
Bottom ash	78,055	3.27	254,809	Dry disposal
FGD	651,535	4.85	3,160,987	Dry disposal
Total handling			3,987,388	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	175,015	0.80	139,521	open on road truck (16cy) 3 mi. haul
Bottom ash	78,055	0.80	62,225	open on road truck (16cy) 3 mi. haul
FGD	651,535	0.80	519,401	open on road truck (16cy) 3 mi. haul
Total transportation			721,148	
Landfill costs				
Flyash	175,015	1.12	196,093	
Bottom ash	78,055	0.95	74,001	
FGD	651,535	0.78	507,161	
Total landfill cost			777,255	
Leachate Treatment Plant O and M			\$206,378	
Total non-administrative O and M			\$5,692,169	

Administrative O&M Cost Items

Manifesting	\$29,725
Groundwater monitoring	\$33,504
Inspection	\$16,031
Personnel training	\$1,120
Non-sudden occurrence insurance	\$57,308
General administration	\$83,202
Total Annual Administration cost	\$220,889
Total annual operation and maintenance cost	\$5,913,058

Post closure O&M costs

Existing site (1980-2010)	\$73,878
New site	
Groundwater monitoring	\$67,000
Inspection	\$32,062
Maintenance	\$109,865
Administrative services	\$5,225
Total annual post closure cost (2014 - 2044)	\$214,159

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TABLE 4.13
HAZARDOUS MAX 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	5,986,936	1.0000	5,986,936	Begin post closure operation and maintenance of existing site
1981	5,986,936	0.9775	5,852,230	
1982	5,986,936	0.9555	5,720,317	
1983	5,986,936	0.9341	5,592,397	
1984	5,986,936	0.9131	5,466,671	Begin post closure operation and maintenance of existing site
1985	5,986,936	0.8925	5,343,340	
1986	5,986,936	0.8723	5,223,602	
1987	5,986,936	0.8528	5,105,659	
1988	5,986,936	0.8337	4,991,309	
1989	5,986,936	0.8149	4,878,754	
1990	5,986,936	0.7966	4,769,193	
1991	5,986,936	0.7787	4,662,027	
1992	5,986,936	0.7612	4,557,256	
1993	5,986,936	0.7441	4,454,879	
1994	5,986,936	0.7273	4,354,299	
1995	5,986,936	0.7110	4,256,711	
1996	5,986,936	0.6950	4,160,921	
1997	5,986,936	0.6794	4,067,524	
1998	5,986,936	0.6641	3,975,924	
1999	5,986,936	0.6492	3,886,719	End post closure operation and maintenance of existing site
2000	5,986,936	0.6346	3,799,310	
2001	5,986,936	0.6203	3,713,696	
2002	5,986,936	0.6064	3,630,478	
2003	5,986,936	0.5927	3,548,457	
2004	5,986,936	0.5794	3,468,831	Begin post closure operation and maintenance
2005	5,986,936	0.5664	3,391,001	
2006	5,986,936	0.5536	3,314,368	
2007	5,986,936	0.5412	3,240,130	
2008	5,986,936	0.5290	3,167,089	
2009	5,986,936	0.5171	3,095,845	
2010	5,986,936	0.5055	3,026,396	
2011	5,913,058	0.4941	2,921,642	
2012	5,913,058	0.4830	2,856,007	
2013	5,913,058	0.4722	2,792,146	
2014	5,913,058	0.4616	2,729,468	Begin post closure operation and maintenance
2015	214,159	0.4512	96,629	
2016	214,159	0.4410	94,444	
2017	214,159	0.4311	92,324	
2018	214,159	0.4214	90,247	
2019	214,159	0.4120	88,234	
2020	214,159	0.4027	86,242	
2021	214,159	0.3936	84,293	
2022	214,159	0.3848	82,408	
2023	214,159	0.3761	80,545	
2024	214,159	0.3677	78,746	
2025	214,159	0.3594	76,969	

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[Plant # 6]

TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	214,159	0.3513	75,234	
2027	214,159	0.3434	73,542	
2028	214,159	0.3357	71,893	
2029	214,159	0.3282	70,287	
2030	214,159	0.3208	68,702	
2031	214,159	0.3136	67,160	
2032	214,159	0.3065	65,640	
2033	214,159	0.2996	64,162	
2034	214,159	0.2929	62,727	
2035	214,159	0.2863	61,314	
2036	214,159	0.2799	59,943	
2037	214,159	0.2736	58,594	
2038	214,159	0.2674	57,266	
2039	214,159	0.2614	55,981	
2040	214,159	0.2555	54,718	
2041	214,159	0.2498	53,497	
2042	214,159	0.2442	52,298	
2043	214,159	0.2387	51,120	
2044	214,159	0.2333	49,963	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$148,126,852	
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			\$4,314,366	

[Plant # 6]

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 6

Levelized Capital Cost

\$16,528,599

Levelized Operation and Maintenance Costs

\$4,314,366

Total Levelized Revenue Requirement

\$20,842,965

Levelized Revenue Requirement per Ton of Waste Disposed

\$23.04

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$26.77

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 295,000	\$ 5,143,000	\$ 5,438,000	\$ 6.46	\$ 7.15
Non-Hazardous	1,891,000	5,159,000	7,050,000	8.38	9.27
Hazardous Minimum	13,042,000	4,314,000	17,356,000	19.19	22.29
Hazardous Maximum	16,529,000	4,314,000	20,843,000	23.04	26.77

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data 1980, Kingston, MA.

RCRA Impact
Case Study of Plant 8

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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal in the utility industry. These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 8 is located along the Mississippi River in eastern Iowa and has a 1980 nameplate generating capacity of 210 MW. The plant has five boilers, all of which are equipped to burn coal or gas. Natural gas is used for start-up and combustion stabilization. Boilers 5 and 9 are dry-bottom, pulverized coal tangentially-fired units and boilers 6,7, and 8 are dry-bottom, pulverized coal front-fired units. No new boiler units are planned for this site.

Bituminous coal for the plant is obtained primarily from Illinois. Coal is transported to the facility by rail and placed in storage or conveyed to a 3500-ton capacity bunker. A 90-day stockpile is normally maintained on-site. Coal consumption for 1980 was 317,300 tons. The

average analysis of the coal consumed during 1980 was 2.66 percent sulfur, 10.27 percent ash, and 10,291 BTU's/lb. The 1985 and 1990 rates of coal consumption are projected to both be 77,000 tons and 150,000 tons respectively.

Each of the boilers is equipped with an electrostatic precipitator (ESP). The average collection efficiency for the ESP's is 99.5 percent. Based on the utility's analysis, this collection efficiency is sufficient to meet the particulate regulations of $0.8 \text{ lb}/10^6 \text{ BTU}$. None of the boilers are equipped with SO_2 control systems as noted in Table 1.1 which summarizes the plant characteristics.

EXISTING DISPOSAL

The schematic flow diagram for the existing disposal practice at the plant is illustrated in Figure 1.2. The quantities of waste materials generated for 1980 and projected for 1985 and 1990 are summarized in Table 1.2.

Fly ash from boilers 5, 6, 7, and 8 is collected dry at the precipitators and then sluiced to an on-site ash pond (Figure 1.3). The fly ash collected from the Boiler 9 precipitator is transferred to a silo. The silo is maintained on-site for short term storage of the fly ash prior to sale or off-site disposal. All bottom ash is disposed of by sluicing to the same ash pond. In 1979, fly ash and bottom ash were dredged from the pond to an on-site temporary ash storage area. A contractor trucks the fly ash and bottom ash to an off-site landfill for disposal. Each year a portion of the ash is excavated and loaded into trucks for landfill disposal off-site.

Occasional boiler cleaning wastes and some equipment cooling water are discharged directly to the ash pond. Effluent from the pond is neutralized before discharging into the river.

SCHEMATIC FLOW DIAGRAM

FIGURE 1.2

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PLANT 8 367

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 8

Boiler	Stack	MW (Nameplate)	Year of Start-up	1980 Availability Factor	1980 Coal Used (tons)	1985 Coal Projections (tons)	1990 Coal Projections (tons)	Type of Control	
								Particulate	SO ₂
5	5	22.5 ¹	1937	81.5%	9,000	Retired	Retired	ESP	None
6	6	(1)	1944	79.3	10,300	77,000 ³	150,000 ³	ESP	None
7	9	51.0 ²	1949	92.7	48,500	(3)	(3)	ESP	None
8	9	(2)	1949	90.4	39,200	(3)	(3)	ESP	None
9	9	<u>136.00</u>	1961	87.2	<u>210,300</u>	<u>(3)</u>	<u>(3)</u>	ESP	None
Totals		209.50			317,300	77,000 ³	150,000 ³		

- (1) Number applies to Boilers 5 & 6, however, in 1982 boiler 5 was retired from service.
 (2) Number applies to Boilers 7 & 8
 (3) Coal consumption is for all units

TABLE 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 8

Waste Product	1980- 1982 Values	1983- 1989 Values	1990- 2014 Values	35-Year Average
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	25,600	6,200	12,000	12,005
Tons Sold	<u>11,000</u>	<u>1,100</u>	<u>4,300</u>	<u>4,234</u>
Tons Disposed	14,600	5,100	7,700	7,771
<u>Bottom Ash (Dry Weight)</u>				
Tons Produced	6,400	1,500	3,000	2,991
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	6,400	1,500	3,000	2,991
<u>Other Wastes</u>				
Coal Pile Runoff (MG/yr)	5.0	5.0	5.0	

Average is for 1980-2014, assuming that the 1990 values remain constant through 2014.

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates.

The existing practice of ash dredging and excavation from both the pond and the storage area, with hauling to a landfill will be adequate to provide disposal until 2014. When the active life of the ash pond and storage area is exhausted, an average six (6) inch layer of topsoil would be placed and compacted on these areas. These areas would be seeded to establish a vegetative cover for erosion control.

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs

CURRENT PRACTICE HANDLING & DISPOSAL

FIGURE 2.1

based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extentions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 8

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	289.5 mw
Generating capacity of largest boiler	136 mw

Waste Production Information*

Fly ash	7771 dry ton/yr
Bottom Ash	2991 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	55 lb/cu ft
Bottom ash	55 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

[8001-18-1983010:20:46]

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TABLE 2.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 2014

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	\$267,031
--------------	-----------

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)	\$400,546
---	-----------

* Site cost adjustment factor (SCAF)= 1.091

Site Unit cost= SCAF x National Average Unit Cost

[8801-18-1983010:20:46]

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TABLE 2.3
CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	0	0	0.9131	0
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	400,546	0.4512	180,726

Total Present Worth of Future Capital Expenditures :

\$180,726

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$13,374

[Plant # 8]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	7,771	2.73	21,195	Wet disposal
Bottom ash	2,991	2.73	8,158	Wet disposal
Total handling			29,353	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	

Annual operation and maintenance cost \$29,353
 Non-annual ash excavation cost 24242 c.y. @ \$ 5.19316 /c.y = \$ 125892.6 in year 1982
 Non-annual ash excavation cost ~~100000~~ c.y. @ \$ 1.49467 /c.y = \$ 149467 in year 1983
 Non-annual ash excavation cost ~~100000~~ c.y. @ \$ 5.19316 /c.y = \$ 519316 in year 1984
 Non-annual ash excavation cost 18858 c.y. @ \$ 5.19316 /c.y = \$ 97932.6 in year 1989
 Non-annual ash excavation cost ~~100000~~ c.y. @ \$ 1.49467 /c.y = \$ 149467 in year 1996
 Non-annual ash excavation cost 38965 c.y. @ \$ 5.19316 /c.y = \$ 202351.5 in year 1997
 Non-annual ash excavation cost 68965 c.y. @ \$ 1.49467 /c.y = \$ 103079.9 in year 2006
 Non-annual ash excavation cost 134675 c.y. @ \$ 5.19316 /c.y = \$ 699388.8 in year 2014

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NOTES ON PLANT 8

Non-annual ash excavation costs

1982 costs represent the 1980, 1981 and 1982 partial excavations and landfilling of ash from the pond

1983 costs represent the dredging of the ash from the pond to the storage area

1984 costs represent the excavation and the landfilling of the ash from the storage area

1989 costs represent the 1983 through 1989 partial excavations and landfilling of ash from the pond

1996 costs represent the dredging of the ash from the pond to the storage area

1997 costs represent the partial excavation and landfilling of the ash from the storage area

2006 costs represent the partial dredging of the ash from the pond to the storage area

2014 costs represent the 1990 through 2014 partial excavations and landfilling of ash from the pond

TABLE 2.5
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	29,353	1.0000	29,353
1981	29,353	0.9775	28,693
1982	155,246	0.9555	148,338
1983	178,820	0.9341	167,036
1984	548,669	0.9131	500,990
1985	29,353	0.8925	26,198
1986	29,353	0.8725	25,610
1987	29,353	0.8528	25,032
1988	29,353	0.8337	24,472
1989	127,286	0.8149	103,725
1990	29,353	0.7966	23,383
1991	29,353	0.7787	22,857
1992	29,353	0.7612	22,344
1993	29,353	0.7441	21,842
1994	29,353	0.7273	21,348
1995	29,353	0.7110	20,870
1996	178,820	0.6950	124,280
1997	231,705	0.6794	157,420
1998	29,353	0.6641	19,493
1999	29,353	0.6492	19,056
2000	29,353	0.6346	18,627
2001	29,353	0.6203	18,208
2002	29,353	0.6064	17,800
2003	29,353	0.5927	17,398
2004	29,353	0.5794	17,007
2005	29,353	0.5664	16,626
2006	132,433	0.5536	73,315
2007	29,353	0.5412	15,386
2008	29,353	0.5290	15,328
2009	29,353	0.5171	15,178
2010	29,353	0.5055	14,858
2011	29,353	0.4941	14,503
2012	29,353	0.4830	14,177
2013	29,353	0.4722	13,860
2014	728,742	0.4616	336,387

Total Present Worth of Future Costs :

\$2,151,577

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
 (Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$88,146

[Plant # 8]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 8

Levelized Capital Cost

\$13,374

Levelized Operation and Maintenance Costs

\$88,146

Total Levelized Revenue Requirement

\$101,520

Levelized Revenue Requirement per Ton of Waste Disposed

\$9.43

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$7.00

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of ground-water monitoring wells around the existing pond and temporary storage area. The temporary storage area would be modified with a protective earthen cover over a clay liner to minimize leachate migration. Upon closure both the pond and storage area would receive a 12-inch clay cap. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes, would continue to be discharged to the ash pond.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the

NON-HAZARDOUS HANDLING & DISPOSAL

FIGURE 3.1

escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5.

A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

TABLE 3.1

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 8

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	289.5 mw
Generating capacity of largest boiler	136 mw

Waste Production Information*

Fly ash	7771 dry ton/yr
Bottom Ash	2991 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	55 lb/cu ft
Bottom ash	55 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 3.2

NON-HAZARDOUS CAPITAL COSTSConstruction Cost Items for Period 1
1980 - 1984

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
borrow material import	32,912 [cy]		8.07	265,712
clay liner/cap placement	32,912 [cy]		5.13	168,763
clay import	32,912 [cy]		5.46	179,535
CONSTRUCTION COST TOTAL				\$614,010
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items =				\$614,010 x 0.50 =
				\$307,005
CONSTRUCTION CAPITAL REQUIREMENT =				\$921,014

Closure Cost \$0.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items) \$0.

* Site cost adjustment factor (SCAF) = 1.091

Site Unit cost = SCAF x National Average Unit Cost

[8001-18-1983010:25:10]

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TABLE 3.2 (continued)

Construction Cost Items for Period 2
1985 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
<hr/>				
groundwater monitoring wells	296 (14)		13.09	3,875
CONSTRUCTION COST TOTAL				\$3,875
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items =	$\$3,875 \times 0.50 =$			\$1,938
CONSTRUCTION CAPITAL REQUIREMENT =				\$5,813

Closure Cost \$2,172,985.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items) \$3,259,478.

* Site cost adjustment factor (SCAF) = 1.091

Site Unit cost = SCAF x National Average Unit Cost

(8801-18-1983010:25:10)

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TABLE 3.3
NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations
 Nominal Return : 8.4 %
 Inflation Rate : 6.0 %
 Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	921,014	0	1.0000	921,014
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	5,813	0	0.9131	5,308
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	3,259,478	0.4512	1,470,676

Total Present Worth of Future Capital Expenditures :

\$2,396,998

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$177,378

[Plant # 8]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1984

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	7,771	2.73	21,195	Wet disposal
Bottom ash	2,991	2.73	8,158	Wet disposal
Total handling			29,353	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	

Annual operation and maintenance cost \$29,353
 Non-annual ash excavation cost 24242 c.y. @ \$ 5.19316 /c.y = \$ 125892.6 in year 1982
 Non-annual ash excavation cost 100000 c.y. @ \$ 1.49467 /c.y = \$ 149467 in year 1983
 Non-annual ash excavation cost 100000 c.y. @ \$ 5.19316 /c.y = \$ 519316 in year 1984

[8001-18-1983010:25:18]

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NOTES ON PLANT 8

Non-annual ash excavation costs

- 1982 costs represent the 1980, 1981 and 1982 partial excavations and landfilling of ash from the pond
- 1983 costs represent the dredging of the ash from the pond to the storage area
- 1984 costs represent the excavation and the landfilling of the ash from the storage area

TABLE 3.4 (continued)

O&M Costs for Period 2
1985 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	7,771	2.73	21,195	Wet disposal
Bottom ash	2,991	2.73	8,158	Wet disposal
Total handling			29,353	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Groundwater monitoring			8,351	

Annual operation and maintenance cost \$37,705
 Non-annual ash excavation cost 18858 c.y. @ \$ 5.19316 /c.y = \$ 97932.6 in year 1989
 Non-annual ash excavation cost ~~18858~~ c.y. @ \$ 1.49467 /c.y = \$ 149467 in year 1996
 Non-annual ash excavation cost 38965 c.y. @ \$ 5.19316 /c.y = \$ 202351.5 in year 1997
 Non-annual ash excavation cost 68965 c.y. @ \$ 1.49467 /c.y = \$ 103079.9 in year 2006
 Non-annual ash excavation cost 134675 c.y. @ \$ 5.19316 /c.y = \$ 699388.8 in year 2014

[8001-18-1983010:25:18]

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- 1989 costs represent the 1983 through 1989 partial excavations and landfilling of ash from the pond
- 1996 costs represent the dredging of the ash from the pond to the storage area
- 1997 costs represent the partial excavation and landfilling of the ash from the storage area
- 2006 costs represent the partial dredging of the ash from the pond to the storage area
- 2014 costs represent the 1990 through 2014 partial excavations and landfilling of ash from the pond

TABLE 3.5
NON-HAZARDOUS 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	29,353	1.0000	29,353
1981	29,353	0.9775	28,693
1982	155,246	0.9555	148,338
1983	178,820	0.9341	167,036
1984	548,669	0.9131	500,990
1985	37,705	0.8925	33,652
1986	37,705	0.8725	32,898
1987	37,705	0.8528	32,155
1988	37,705	0.8337	31,435
1989	135,637	0.8149	110,531
1990	37,705	0.7966	30,036
1991	37,705	0.7787	29,361
1992	37,705	0.7612	28,701
1993	37,705	0.7441	28,056
1994	37,705	0.7273	27,423
1995	37,705	0.7110	26,808
1996	187,172	0.6950	130,085
1997	240,056	0.6794	163,094
1998	37,705	0.6641	25,040
1999	37,705	0.6492	24,478
2000	37,705	0.6346	23,928
2001	37,705	0.6203	23,388
2002	37,705	0.6064	22,864
2003	37,705	0.5927	22,348
2004	37,705	0.5794	21,846
2005	37,705	0.5664	21,356
2006	140,784	0.5536	77,938
2007	37,705	0.5412	20,406
2008	37,705	0.5290	19,946
2009	37,705	0.5171	19,497
2010	37,705	0.5055	19,060
2011	37,705	0.4941	18,630
2012	37,705	0.4830	18,212
2013	37,705	0.4722	17,804
2014	737,093	0.4616	340,242

Total Present Worth of Future Costs :

\$2,315,625

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$94,863

[Plant # 8]

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 8

Levelized Capital Cost

\$177,378

Levelized Operation and Maintenance Costs

\$94,863

Total Levelized Revenue Requirement

\$272,241

Levelized Revenue Requirement per Ton of Waste Disposed

\$25.29

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$18.78

SECTION 4

HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

The proposed design consists of acquiring a tract of land north of the plant site. For the purpose of this analysis, it has been determined that it will be most cost effective in the future if dry handling systems are utilized for the disposal of the fly ash and bottom ash. In the future, all fly ash and bottom ash will be trucked to the new landfill. Leachate treatment facilities are provided and were sized based on a 10-year, 24-hour rainfall event falling on half the area of one open cell. Internal cell diking will preclude contamination of all storm water runoff. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes could be used to moisture condition the ash before placement in the landfill.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities

Design FactorHazardous MinimumHazardous Maximum

2. Liner System

Use a single liner system
as specified in the EPA
guidance documents

Use a double liner
system as specified in
the EPA guidance
documents

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. It was assumed that because of RCRA restrictions ash would no longer be able to be sold for other uses. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed cells on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Due to the small volume of ash projected after 1985, the maximum cell life had to be set beyond the five year maximum. In order to maintain a practical cell size, the cell life was lengthened to 11.7 years. Figure 4.1 is a layout of the three cells which are proposed for ash disposal under the hazardous waste scenario. Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

FIGURE 4.1

HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION ⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.2

HAZARDOUS MAXIMUM LANDFILL – TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.3

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 8

Design Mode: Hazardous Min

Date 101-19-1982

Power Plant Information (1980)

Generating capacity of plant	209.5 mw
Generating capacity of largest boiler	136 mw

Waste Production Information *

Fly ash	12005 dry ton/yr
Bottom Ash	2991 dry ton/yr
No FGD	
Waste densities (as disposed)	

Fly ash	66 lb/cu ft
Bottom ash	66 lb/cu ft

General Disposal Site Information

Site area	100 acres
Percent heavily wooded	0 %
Percent lightly wooded	0 %
Site perimeter	8400 ft
Distance to plant	3 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	1200 ft
Thickness of soils above bedrock	50 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	30 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	2 mi

Climatic Information

Maximum frost penetration	50 in
Total annual precipitation	32.89 in
10-yr, 24-hr rainfall event	4.6 in

* note: Average for period 1980- 2014 . If dry disposal is utilized, densities reflect a 1.2 compaction factor.

[8001-19-1982#18:36:24]

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HAZARDOUS MIN CELL GEOMETRY

Disposal Cell Cross-Section
Dry Landfill w/ Single Liner

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980- 2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	100	[acres]	3,273	327,300
clear and grub	42	[acres]	1,435	60,469
final grading	42	[acres]	595	24,973
cut & fill non-compacted	232,207	[cy]	1.66	385,074
on-site structural cut/fill	119,205	[cy]	2.61	310,826
topsoil removal & stockpile	88,986	[cy]	1.66	134,300
sand collection zone pitant	88,418	[cy]	9.61	849,847
sand import	88,418	[cy]	6.93	612,546
clay liner/cap placement	89,887	[cy]	5.13	460,911
synthetic membrane	1,960,528	[sf]	0.61	1,197,004
seeding and mulching -grass	203,280	[sy]	0.46	93,147
gravel stabilization	3,967	[sy]	0.76	3,030
plastic filter fabric	217,837	[sy]	0.79	171,115
light duty bituminous road	4,390	[lf]	13.83	60,731
heavy duty bituminous road	300	[lf]	18.15	5,446
perimeter fencing	8,400	[ft]	13.09	109,973
plastic pipe, pvc-4"	4,729	[lf]	10.86	51,336
plastic pipe, pvc-6"	6,798	[lf]	15.63	106,280
leachate collect sumps	100	[lf]	183	18,400
soil borings	1,050	[lf]	16.37	17,183
groundwater monitoring wells	311	[lf]	13.09	4,076
Offsite treatment of wastes				
CELL CONSTRUCTION COST SUBTOTAL				\$5,004,827.
Leachate Treatment Plant Construction Cost				\$0.
Wet-to-dry conversion cost of Bottom ash				\$764,785
Construction Cost for Closure of Existing Disposal Site(s)				\$1,122,639.
CONSTRUCTION COST TOTAL				\$6,892,251.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
50%				
Other Capital Items = \$6,892,251. x 0.50 =				\$3,446,125.
Permitting Cost				\$250,000
TOTAL CAPITAL REQUIREMENT =				\$10,588,380.

* Site Cost Adjustment Factor (SCAF) = 1.091
 Site Unit Cost = SCAF x National-Average Unit Cost

[B#01-19-1982#18:36:24]

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TABLE 4.4

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	5,583,549	1.0000	5,583,549
1992	2,502,414	0.7612	1,904,838
2003	2,502,414	0.5927	1,483,181

Total Cap Exp \$10,588,377

Present Worth of all Capital Costs

\$8,971,567

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$663,896

[Plant # 8]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	12,005	3.82	45,841	Dry disposal
Bottom ash	2,991	3.82	11,421	Dry disposal
Total handling			57,262	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	12,005	0.93	11,191	open on road truck (16cy) 3 mi. haul
Bottom ash	2,991	0.93	2,788	open on road truck (16cy) 3 mi. haul
Total transportation			13,979	
Landfill costs				
Flyash	12,005	1.31	15,729	
Bottom ash	2,991	1.31	3,919	
Total landfill cost			19,647	
Leachate Treatment Plant O and M			\$0	
Total non-administrative O and M			\$90,889	

Administrative O&M Cost Items

Manifesting	\$8,553
Groundwater monitoring	\$8,240
Inspection	\$1,320
Personnel training	\$1,309
Non-sudden occurrence insurance	\$19,143
General administration	\$40,029
Total Annual Administration cost	\$78,602
Total annual operation and maintenance cost	\$169,491

Post closure O&M costs

Existing site (1980-2010)	\$29,170
New site	
Groundwater monitoring	\$16,496
Inspection	\$2,640
Maintenance	\$8,687
Administrative services	\$6,110
Total annual post closure cost (2014 - 2044)	\$33,932

[8801-19-1982018:36:24]

TABLE 4.6
HAZARDOUS MIN O&M COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 2.0 %
Real Return : 2.3 %

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
1980	198,661	1.0000	198,661	Begin post closure operation and maintenance of existing site
1981	198,661	0.9775	194,191	
1982	198,661	0.9555	189,821	
1983	198,661	0.9341	185,569	
1984	198,661	0.9131	181,397	
1985	198,661	0.8925	177,305	
1986	198,661	0.8725	173,332	
1987	198,661	0.8528	169,418	
1988	198,661	0.8337	165,624	
1989	198,661	0.8149	161,889	
1990	198,661	0.7966	158,253	
1991	198,661	0.7787	154,697	
1992	198,661	0.7612	151,221	
1993	198,661	0.7441	147,824	
1994	198,661	0.7273	144,486	
1995	198,661	0.7110	141,248	
1996	198,661	0.6950	138,069	
1997	198,661	0.6794	134,970	
1998	198,661	0.6641	131,931	
1999	198,661	0.6492	128,971	
2000	198,661	0.6346	126,070	
2001	198,661	0.6203	123,229	
2002	198,661	0.6064	120,468	
2003	198,661	0.5927	117,746	
2004	198,661	0.5794	115,104	
2005	198,661	0.5664	112,522	
2006	198,661	0.5536	109,979	
2007	198,661	0.5412	107,515	
2008	198,661	0.5290	105,092	
2009	198,661	0.5171	102,728	
2010	198,661	0.5055	100,423	End post closure operation and maintenance of existing site
2011	169,491	0.4941	83,746	
2012	169,491	0.4830	81,864	
2013	169,491	0.4722	80,034	
2014	169,491	0.4616	78,237	Begin post closure operation and maintenance
2015	33,932	0.4512	15,310	
2016	33,932	0.4410	14,964	
2017	33,932	0.4311	14,628	
2018	33,932	0.4214	14,299	
2019	33,932	0.4120	13,980	
2020	33,932	0.4027	13,664	
2021	33,932	0.3936	13,358	
2022	33,932	0.3848	13,057	
2023	33,932	0.3761	12,762	
2024	33,932	0.3677	12,477	
2025	33,932	0.3594	12,195	

(continued next page)

[Plant # 8]

TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$
2026	33,932	0.3513	11,920
2027	33,932	0.3434	11,652
2028	33,932	0.3357	11,391
2029	33,932	0.3282	11,136
2030	33,932	0.3208	10,885
2031	33,932	0.3136	10,641
2032	33,932	0.3065	10,400
2033	33,932	0.2996	10,166
2034	33,932	0.2929	9,939
2035	33,932	0.2863	9,715
2036	33,932	0.2799	9,498
2037	33,932	0.2736	9,284
2038	33,932	0.2674	9,073
2039	33,932	0.2614	8,870
2040	33,932	0.2555	8,670
2041	33,932	0.2498	8,476
2042	33,932	0.2442	8,286
2043	33,932	0.2387	8,100
2044	33,932	0.2333	7,916

End post closure operation
and maintenance

Total Present Worth of Future Costs :

\$5,130,344

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

\$149,427

[Plant # 8]

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 8

Levelized Capital Cost

\$663,896

Levelized Operation and Maintenance Costs

\$149,427

Total Levelized Revenue Requirement

\$813,323

Levelized Revenue Requirement per Ton of Waste Disposed

\$54.23

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$48.32

TABLE 4.8

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 8

Design Mode: Hazardous Max

Date 01-19-1982

Power Plant Information (1980)

Generating capacity of plant	289.5 mw
Generating capacity of largest boiler	136 mw

Waste Production Information *

Fly ash	12005 dry ton/yr
Bottom Ash	2991 dry ton/yr

No FGD

Waste densities (as disposed)

Fly ash	66 lb/cu ft
Bottom ash	66 lb/cu ft

General Disposal Site Information

Site area	100 acres
Percent heavily wooded	0 %
Percent lightly wooded	0 %
Site perimeter	8400 ft
Distance to plant	3 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	1200 ft
Thickness of soils above bedrock	50 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	30 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	2 mi

Climatic Information

Maximum frost penetration	50 in
Total annual precipitation	32.89 in
10-yr, 24-hr rainfall event	4.6 in

* note: Average for period 1980- 2014 . If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	3
Cell volume	196367.8 cu yd
Depth of waste at edge of fill	20 ft
Cell dimensions	
length at top	933 ft
width at top	311 ft
length at bottom	853 ft
width at bottom	231 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	3892 ft

**Disposal Cell Cross-Section
Dry Landfill w/ Double Liner**

NOTE: Datum is below existing ground surface an average of 16 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS

Construction Cost Items (1980- 2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	100	[acres]	3,273	327,300
clear and grub	42	[acres]	1,435	60,469
final grading	42	[acres]	595	24,973
cut & fill non-compacted	327,577	[cy]	1.66	543,227
on-site structural cut/fill	111,225	[cy]	2.61	290,917
topsoil removal & stockpile	81,611	[cy]	1.66	135,338
sand collection zone piment	110,154	[cy]	9.61	1,058,771
sand import	110,154	[cy]	6.93	763,132
clay liner/cap placement	179,079	[cy]	5.13	918,264
synthetic membrane	2,005,091	[sf]	0.61	1,225,030
seeding and mulching -grass	203,200	[sy]	0.46	93,147
gravel stabilization	3,967	[sy]	0.76	3,030
plastic filter fabric	222,788	[sy]	0.79	175,004
light duty bituminous road	4,390	[lf]	13.83	60,731
heavy duty bituminous road	300	[lf]	18.15	5,446
perimeter fencing	8,400	[ft]	13.09	109,973
plastic pipe, pvc-4"	9,450	[lf]	10.86	102,672
plastic pipe, pvc-6"	13,596	[lf]	15.63	212,560
leachate collect sumps	100	[lf]	103	10,300
soil borings	1,050	[lf]	16.37	17,183
groundwater monitoring wells	311	[lf]	13.09	4,076
Offsite treatment of wastes				
CELL CONSTRUCTION COST SUBTOTAL				\$6,148,806.
Leachate Treatment Plant Construction Cost				\$0.
Wet-to-dry conversion cost of Bottom ash				\$764,785
Construction Cost for Closure of Existing Disposal Site(s)				\$2,366,379.
CONSTRUCTION COST TOTAL				\$9,279,970.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
50%				
Other Capital Items = \$9,279,970. x 0.50 =				\$4,639,985.
Permitting Cost				\$500,000
TOTAL CAPITAL REQUIREMENT =				\$14,419,965.

* Site Cost Adjustment Factor (SCAF) = 1.091
 Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.11

HAZARDOUS MAX 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	8,271,148	1.0000	8,271,148
1992	3,074,403	0.7612	2,340,236
2003	3,074,403	0.5927	1,822,199
Total Cap Exp	\$14,419,954		
Present Worth of all Capital Costs			\$12,433,582
Total Levelizing Factor (LF) =		0.0740	
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$920,085

[Plant # 8]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS**Non-Administrative Annual O&M Costs**

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	12,005	3.82	45,841	Dry disposal
Bottom ash	2,991	3.82	11,421	Dry disposal
Total handling			57,262	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	12,005	0.93	11,191	open on road truck (16cy) 3 mi. haul
Bottom ash	2,991	0.93	2,788	open on road truck (16cy) 3 mi. haul
Total transportation			13,979	
<u>Landfill costs</u>				
Flyash	12,005	1.31	15,729	
Bottom ash	2,991	1.31	3,919	
Total landfill cost			19,647	
Leachate Treatment Plant O and M			\$0	
Total non-administrative O and M			\$98,889	

Administrative O&M Cost Items

Manifesting	\$8,553
Groundwater monitoring	\$8,248
Inspection	\$1,320
Personnel training	\$1,309
Non-sudden occurrence insurance	\$19,143
General administration	\$40,029
Total Annual Administration cost	\$78,602
Total annual operation and maintenance cost	\$169,491

Post closure O&M costs

Existing site (1980-2010)	\$29,170
New site	
Groundwater monitoring	\$16,496
Inspection	\$2,640
Maintenance	\$8,687
Administrative services	\$6,110
Total annual post closure cost (2014 - 2044)	\$33,932

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TABLE 4.13
HAZARDOUS MAX 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	198,661	1.0000	198,661	Begin post closure operation and maintenance of existing site
1981	198,661	0.9775	194,191	
1982	198,661	0.9555	189,821	
1983	198,661	0.9341	185,569	
1984	198,661	0.9131	181,397	
1985	198,661	0.8925	177,305	
1986	198,661	0.8725	173,332	
1987	198,661	0.8528	169,418	
1988	198,661	0.8337	165,624	
1989	198,661	0.8149	161,889	
1990	198,661	0.7966	158,253	
1991	198,661	0.7787	154,697	
1992	198,661	0.7612	151,221	
1993	198,661	0.7441	147,824	
1994	198,661	0.7273	144,486	
1995	198,661	0.7110	141,248	
1996	198,661	0.6950	138,069	
1997	198,661	0.6794	134,970	
1998	198,661	0.6641	131,931	
1999	198,661	0.6492	128,971	
2000	198,661	0.6346	126,070	
2001	198,661	0.6203	123,229	
2002	198,661	0.6064	120,468	
2003	198,661	0.5927	117,746	
2004	198,661	0.5794	115,104	
2005	198,661	0.5664	112,522	
2006	198,661	0.5536	109,979	
2007	198,661	0.5412	107,515	
2008	198,661	0.5290	105,092	End post closure operation and maintenance of existing site
2009	198,661	0.5171	102,728	
2010	198,661	0.5055	100,423	
2011	169,491	0.4941	83,746	
2012	169,491	0.4830	81,864	Begin post closure operation and maintenance
2013	169,491	0.4722	80,034	
2014	169,491	0.4616	78,237	
2015	33,932	0.4512	15,310	
2016	33,932	0.4410	14,964	
2017	33,932	0.4311	14,628	
2018	33,932	0.4214	14,299	
2019	33,932	0.4120	13,980	
2020	33,932	0.4027	13,664	
2021	33,932	0.3936	13,356	
2022	33,932	0.3848	13,057	
2023	33,932	0.3761	12,762	
2024	33,932	0.3677	12,477	
2025	33,932	0.3594	12,195	

(continued next page)

[Plant # 8]

TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	33,932	0.3513	11,920	
2027	33,932	0.3434	11,652	
2028	33,932	0.3357	11,391	
2029	33,932	0.3282	11,136	
2030	33,932	0.3208	10,885	
2031	33,932	0.3136	10,641	
2032	33,932	0.3065	10,400	
2033	33,932	0.2996	10,166	
2034	33,932	0.2929	9,939	
2035	33,932	0.2863	9,715	
2036	33,932	0.2799	9,498	
2037	33,932	0.2736	9,284	
2038	33,932	0.2674	9,073	
2039	33,932	0.2614	8,870	
2040	33,932	0.2555	8,670	
2041	33,932	0.2498	8,476	
2042	33,932	0.2442	8,286	
2043	33,932	0.2387	8,100	
2044	33,932	0.2333	7,916	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$5,130,344	
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			\$149,427	

[Plant # 8]

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 8

Levelized Capital Cost

\$920,085

Levelized Operation and Maintenance Costs

\$149,427

Total Levelized Revenue Requirement

\$1,069,512

Levelized Revenue Requirement per Ton of Waste Disposed

\$71.32

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$63.54

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 13,000	\$ 88,000	\$ 101,000	\$ 9.43	\$ 7.00
Non-Hazardous	177,000	95,000	272,000	25.29	18.78
Hazardous Minimum	664,000	149,000	813,000	54.23	48.32
Hazardous Maximum	920,000	149,000	1,069,000	71.32	63.54

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data 1980, Kingston, MA.

RCRA Impact
Case Study of Plant 9

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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal in the utility industry. These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 9 is located in eastern Kansas and has a current nameplate generating capacity of 1,468 MW. The plant has two units. Unit 1 has a wet-bottom cyclone coal-fired boiler. Unit 2 has a dry-bottom pulverized coal-fired boiler. Fuel oil is used only for start-up and combustion stabilization.

Bituminous coal is mined adjacent to the plant for Unit 1. Sub-bituminous coal for Unit 2 is shipped by unit train from the Powder River Basin of Wyoming. Normally a 90-day stockpile of coal is maintained on-site. The coal consumption for 1980 was 1,225,000 tons in Unit 1 and 2,232,000 tons in Unit 2. The average analysis of the coal burned in Unit 1 was 5.39 percent sulfur, 26.85 percent ash content, and 9,421

BTU's/lb. The average analysis of the coal burned in Unit 2 was 0.46 percent sulfur, 8.3 percent ash, and 8,481 BTU's/lb. Projected 1985 and 2000 rates of coal consumption are 1,600,000 tons of bituminous and 2,400,000 tons of sub-bituminous.

Unit 1 is equipped with a wet limestone slurry scrubber for treatment of the sulfur in the flue gas and the collection of the fly ash. Unit 2 is equipped with an electrostatic precipitator. Both units presently meet the Federal and state emission limits. Table 1.1 summarizes plant characteristics including year of boiler start-up, 1980 availability factor, coal used, and air pollution control equipment.

EXISTING DISPOSAL

The schematic flow diagram of the existing disposal facilities for the plant is shown in Figure 1.2. The quantities of waste materials generated are summarized in Table 1.2.

The fly ash and calcium sulfate sludge from Unit 1 is sluiced to an on-site disposal pond. The water discharge from this pond flows into the lake as shown in Figure 1.3. The fly ash collected by the ESP on Unit 2 is transferred to a dry storage silo for sales. The unsold fly ash is trucked to the on-site landfill disposal area. The bottom slag from Unit 1 and the bottom ash from Unit 2 are sluiced to separate dewatering bins. The unsold portions of the bottom ash and boiler slag are trucked to the on-site landfill disposal area. There are auxiliary lines provided to allow the bottom ash and slag to be sluiced to an ash pond.

Over 80 percent of the fly ash from Unit 2 is sold by brokers as a pozzolan in concrete and approximately 90 percent of the boiler slag is sold for road base or deicing aggregate. Markets have not been developed for Unit 1 scrubber sludge or Unit 2 bottom ash.

In addition to the fly ash and scrubber sludge, the disposal pond receives direct discharges from the coal pile runoff, dewatering bins, landfill runoff, chemical boiler cleaning wastes, and water treatment underflow. The overflow from the pond is discharged into the cooling water discharge canal which flows into the lake. Yard and floor drains discharge directly to the lake.

SCHEMATIC FLOW DIAGRAM

FIGURE 1.2

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 9

Boiler	Stack	MW (Nameplate)	Year of Start-up	1980 Availability Factor	1980 Coal Used (tons)	1985 Coal Projections (tons)	2000 Coal Projections (tons)	Type of Control	
								Particulate	SO ₂
1	1	838	1972	44%	1,225,000	1,600,000	1,600,000	Scrubber	Scrubber
2	2	630	1977	78%	2,232,000	2,400,000	2,400,000	ESP	NONE
TOTAL		1,468			3,457,000	4,000,000	4,000,000		

TABLE 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 9

Waste Product	1980 Values	1985 Values	1990 Values	35-Year Average*
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	130,000	140,000	140,000	139,143
Tons Sold	<u>108,000</u>	<u>112,000</u>	<u>112,000</u>	<u>111,313</u>
Tons Disposed	22,000	28,000	28,000	27,830
<u>Bottom Ash (Dry Weight)</u>				
Tons Produced	55,000	59,000	59,000	352,657
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>264,600</u>
Tons Disposed	55,000	59,000	59,000	88,057
<u>Bottom Slag (Dry Weight)</u>				
Tons Produced	230,000	300,000	300,000	*
Tons Sold	<u>210,000</u>	<u>270,000</u>	<u>270,000</u>	*
Tons Disposed	20,000	30,000	30,000	*
<u>Scrubber Sludge (Dry Weight)</u>				
Tons Produced**	511,000	667,000	667,000	653,630
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed**	511,000	667,000	667,000	653,630
<u>Other Wastes</u>				
Coal Pile Runoff (MG/yr)	6.6	6.6	6.6	

* Average is for 1980-2014, assuming that the 2000 values remain constant through 2014. Bottom slag is included in the bottom ash quantities.

**Includes approximately 19 percent fly ash by weight.

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates.

In 1980, the existing sludge and ash pond had a remaining life of 27 years. To provide sufficient ash disposal capacity over the 35 year design period, it would be necessary to raise the existing perimeter dikes by ten feet (Figure 2.2). The perimeter dike modifications (Figure 2.3) would be constructed entirely of compacted materials which are available on-site. A six-inch layer of topsoil would be placed and compacted on the slopes of the dikes. The slopes would be seeded to produce a thick ground cover which would provide erosion protection of the dike. During construction it will also be necessary to raise the elevation of the sluice lines which discharge to the pond.

Miscellaneous low volume wastes, e.g. coal pile runoff, etc., currently generated by the plant would continue to be sent to the sludge and ash pond. When the life of the disposal pond is exhausted, and average six (6) inch layer of topsoil would be placed on the disposal areas. These areas would be seeded to establish a vegetative cover for erosion control.

CURRENT PRACTICE HANDLING & DISPOSAL

FIGURE 2.1

PERIMETER DIKE - TYPICAL SECTION

FIGURE 2.3

The existing landfill has sufficient capacity for the estimated waste disposal through the year 2014. Fly ash and bottom ash would continue to be trucked to the landfill area. A water truck would be used to control dust at the landfill. A dozer would be required to spread the fly ash and bottom ash at the proposed landfill. At closure, a proposed 12-inch layer of topsoil would be placed and compacted on the disposal areas. These areas would be seeded to establish a vegetative cover to control erosion.

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 9

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	1468 MW
Generating capacity of largest boiler	838 MW

Waste Production Information*

Fly ash	27830 dry ton/yr
Bottom Ash	88057 dry ton/yr
FGD sludge	653630 dry ton/yr
Waste densities (as disposed):	
Fly ash	58.8 lb/cu ft
Bottom ash	70.1 lb/cu ft
FGD sludge	101.2 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

[9#11-11-1980#12:A1:20]

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TABLE 2.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 2006

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				\$0.
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
* Site cost adjustment factor (SCAF) = 1.022				
Site Unit cost = SCAF x National Average Unit Cost				
[9011-11-1982010:41:20]				PAGE 2

TABLE 2.2 (continued)

Construction Cost Items for Period 2
2007 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
on-site structural cut/fill	614,360 [cy]		2.44	1,500,823
topsoil placement & grading	71,073 [cy]		1.73	122,756
topsoil removal & stockpile	71,073 [cy]		1.55	110,408
seeding and mulching -grass	213,219 [sy]		0.43	91,522
gravel roadways	4,065 [lf]		3.07	12,546
miscellaneous structures	29,000 [ls]		1.02	29,638

CONSTRUCTION COST TOTAL

\$1,867,494.

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%
	50%

Other Capital Items = \$1,867,494. x 0.50 =

\$933,747

CONSTRUCTION CAPITAL REQUIREMENT =

\$2,801,240.

Closure Cost

\$2,264,856.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$3,397,288.

* Site cost adjustment factor (SCAF)= 1.022

Site Unit cost= SCAF x National Average Unit Cost

[9011-11-1982#10:41:20]

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TABLE 2.3
CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	0	0	0.9131	0
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	2,801,240	0	0.5536	1,550,766
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	3,397,288	0.4512	1,532,856
Total Present Worth of Future Capital Expenditures :				\$3,083,623

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$228,188

[Plant # 9]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 2006

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	27,830	3.58	99,540	Dry disposal
Bottom ash	88,057	3.58	314,960	Dry disposal
F60	653,630	2.55	1,670,025	Wet disposal
Total handling			2,084,525	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	27,830	4.29	119,475	bulk pneumatic tanker 1 mi. haul
Bottom ash	88,057	0.50	44,097	open on road truck (leaky) 1 mi. haul
Total transportation			163,572	
Landfill costs				
Flyash	27,830	1.33	38,339	
Bottom ash	88,057	1.16	101,753	
Total landfill cost			140,092	

Annual operation and maintenance cost \$2,388,216

[911-11-1981A10:41:20]

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TABLE 2.4 (continued)

O&M Costs for Period 2
2007 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	27,830	3.58	99,549	Dry disposal
Bottom ash	88,057	3.58	314,980	Dry disposal
FGD	653,630	2.55	1,670,025	Wet disposal
Total handling			2,084,552	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	27,830	4.29	119,475	bulk pneumatic tanker 1 mi. haul
Bottom ash	88,057	0.50	44,097	open on road truck (loose) 1 mi. haul
Total transportation			163,572	
Landfill costs				
Flyash	27,830	1.38	38,339	
Bottom ash	88,057	1.16	101,753	
Total landfill cost			140,092	
Annual operation and maintenance cost			\$2,388,216	

[9#11-11-1982#10:41:20]

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TABLE 2.5
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	2,388,216	1.0000	2,388,216
1981	2,388,216	0.9775	2,334,481
1982	2,388,216	0.9555	2,281,940
1983	2,388,216	0.9341	2,230,833
1984	2,388,216	0.9131	2,180,680
1985	2,388,216	0.8925	2,131,483
1986	2,388,216	0.8725	2,083,718
1987	2,388,216	0.8528	2,036,671
1988	2,388,216	0.8337	1,991,056
1989	2,388,216	0.8149	1,946,157
1990	2,388,216	0.7966	1,902,453
1991	2,388,216	0.7787	1,859,704
1992	2,388,216	0.7612	1,817,910
1993	2,388,216	0.7441	1,777,072
1994	2,388,216	0.7273	1,736,949
1995	2,388,216	0.7110	1,698,022
1996	2,388,216	0.6950	1,659,810
1997	2,388,216	0.6794	1,622,554
1998	2,388,216	0.6641	1,586,014
1999	2,388,216	0.6492	1,550,430
2000	2,388,216	0.6346	1,515,562
2001	2,388,216	0.6203	1,481,410
2002	2,388,216	0.6064	1,448,214
2003	2,388,216	0.5927	1,415,496
2004	2,388,216	0.5794	1,383,732
2005	2,388,216	0.5664	1,352,686
2006	2,388,216	0.5536	1,322,116
2007	2,388,216	0.5412	1,292,502
2008	2,388,216	0.5290	1,263,366
2009	2,388,216	0.5171	1,234,946
2010	2,388,216	0.5055	1,207,243
2011	2,388,216	0.4941	1,180,018
2012	2,388,216	0.4830	1,153,508
2013	2,388,216	0.4722	1,127,716
2014	2,388,216	0.4616	1,102,401

Total Present Worth of Future Costs :

\$58,297,069

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$2,388,216

[Plant # 9]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 9

Levelized Capital Cost

\$228,188

Levelized Operation and Maintenance Costs

\$2,388,216

Total Levelized Revenue Requirement

\$2,616,404

Levelized Revenue Requirement per Ton of Waste Disposed

\$3.40

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$4.31

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of ground-water monitoring wells around the existing pond and landfill. Closure of both the pond and landfill would require a 12-inch clay cap to be installed. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes, would continue to be discharged to the pond.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

NON-HAZARDOUS HANDLING & DISPOSAL

Operation Activity
Construction Activity

PLANT 9

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5.

A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

TABLE 3.1

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 9

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	1468 MW
Generating capacity of largest boiler	838 MW

Waste Production Information*

Fly ash	27830 dry ton/yr
Bottom Ash	88657 dry ton/yr
FGD sludge	653630 dry ton/yr
Waste densities (as disposed)	
Fly ash	58.8 lb/cu ft
Bottom ash	70.1 lb/cu ft
FGD sludge	101.2 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 3.2

NON-HAZARDOUS CAPITAL COSTSConstruction Cost Items for Period 1
1980 - 1984

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				\$0.
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
* Site cost adjustment factor (SCAF) = 1.022				
Site Unit cost = SCAF x National Average Unit Cost				
[9#11-11-1982#10:26:19]				PAGE 2

TABLE 3.2 (continued)

Construction Cost Items for Period 2
 1985 - 2006

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
<hr/>				
groundwater monitoring wells	510 [1f]		12.26	6,255
CONSTRUCTION COST TOTAL				\$6,255
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items =	$\$6,255 \times 0.50 =$			\$3,127
CONSTRUCTION CAPITAL REQUIREMENT =				\$9,382
<hr/>				
Closure Cost			\$0.	
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
<hr/>				
* Site cost adjustment factor (SCAF) = 1.022				
Site Unit cost = SCAF x National Average Unit Cost				

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TABLE 3.2 (continued)

Construction Cost Items for Period 3
2007 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
on-site structural cut/fill	614,360 [cy]		2.44	1,500,623
topsoil placement & grading	71,073 [cy]		1.73	122,756
topsoil removal & stockpile	71,073 [cy]		1.55	110,408
seeding and mulching -grass	213,219 [sy]		0.43	91,522
gravel roadways	4,065 [lf]		3.09	12,546
miscellaneous structures	29,000 [ls]		1.02	29,638

CONSTRUCTION COST TOTAL**\$1,867,474.**

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%Other Capital Items = $\$1,867,474 \times 0.50 =$

\$933,747

CONSTRUCTION CAPITAL REQUIREMENT =**\$2,801,240.**

Closure Cost

\$14,019,880.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)**\$21,029,820.**

* Site cost adjustment factor (SCAF) = 1.022

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 3.3
NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION: CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	9,382	0	0.9131	8,567
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	2,801,240	0	0.5536	1,550,766
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	21,029,820	0.4512	9,488,655

Total Present Worth of Future Capital Expenditures :

\$11,047,988

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$817,551

[Plant # 9]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1984

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	27,830	3.58	99,548	Dry disposal
Bottom ash	88,057	3.58	314,960	Dry disposal
F6D	653,630	2.55	1,670,025	Wet disposal
Total handling			2,084,552	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	27,830	4.29	119,475	bulk pneumatic tanker 1 mi. haul
Bottom ash	88,057	0.50	44,097	open on road truck (16cy) 1 mi. haul
Total transportation			163,572	
Landfill costs				
Flyash	27,830	1.33	38,339	
Bottom ash	88,057	1.16	101,753	
Total landfill cost			140,092	
Annual operation and maintenance cost			\$2,388,216	

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TABLE 3.4 (continued)

O&M Costs for Period 2
1985 to 2006

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	27,830	3.58	99,548	Dry disposal
Bottom ash	88,857	3.58	314,980	Dry disposal
F6D	653,630	2.55	1,670,025	Wet disposal
Total handling			2,084,552	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	27,830	4.29	119,475	bulk pneumatic tanker 1 mi. haul
Bottom ash	88,857	0.50	44,097	open on road truck (16cy) 1 mi. haul
Total transportation			163,572	
Landfill costs				
Flyash	27,830	1.33	38,339	
Bottom ash	88,857	1.16	101,753	
Total landfill cost			140,092	
Groundwater monitoring			11,497	
Annual operation and maintenance cost			\$2,399,713	

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TABLE 3.4 (continued)

O&M Costs for Period 3
2007 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	27,830	3.56	99,548	Dry disposal
Bottom ash	88,057	3.56	314,980	Dry disposal
FGD	653,630	2.55	1,670,025	Wet disposal
Total handling			2,084,552	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	27,830	4.29	119,475	bulk pneumatic tanker 1 mi. haul
Bottom ash	88,057	0.50	44,057	open on road truck (16cy) 1 mi. haul
Total transportation			163,572	
<u>Landfill costs</u>				
Flyash	27,830	1.38	38,339	
Bottom ash	88,057	1.16	101,753	
Total landfill cost			140,092	
Groundwater monitoring			11,497	
Annual operation and maintenance cost			\$2,399,713	

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TABLE 3.5
NON-HAZARDOUS 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	2,388,216	1.0000	2,388,216
1981	2,388,216	0.9775	2,334,481
1982	2,388,216	0.9555	2,281,940
1983	2,388,216	0.9341	2,230,833
1984	2,388,216	0.9131	2,180,680
1985	2,399,713	0.8925	2,141,744
1986	2,399,713	0.8725	2,093,750
1987	2,399,713	0.8528	2,046,475
1988	2,399,713	0.8337	2,000,641
1989	2,399,713	0.8149	1,955,526
1990	2,399,713	0.7966	1,911,611
1991	2,399,713	0.7787	1,868,657
1992	2,399,713	0.7612	1,826,662
1993	2,399,713	0.7441	1,785,626
1994	2,399,713	0.7273	1,745,311
1995	2,399,713	0.7110	1,706,196
1996	2,399,713	0.6950	1,667,801
1997	2,399,713	0.6794	1,630,365
1998	2,399,713	0.6641	1,593,649
1999	2,399,713	0.6492	1,557,894
2000	2,399,713	0.6346	1,522,858
2001	2,399,713	0.6203	1,488,542
2002	2,399,713	0.6064	1,455,186
2003	2,399,713	0.5927	1,422,310
2004	2,399,713	0.5794	1,390,394
2005	2,399,713	0.5664	1,359,197
2006	2,399,713	0.5536	1,328,481
2007	2,399,713	0.5412	1,298,725
2008	2,399,713	0.5290	1,269,448
2009	2,399,713	0.5171	1,240,892
2010	2,399,713	0.5055	1,213,055
2011	2,399,713	0.4941	1,185,698
2012	2,399,713	0.4830	1,159,061
2013	2,399,713	0.4722	1,133,144
2014	2,399,713	0.4616	1,107,708

Total Present Worth of Future Costs :

\$58,522,756

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$2,397,462

[Plant # 9]

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 9

Levelized Capital Cost

\$817,551

Levelized Operation and Maintenance Costs

\$2,397,462

Total Levelized Revenue Requirement

\$3,215,013

Levelized Revenue Requirement per Ton of Waste Disposed

\$4.18

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$5.30

SECTION 4 HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

The proposed design consists of acquiring a tract of land approximately 3 miles south of the power plant. For the purpose of this analysis, it has been determined that it will be necessary in the future to have a dry handling system for the disposal of the FGD sludge. In the future, all fly ash, bottom ash and FGD sludge will be trucked to the new landfill. Leachate treatment facilities are provided and were sized based on a 10-year, 24-hour rainfall event falling on half the area of one open cell. Internal cell diking will preclude contamination of all storm water runoff. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes could be used to moisture condition the ash before placement in the landfill.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities

Design FactorHazardous MinimumHazardous Maximum

2. Liner System

Use a single liner system
as specified in the EPA
guidance documents

Use a double liner
system as specified in
the EPA guidance
documents

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. It was assumed that because of RCRA restrictions ash would no longer be able to be sold for other uses. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed cells on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Figure 4.1 is a layout of the fourteen cells which are proposed for ash and sludge disposal under the hazardous waste scenario. Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the

HAZARDOUS MINIMUM SURFACE IMPOUNDMENT - TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.2

HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION ⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 9

Design Mode: Hazardous Min

Date 11-10-1982

Power Plant Information (1980)

Generating capacity of plant	1468 mw
Generating capacity of largest boiler	838 mw

Waste Production Information *

Fly ash	139143 dry ton/yr
Bottom Ash	352657 dry ton/yr
FGD sludge	653630 dry ton/yr
Waste densities (as disposed)	
Fly ash	70.6 lb/cu ft
Bottom ash	84.1 lb/cu ft
FGD sludge	121.4 lb/cu ft

General Disposal Site Information

Site area	1515 acres
Percent heavily wooded	1 %
Percent lightly wooded	1 %
Site perimeter	39300 ft
Distance to plant	3 mi
Distance to main road	400 ft
Distance from disposal site to leachate treatment plant	4000 ft
Thickness of soils above bedrock	70 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	7 ft

Construction Materials

Clay availability on-site	no
Clay import distance	10 mi
Sand availability on-site	no
Sand import distance	1 mi

Climatic Information

Maximum frost penetration	30 in
Total annual precipitation	35.58 in
10-yr, 24-hr rainfall event	5.3 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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TABLE 4.2

HAZARDOUS MIN CELL GEOMETRY

Number of cells	14
Cell volume	2142132 cu yd
Depth of waste at edge of fill	40 ft
Cell dimensions	
length at top	2142 ft
width at top	714 ft
length at bottom	1982 ft
width at bottom	554 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	27572 ft

Disposal Cell Cross-Section
Dry Landfill w/ Single Liner

NOTE: Datum is below existing ground surface an average of 2 feet at this site

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	1,515	[acres]	3,066	4,644,990
clear and grub	1,244	[acres]	1,344	1,672,305
heavy stump removal	12	[acres]	920	11,445
light stump removal	12	[acres]	552	6,867
final grading	1,242	[acres]	557	691,949
cut & fill non-compacted	2,023,559	[cy]	1.55	3,143,477
borrow material import	11,079,130	[cy]	7.56	83,789,244
topsoil removal & stockpile	1,919,129	[cy]	1.55	2,981,252
sand collection zone plant	2,000,534	[cy]	9.00	18,732,754
sand import	2,000,534	[cy]	6.49	13,502,041
clay liner/cap placement	2,023,559	[cy]	4.80	9,719,963
clay import	2,023,559	[cy]	5.11	10,340,386
synthetic membrane	45,348,090	[sf]	0.57	25,953,619
seeding and mulching -grass	6,012,732	[sy]	0.43	2,580,905
gravel stabilization	3,967	[sy]	0.72	2,858
plastic filter fabric	5,038,677	[sy]	0.74	3,707,660
light duty bituminous road	20,642	[lf]	12.96	267,499
heavy duty bituminous road	400	[lf]	17.01	6,802
perimeter fencing	39,300	[ft]	12.26	481,975
plastic pipe, pvc-4"	122,979	[lf]	10.17	1,250,562
plastic pipe, pvc-6"	63,976	[lf]	14.65	936,945
leachate collect sumps	3,500	[lf]	96.07	336,238
jacking & boring 36" casing	60	[lf]	301	18,060
soil borings	16,771	[lf]	15.33	257,100
groundwater monitoring wells	937	[lf]	12.26	11,497

CELL CONSTRUCTION COST SUBTOTAL

\$185,048,400.

Leachate Treatment Plant Construction Cost

\$2,364,802.

No Wet-to-Dry Conversion for Fly Ash or Bottom Ash

Wet-to-Dry Conversion Cost of FGD wastes \$12,224,380.

Construction Cost for Closure of Existing Disposal Site(s)

\$836,605

CONSTRUCTION COST TOTAL

\$200,474,400.

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%

Other Capital Items = \$200,474,400. x 0.50 =

\$100,237,200.

Permitting Cost

\$250,000

TOTAL CAPITAL REQUIREMENT =

\$300,961,600.

* Site Cost Adjustment Factor (SCAF) = 1.022

Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.4

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	43,215,590	1.0000	43,215,590
1983	19,826,610	0.9341	18,520,036
1985	19,826,610	0.8925	17,695,249
1988	19,826,610	0.8337	16,529,445
1990	19,826,610	0.7966	15,793,878
1993	19,826,610	0.7441	14,752,981
1995	19,826,610	0.7110	14,096,720
1998	19,826,610	0.6641	13,166,852
2000	19,826,610	0.6346	12,581,967
2003	19,826,610	0.5927	11,751,232
2005	19,826,610	0.5664	11,229,792
2008	19,826,610	0.5290	10,488,277
2010	19,826,610	0.5055	10,022,351
2013	19,826,610	0.4722	9,362,125

Total Cap Exp \$300,961,520

Present Worth of all Capital Costs \$219,206,494

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST \$16,221,281

[Plant # 9]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	139,143	3.58	497,715	Dry disposal
Bottom ash	352,657	3.58	1,261,454	Dry disposal
FGD	653,630	5.31	3,473,651	Dry disposal
Total handling			5,232,820	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	139,143	4.42	614,578	bulk pneumatic tanker 3 mi. haul
Bottom ash	352,657	0.87	307,955	open on road truck (16cy) 3 mi. haul
FGD	653,630	0.87	570,777	open on road truck (16cy) 3 mi. haul
Total transportation			1,493,310	
Landfill costs				
Flyash	139,143	1.15	159,646	
Bottom ash	352,657	0.96	339,670	
FGD	653,630	0.67	436,128	
Total landfill cost			935,444	
Leachate Treatment Plant O and M			\$227,835	
Total non-administrative O and M			\$7,889,410	

Administrative O&M Cost Items

Manifesting	\$39,206
Groundwater monitoring	\$53,118
Inspection	\$18,735
Personnel training	\$1,226
Non-sudden occurrence insurance	\$67,639
General administration	\$105,660
Total Annual Administration cost	\$285,584
Total annual operation and maintenance cost	\$8,174,994

Post closure O&M costs

Existing site (1980-2010)	\$91,695
New site	
Groundwater monitoring	\$106,237
Inspection	\$37,470
Maintenance	\$128,561
Administrative services	\$5,723
Total annual post closure cost (2014-2044)	\$277,991

TABLE 4.6
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	8,266,689	1.0000	8,266,689	Begin post closure operation and maintenance of existing site
1981	8,266,689	0.9775	8,080,688	
1982	8,266,689	0.9555	7,898,821	
1983	8,266,689	0.9341	7,721,914	
1984	8,266,689	0.9131	7,548,314	End post closure operation and maintenance of existing site
1985	8,266,689	0.8925	7,378,020	
1986	8,266,689	0.8725	7,212,686	
1987	8,266,689	0.8528	7,049,832	
1988	8,266,689	0.8337	6,891,939	
1989	8,266,689	0.8149	6,736,525	
1990	8,266,689	0.7966	6,585,244	
1991	8,266,689	0.7787	6,437,271	
1992	8,266,689	0.7612	6,292,604	
1993	8,266,689	0.7441	6,151,243	
1994	8,266,689	0.7273	6,012,363	
1995	8,266,689	0.7110	5,877,618	
1996	8,266,689	0.6950	5,745,349	
1997	8,266,689	0.6794	5,616,389	
1998	8,266,689	0.6641	5,489,908	
1999	8,266,689	0.6492	5,366,734	Begin post closure operation and maintenance
2000	8,266,689	0.6346	5,246,041	
2001	8,266,689	0.6203	5,127,827	
2002	8,266,689	0.6064	5,012,920	
2003	8,266,689	0.5927	4,899,667	
2004	8,266,689	0.5794	4,789,720	
2005	8,266,689	0.5664	4,682,253	
2006	8,266,689	0.5536	4,576,439	
2007	8,266,689	0.5412	4,473,932	
2008	8,266,689	0.5290	4,373,078	
2009	8,266,689	0.5171	4,274,705	
2010	8,266,689	0.5055	4,178,811	
2011	8,174,994	0.4941	4,039,245	
2012	8,174,994	0.4830	3,948,522	
2013	8,174,994	0.4722	3,860,252	
2014	8,174,994	0.4616	3,773,577	Begin post closure operation and maintenance
2015	277,991	0.4512	125,430	
2016	277,991	0.4410	122,594	
2017	277,991	0.4311	119,842	
2018	277,991	0.4214	117,145	
2019	277,991	0.4120	114,532	
2020	277,991	0.4027	111,947	
2021	277,991	0.3936	109,417	
2022	277,991	0.3848	106,971	
2023	277,991	0.3761	104,552	
2024	277,991	0.3677	102,217	
2025	277,991	0.3594	99,910	

(continued next page)

[Plant # 9]

TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	277,991	0.3513	97,658	
2027	277,991	0.3434	95,462	
2028	277,991	0.3357	93,322	
2029	277,991	0.3282	91,237	
2030	277,991	0.3208	89,180	
2031	277,991	0.3136	87,178	
2032	277,991	0.3065	85,204	
2033	277,991	0.2996	83,286	
2034	277,991	0.2929	81,424	
2035	277,991	0.2863	79,589	
2036	277,991	0.2799	77,810	
2037	277,991	0.2736	76,058	
2038	277,991	0.2674	74,335	
2039	277,991	0.2614	72,667	
2040	277,991	0.2555	71,027	
2041	277,991	0.2498	69,442	
2042	277,991	0.2442	67,885	
2043	277,991	0.2387	66,356	
2044	277,991	0.2333	64,855	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$204,375,671	
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			\$5,952,678	

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 9

Levelized Capital Cost

\$16,221,281

Levelized Operation and Maintenance Costs

\$5,952,678

Total Levelized Revenue Requirement

\$22,173,959

Levelized Revenue Requirement per Ton of Waste Disposed

\$19.36

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$25.92

TABLE 4.8

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 9

Design Mode: Hazardous Max

Date 11-10-1982

Power Plant Information (1980)

Generating capacity of plant	1468 MW
Generating capacity of largest boiler	838 MW

Waste Production Information *

Fly ash	139143 dry ton/yr
Bottom Ash	352657 dry ton/yr
FGD sludge	653630 dry ton/yr
Waste densities (as disposed)	
Fly ash	70.6 lb/cu ft
Bottom ash	84.1 lb/cu ft
FGD sludge	121.4 lb/cu ft

General Disposal Site Information

Site area	1515 acres
Percent heavily wooded	1 %
Percent lightly wooded	1 %
Site perimeter	39300 ft
Distance to plant	3 mi
Distance to main road	400 ft
Distance from disposal site to leachate treatment plant	4000 ft
Thickness of soils above bedrock	70 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	7 ft

Construction Materials

Clay availability on-site	no
Clay import distance	10 mi
Sand availability on-site	no
Sand import distance	1 mi

Climatic Information

Maximum frost penetration	30 in
Total annual precipitation	35.58 in
10-yr, 24-hr rainfall event	5.3 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

[9011-10-1982#13:31:32]

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TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	14
Cell volume	2142132 cu yd
Depth of waste at edge of fill	40 ft
Cell dimensions	
length at top	2142 ft
width at top	714 ft
length at bottom	1982 ft
width at bottom	554 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	27572 ft

**Disposal Cell Cross-Section
Dry Landfill w/ Double Liner**

NOTE: Datum is below existing ground surface an average of 2 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	1,515	[acres]	3,066	4,644,990
clear and grub	1,244	[acres]	1,344	1,672,305
heavy stump removal	12	[acres]	920	11,445
light stump removal	12	[acres]	552	6,867
final grading	1,242	[acres]	557	691,949
cut & fill non-compacted	2,064,194	[cy]	1.55	3,206,602
borrow material import	12,376,430	[cy]	7.56	93,600,465
topsoil removal & stockpile	1,952,992	[cy]	1.55	3,033,856
sand collection zone p/cmt	2,543,122	[cy]	9.00	22,897,813
sand import	2,543,122	[cy]	6.49	16,504,099
clay liner/cap placement	4,083,843	[cy]	4.80	19,616,331
clay import	4,083,843	[cy]	5.11	20,868,438
synthetic membrane	45,808,370	[sf]	0.57	26,217,046
seeding and mulching -grass	6,012,732	[sy]	0.43	2,586,905
gravel stabilization	3,967	[sy]	0.72	2,838
plastic filter fabric	5,089,818	[sy]	0.74	3,745,292
light duty bituminous road	20,642	[lf]	12.96	267,499
heavy duty bituminous road	400	[lf]	17.01	6,802
perimeter fencing	39,300	[ft]	12.26	481,975
plastic pipe, pvc-4"	245,958	[lf]	10.17	2,501,125
plastic pipe, pvc-6"	127,952	[lf]	14.65	1,873,890
leachate collect sumps	3,500	[lf]	96.07	336,238
jacking & boring 36" casing	60	[lf]	301	18,060
soil borings	16,771	[lf]	15.33	257,100
groundwater monitoring wells	937	[lf]	12.26	11,497

CELL CONSTRUCTION COST SUBTOTAL

\$225,055,500.

Leachate Treatment Plant Construction Cost

\$2,364,802.

No Wet-to-Dry Conversion for Fly Ash or Bottom Ash

Wet-to-Dry Conversion Cost of FGD wastes \$12,224,580.

Construction Cost for Closure of Existing Disposal Site(s)

\$2,131,672

CONSTRUCTION COST TOTAL

\$241,776,500.

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%

Other Capital Items = \$241,776,500. x 0.50 =

\$120,888,250.

Permitting Cost

\$500,000

TOTAL CAPITAL REQUIREMENT =

\$363,164,800.

* Site Cost Adjustment Factor (SCAF) = 1.022

Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.11

HAZARDOUS MAX 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	49,694,670	1.0000	49,694,670
1983	24,113,090	0.9341	22,524,037
1985	24,113,090	0.8925	21,520,933
1988	24,113,090	0.8337	20,103,083
1990	24,113,090	0.7966	19,208,487
1993	24,113,090	0.7441	17,942,550
1995	24,113,090	0.7110	17,144,407
1998	24,113,090	0.6641	16,013,503
2000	24,113,090	0.6346	15,302,167
2003	24,113,090	0.5927	14,291,828
2005	24,113,090	0.5664	13,657,654
2008	24,113,090	0.5290	12,755,825
2010	24,113,090	0.5055	12,189,167
2013	24,113,090	0.4722	11,386,201
Total Cap Exp	\$363,164,840		
Present Worth of all Capital Costs			\$263,734,513
Total Levelizing Factor (LF) =		0.0740	
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$19,516,354

[Plant # 9]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	139,143	3.58	497,715	Dry disposal
Bottom ash	352,657	3.58	1,261,454	Dry disposal
FGD	653,630	5.31	3,473,651	Dry disposal
Total handling			5,232,820	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	139,143	4.42	614,578	bulk pneumatic tanker 3 mi. haul
Bottom ash	352,657	0.87	307,955	open on road truck (16cy) 3 mi. haul
FGD	653,630	0.87	570,777	open on road truck (16cy) 3 mi. haul
Total transportation			1,493,310	
Landfill costs				
Flyash	139,143	1.15	159,646	
Bottom ash	352,657	0.96	339,670	
FGD	653,630	0.67	436,128	
Total landfill cost			935,444	
Leachate Treatment Plant O and M			\$227,835	
Total non-administrative O and M			-----\$7,889,410-----	

Administrative O&M Cost Items

Manifesting	\$39,206
Groundwater monitoring	\$53,118
Inspection	\$18,735
Personnel training	\$1,226
Non-sudden occurrence insurance	\$67,639
General administration	\$105,660
Total Annual Administration cost	-----\$285,584-----
Total annual operation and maintenance cost	\$8,174,994

Post closure O&M costs

Existing site (1980-2010)	\$91,695
New site	
Groundwater monitoring	\$106,257
Inspection	\$37,470
Maintenance	\$128,561
Administrative services	\$5,723
Total annual post closure cost (2014-2044)	-----\$277,991-----

TABLE 4.13

HAZARDOUS MAX 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	8,266,689	1.0000	8,266,689	Begin post closure operation and maintenance of existing site
1981	8,266,689	0.9775	8,080,688	
1982	8,266,689	0.9555	7,898,821	
1983	8,266,689	0.9341	7,721,914	
1984	8,266,689	0.9131	7,548,314	End post closure operation and maintenance of existing site
1985	8,266,689	0.8925	7,378,020	
1986	8,266,689	0.8725	7,212,686	
1987	8,266,689	0.8528	7,049,832	
1988	8,266,689	0.8337	6,891,939	
1989	8,266,689	0.8149	6,736,525	
1990	8,266,689	0.7966	6,585,244	
1991	8,266,689	0.7787	6,437,271	
1992	8,266,689	0.7612	6,292,604	
1993	8,266,689	0.7441	6,151,243	
1994	8,266,689	0.7273	6,012,363	
1995	8,266,689	0.7110	5,877,616	
1996	8,266,689	0.6950	5,745,349	
1997	8,266,689	0.6794	5,616,389	
1998	8,266,689	0.6641	5,489,908	
1999	8,266,689	0.6492	5,366,734	Begin post closure operation and maintenance
2000	8,266,689	0.6346	5,246,041	
2001	8,266,689	0.6203	5,127,827	
2002	8,266,689	0.6064	5,012,920	
2003	8,266,689	0.5927	4,899,667	
2004	8,266,689	0.5794	4,789,720	
2005	8,266,689	0.5664	4,682,253	
2006	8,266,689	0.5536	4,576,439	
2007	8,266,689	0.5412	4,473,932	
2008	8,266,689	0.5290	4,373,078	
2009	8,266,689	0.5171	4,274,705	
2010	8,266,689	0.5055	4,178,811	
2011	8,174,994	0.4941	4,039,265	
2012	8,174,994	0.4830	3,948,522	
2013	8,174,994	0.4722	3,860,232	
2014	8,174,994	0.4616	3,773,577	End post closure operation and maintenance of existing site
2015	277,991	0.4512	125,430	
2016	277,991	0.4410	122,594	
2017	277,991	0.4311	119,842	
2018	277,991	0.4214	117,145	
2019	277,991	0.4120	114,532	
2020	277,991	0.4027	111,947	
2021	277,991	0.3936	109,417	
2022	277,991	0.3848	106,971	
2023	277,991	0.3761	104,552	
2024	277,991	0.3677	102,217	
2025	277,991	0.3594	99,910	

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TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	277,991	0.3513	97,658	
2027	277,991	0.3434	95,462	
2028	277,991	0.3357	93,322	
2029	277,991	0.3282	91,237	
2030	277,991	0.3208	89,180	
2031	277,991	0.3136	87,178	
2032	277,991	0.3065	85,204	
2033	277,991	0.2996	83,286	
2034	277,991	0.2929	81,424	
2035	277,991	0.2863	79,589	
2036	277,991	0.2799	77,810	
2037	277,991	0.2736	76,058	
2038	277,991	0.2674	74,335	
2039	277,991	0.2614	72,667	
2040	277,991	0.2555	71,027	
2041	277,991	0.2498	69,442	
2042	277,991	0.2442	67,885	
2043	277,991	0.2387	66,356	
2044	277,991	0.2333	64,855	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$204,375,671	
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			\$5,952,678	

[Plant # 9]

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 9

Levelized Capital Cost

\$19,516,354

Levelized Operation and Maintenance Costs

\$5,952,678

Total Levelized Revenue Requirement

\$25,469,032

Levelized Revenue Requirement per Ton of Waste Disposed

\$22.24

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$29.77

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 228,000	\$ 2,388,000	\$ 2,616,000	\$ 3.40	\$ 4.31
Non-Hazardous	818,000	2,397,000	3,215,000	4.18	5.30
Hazardous Minimum	16,221,000	5,953,000	22,174,000	19.36	25.92
Hazardous Maximum	19,516,000	5,953,000	25,469,000	22.24	29.77

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data 1980,
Kingston, MA.

RCRA Impact
Case Study of Plant 10

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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal in the utility industry. These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 10 is located in central Minnesota along the Mississippi River and has a current nameplate generating capacity of 1,064 MW. The plant has four pulverized coal-fired dry-bottom boilers. Fuel oil is used only for start-up and combustion stabilization.

Sub-bituminous coal for the plant is obtained from Montana. Coal is transported to the facility by rail. Normally a 90-day stockpile of coal is maintained on-site. Coal consumption for 1980 was 2,735,000

tons. The average analysis of the coal consumed during 1980 was 1.14 percent sulfur, 9.35 percent ash content, and 8,648 BTU's/lb. The projected 1985 and 2000 annual rate of coal consumption is 4,000,000 tons.

Units 1 and 2 are equipped with baghouses. Unit 3 has a wet particulate scrubber for ash removal. Unit 4 has an FGD system consisting of a venturi and spray tower absorber. An electrostatic precipitator is used in parallel to the FGD system to provide reheat for the cleaned flue gases. The units presently meet the Federal and state emission limits. Table 1.1 summarizes plant characteristics including year of boiler start-up, 1980 availability factor, coal used and air pollution control equipment.

EXISTING DISPOSAL

The schematic flow diagram of the existing disposal facilities for the plant is shown in Figure 1.2. The quantities of major waste materials generated are summarized in Table 1.2.

Fly ash from Units 1 and 2 is collected dry and stored in a silo for sale or transfer to the Unit 4 dry ash silo. Unit 3 fly ash and scrubber sludge are sluiced to a separate clay lined pond (Pond A - Figure 1.3). Unit 4 passes 95 percent of its flue gas through the FGD system for both fly ash and sulfur removal, the other 5 percent is passed through an electrostatic precipitator. This ESP fly ash and the fly ash from Units 1 and 2 are used as a reagent in the FGD system with all the scrubber waste being sluiced to a disposal pond (Pond B - Figure 1.3). The bottom ash from all four units is sluiced to a storage pond (Pond C - Figure 1.3). All the sluicing water is recycled to the plant. A small portion of the fly ash collected is sold but none of the bottom ash is used commercially.

A wastewater treatment facility receives coal pile runoff, floor and yard drainage, thickener overflow, and other miscellaneous drainages. After treatment the effluent is recycled through the plant and the sludge is discharged to the ash pond. The ash pond receives cooling tower blowdown and other low volume waste streams.

SCHEMATIC FLOW DIAGRAM

FIGURE 1.2

1-5

PLANT 10 501

FIGURE 1.3

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 10

Boiler	Stack	MW (Nameplate)	Year of Start-up	1980 Availability Factor	1980 Coal Used (tons)	1985 Coal Projections (tons)	2000 Coal Projections (tons)	Type of Control	
								Particulate	SO ₂
1	1	73	1958	89	203,000	150,000	100,000	Bag House Filter	None
2	2	73	1959	85	182,000	150,000	100,000	Bag House Filter	None
3	3	364	1973	89	1,177,000	1,600,000	1,600,000	Scrubber	Scrub- ber
4	4	554	1980	61	1,173,000	2,100,000	2,200,000	ESP	Scrub- ber
Total		1,064			2,735,000	4,000,000	4,000,000		

TABLE 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 10

Waste Product	1980 Values	1985 Values	2000 Values	35-Year Average*
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	207,375	299,200	299,200	292,641
Tons Sold	<u>5,800</u>	<u>5,800</u>	<u>5,800</u>	<u>5,800</u>
Tons Disposed	201,575	293,400	293,400	286,841
<u>Bottom Ash (Dry Weight)</u>				
Tons Produced	51,844	74,800	74,800	73,160
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	51,844	74,800	74,800	73,160
<u>Scrubber Sludge (60% Solids)</u>				
Tons Produced	48,064	65,393	65,393	64,155
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	48,064	65,393	65,393	64,155
<u>FGD Sludge (60% Solids)</u>				
Tons Produced	103,822	185,870	194,722	185,700
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	103,822	185,870	194,722	185,700
<u>Other Wastes</u>				
Coal Pile Runoff (MG/yr)	10.9	6.4	6.4	

* Average is for 1980-2014 assuming that the 2000 values remain constant through 2014.

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates.

In 1980, the existing ash and sludge ponds had a remaining life of 26 years. To provide sufficient ash and sludge disposal capacity over the 35 year design period, it was necessary to raise the existing perimeter dikes and interior dike as shown in Figures 2.2, 2.3 and 2.4. the ash and sludge discharge structures and water overflow structure will have to be modified to accommodate the increase in dike elevation. To get the additional 9 years required to meet the 35 year criteria, the existing dikes will have to be raised 10.5 feet.

A perimeter saddle dike (Figure 2.3) would be constructed in 2007 above the existing. The dike would be constructed entirely of compacted materials which are available on-site. A twelve-inch layer of topsoil would be placed and compacted on the slopes of the dikes. The slopes would be seeded to produce a thick ground cover which would provide erosion protection of the dike.

CURRENT PRACTICE HANDLING & DISPOSAL

FIGURE 2.1

CURRENT PRACTICE WASTE DISPOSAL SITE

**MODIFIED ASH
&
SCRUBBER
SLUDGE POND**

**POWER
PLANT**

SCALE 0 1/2 MILE

2-3

PLANT 10 507

FIGURE 2.2

PERIMETER DIKE - TYPICAL SECTION

DIVIDING DIKE – TYPICAL SECTION

Miscellaneous low volume wastes, e.g. coal pile runoff, etc., currently generated by the plant would continue to be sent to the bottom ash pond. At closure, a proposed 6-inch layer of topsoil would be placed and compacted on the disposal areas. These areas would be seeded to establish a vegetative cover to control erosion.

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 10

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	1064 mw
Generating capacity of largest boiler	554 mw

Waste Production Information*

Fly ash	169199 dry ton/yr
Bottom Ash	73160 dry ton/yr
FGD sludge	367497 dry ton/yr
Waste densities (as disposed)	
Fly ash	60 lb/cu ft
Bottom ash	61 lb/cu ft
FGD sludge	100 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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Notes for Plant 10:

FGD SLUDGE: the annual sludge production quantity (367,497 tons) includes 117,642 tons of fly ash which is removed with the sludge in the wet venturi scrubber for Unit 3.

TABLE 2.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 2006

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				\$0.
--------------	--	--	--	------

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
---	--	--	--	------

* Site cost adjustment factor (SCAF)= .987

Site Unit cost= SCAF x National Average Unit Cost

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TABLE 2.2 (continued)

Construction Cost Items for Period 2
2007 - 2014

ITEM	QUANTITY	UNIT	UNIT+ COST	EXTENSION
clear and grub	1	[acres]	1,298	1,298
on-site structural cut/fill	710,630	[cy]	2.36	1,676,326
topsoil placement & grading	36,125	[cy]	1.67	60,258
topsoil removal & stockpile	45,480	[cy]	1.50	68,231
seeding and mulching -grass	216,751	[sy]	0.41	89,852
gravel roadways	17,332	[lf]	2.98	51,662
miscellaneous structures	236,016	[ls]	0.99	232,948
miscellaneous concrete	16,440	[ls]	0.99	16,226

CONSTRUCTION COST TOTAL

\$2,196,801.

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%

Other Capital Items = \$2,196,801. x 0.50 =

\$1,098,401.

CONSTRUCTION CAPITAL REQUIREMENT =

\$3,295,202.

Closure Cost

\$2,241,477.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$3,362,216.

* Site cost adjustment factor (SCAF) = .987

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 2.3
CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	0	0	0.9131	0
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	3,295,202	0	0.5536	1,824,224
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	3,362,216	0.4512	1,517,032

Total Present Worth of Future Capital Expenditures :

\$3,341,256

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$247,253

[Plant # 10]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 2006

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	169,199	3.45	584,498	Dry disposal
Bottom ash	73,160	2.47	180,522	Wet disposal
F6D	367,497	2.47	906,799	Wet disposal
Total handling			1,671,819	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Annual operation and maintenance cost			\$1,671,819	

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TABLE 2.4 (continued)

Costs for Period 2
2007 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	169,199	3.45	584,498	Dry disposal
Bottom ash	73,160	2.47	180,522	Wet disposal
F6D	367,497	2.47	906,799	Wet disposal
Total handling			1,671,819	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	

Annual operation and maintenance cost \$1,671,819

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TABLE 2.5
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	1,671,819	1.0000	1,671,819
1981	1,671,819	0.9775	1,634,203
1982	1,671,819	0.9555	1,597,423
1983	1,671,819	0.9341	1,561,646
1984	1,671,819	0.9131	1,526,538
1985	1,671,819	0.8925	1,492,098
1986	1,671,819	0.8725	1,458,662
1987	1,671,819	0.8528	1,425,727
1988	1,671,819	0.8337	1,393,796
1989	1,671,819	0.8149	1,362,365
1990	1,671,819	0.7966	1,331,771
1991	1,671,819	0.7787	1,301,845
1992	1,671,819	0.7612	1,272,589
1993	1,671,819	0.7441	1,244,001
1994	1,671,819	0.7273	1,215,914
1995	1,671,819	0.7110	1,188,663
1996	1,671,819	0.6950	1,161,914
1997	1,671,819	0.6794	1,135,834
1998	1,671,819	0.6641	1,110,255
1999	1,671,819	0.6492	1,085,345
2000	1,671,819	0.6346	1,060,936
2001	1,671,819	0.6203	1,037,029
2002	1,671,819	0.6064	1,013,791
2003	1,671,819	0.5927	990,887
2004	1,671,819	0.5794	968,652
2005	1,671,819	0.5664	946,918
2006	1,671,819	0.5536	925,519
2007	1,671,819	0.5412	904,788
2008	1,671,819	0.5290	884,392
2009	1,671,819	0.5171	864,498
2010	1,671,819	0.5055	845,105
2011	1,671,819	0.4941	826,046
2012	1,671,819	0.4830	807,489
2013	1,671,819	0.4722	789,433
2014	1,671,819	0.4616	771,712
Total Present Worth of Future Costs :			\$40,809,603
Sum of Present Worth Factors :			24.4103
Levelized O&M Cost = (Present Worth of all O&M Costs) / (Sum of Present Worth Factors)			
LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST			\$1,671,819

[Plant # 10]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 10

Levelized Capital Cost

\$247,253

Levelized Operation and Maintenance Costs

\$1,671,819

Total Levelized Revenue Requirement

\$1,919,072

Levelized Revenue Requirement per Ton of Waste Disposed

\$3.15

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$3.37

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of ground-water monitoring wells around the existing ash and sludge facilities. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes, would continue to be discharged to the bottom ash pond.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

NON-HAZARDOUS HANDLING & DISPOSAL

FIGURE 3.1

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5.

A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 10

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	1064 MW
Generating capacity of largest boiler	554 MW

Waste Production Information*

Fly ash	169199 dry ton/yr
Bottom Ash	73160 dry ton/yr
FGD sludge	367497 dry ton/yr
Waste densities (as disposed)	
Fly ash	60 lb/cu ft
Bottom ash	61 lb/cu ft
FGD sludge	100 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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Notes for Plant 10:

FGD SLUDGE: the annual sludge production quantity (367,497 tons) includes 117,642 tons of fly ash which is removed with the sludge in the wet venturi scrubber for Unit 3.

TABLE 3.2

NON-HAZARDOUS CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1984

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				\$0.
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
* Site cost adjustment factor (SCAF) = .987				
Site Unit cost = SCAF x National Average Unit Cost				
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TABLE 3.2 (continued)

Construction Cost Items for Period 2
 1985 - 2006

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
<hr/>				
groundwater monitoring wells	1,200 [1f]		11.84	14,213
CONSTRUCTION COST TOTAL				\$14,213
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items =	$\$14,213 \times 0.50 =$			\$7,106
CONSTRUCTION CAPITAL REQUIREMENT =				\$21,319
<hr/>				
Closure Cost			\$0.	
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
<hr/>				
* Site cost adjustment factor (SCAF) = .987				
Site Unit cost = SCAF x National Average Unit Cost				

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TABLE 3.2 (continued)

Construction Cost Items for Period 3
2007 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
clear and grub	1 [acres]		1,298	1,298
on-site structural cut/fill	718,638 [cy]		2.36	1,676,326
topsoil placement & grading	36,125 [cy]		1.67	60,258
topsoil removal & stockpile	45,488 [cy]		1.50	68,231
seeding and mulching -grass	216,751 [sy]		0.41	89,852
gravel roadways	17,332 [lf]		2.98	51,662
miscellaneous structures	236,016 [ls]		0.99	232,948
miscellaneous concrete	16,448 [ls]		0.99	16,226

CONSTRUCTION COST TOTAL**\$2,196,881.**

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%

Other Capital Items = \$2,196,881. x 0.50 =

\$1,098,441.

CONSTRUCTION CAPITAL REQUIREMENT =**\$3,295,282.****Closure Cost****\$18,328,698.****CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)****\$27,481,048.**

* Site cost adjustment factor (SCAF) = .987

Site Unit cost = SCAF x National Average Unit Cost

[10011-30-1982008:30:29]

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TABLE 3.3
NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	21,319	0	0.9131	19,466
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	3,295,202	0	0.5536	1,824,224
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	27,481,040	0.4512	12,399,445

Total Present Worth of Future Capital Expenditures :

\$14,243,135

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$1,053,992

[Plant # 10]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1984

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	169,199	3.45	584,498	Dry disposal
Bottom ash	73,160	2.47	180,522	Wet disposal
FGD	367,497	2.47	906,799	Wet disposal
Total handling			1,671,819	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Annual operation and maintenance cost			\$1,671,819	

[10011-30-1982008:30:29]

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TABLE 3.4 (continued)

O&M Costs for Period 2
1985 to 2006

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	169,199	3.45	584,498	Dry disposal
Bottom ash	73,168	2.47	180,522	Wet disposal
F6D	367,497	2.47	906,799	Wet disposal
Total handling			1,671,819	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Groundwater monitoring			21,640	

Annual operation and maintenance cost \$1,693,459

[10011-30-1982#06:30:29]

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TABLE 3.4 (continued)

O&M Costs for Period 3
2007 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	169,199	3.45	584,498	Dry disposal
Bottom ash	73,160	2.47	180,522	Wet disposal
FGD	367,497	2.47	906,799	Wet disposal
Total handling			1,671,819	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Groundwater monitoring			21,640	
Annual operation and maintenance cost			\$1,693,459	

[10411-30-1982008:30:29]

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TABLE 3.5
NON-HAZARDOUS 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	1,671,819	1.0000	1,671,819
1981	1,671,819	0.9775	1,634,203
1982	1,671,819	0.9555	1,597,423
1983	1,671,819	0.9341	1,561,646
1984	1,671,819	0.9131	1,526,538
1985	1,693,459	0.8925	1,511,412
1986	1,693,459	0.8725	1,477,543
1987	1,693,459	0.8528	1,444,182
1988	1,693,459	0.8337	1,411,837
1989	1,693,459	0.8149	1,380,000
1990	1,693,459	0.7966	1,349,009
1991	1,693,459	0.7787	1,318,697
1992	1,693,459	0.7612	1,289,061
1993	1,693,459	0.7441	1,260,103
1994	1,693,459	0.7273	1,231,653
1995	1,693,459	0.7110	1,204,049
1996	1,693,459	0.6950	1,176,954
1997	1,693,459	0.6794	1,150,536
1998	1,693,459	0.6641	1,124,626
1999	1,693,459	0.6492	1,099,394
2000	1,693,459	0.6346	1,074,669
2001	1,693,459	0.6203	1,050,453
2002	1,693,459	0.6064	1,026,914
2003	1,693,459	0.5927	1,003,713
2004	1,693,459	0.5794	981,190
2005	1,693,459	0.5664	959,175
2006	1,693,459	0.5536	937,499
2007	1,693,459	0.5412	916,500
2008	1,693,459	0.5290	895,840
2009	1,693,459	0.5171	875,688
2010	1,693,459	0.5055	856,044
2011	1,693,459	0.4941	836,738
2012	1,693,459	0.4830	817,941
2013	1,693,459	0.4722	799,651
2014	1,693,459	0.4616	781,701

Total Present Worth of Future Costs :

\$41,234,399

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$1,689,221

[Plant # 10]

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 10

Levelized Capital Cost

\$1,053,992

Levelized Operation and Maintenance Costs

\$1,689,221

Total Levelized Revenue Requirement

\$2,743,213

Levelized Revenue Requirement per Ton of Waste Disposed

\$4.50

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$4.81

SECTION 4

HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

For the purpose of this analysis, it has been determined that it will be most cost effective in the future if surface impoundments are utilized for the disposal of ash and scrubber sludge. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes would continue to be treated and recycled back to the power plant.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities
<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
2. Liner System	Use a single liner system as specified in the EPA guidance documents	Use a double liner system as specified in the EPA guidance documents

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. It was assumed that because of RCRA restrictions ash would no longer be able to be sold for other uses. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed cells on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Figure 4.1 is a layout of the seven surface impoundment cells which are proposed for ash and sludge disposal under the hazardous waste scenario. These cells would be constructed at the current site of the ash and sludge pond. This site was selected because of the large capital investment in place and the relatively small quantity of ash and sludge which has already been disposed. The surface impoundments may be economically constructed by removing the bottom ash from B and C (See Figure 2.2) and constructing a surface impoundment cell in its place. The bottom ash would then be returned to the new cell and the construction sequence could be continued.

Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

HAZARDOUS MINIMUM SURFACE IMPOUNDMENT - TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.2

HAZARDOUS MAXIMUM SURFACE IMPOUNDMENT – TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 10

Design Mode: Hazardous Min

Date 12-01-1982

Power Plant Information (1980)

Generating capacity of plant	1064 mw
Generating capacity of largest boiler	554 mw

Waste Production Information *

Fly ash	174999 dry ton/yr
Bottom Ash	73160 dry ton/yr
FGD sludge	367497 dry ton/yr
Waste densities (as disposed)	
Fly ash	60 lb/cu ft
Bottom ash	61 lb/cu ft
FGD sludge	100 lb/cu ft

General Disposal Site Information

Site area	724 acres
Percent heavily wooded	0 %
Percent lightly wooded	0 %
Site perimeter	21200 ft
Distance to plant	1.25 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	6600 ft
Thickness of soils above bedrock	150 ft
Thickness of topsoil at site	0 ft
Groundwater table depth	20 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	yes

Climatic Information

Maximum frost penetration	90 in
Total annual precipitation	28.41 in
10-yr, 24-hr rainfall event	3.6 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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Notes for Plant 10:

FGD SLUDGE: the annual sludge production quantity (367,497 tons) includes 117,642 tons of fly ash which is removed with the sludge in the wet venturi scrubber for Unit 3.

TABLE 4.2

HAZARDOUS MIN CELL GEOMETRY

Number of cells	7
Cell volume	2889996 cu yd
Depth of waste at edge of fill	31 ft
Cell dimensions	
length at top	2186 ft
width at top	1093 ft
length at bottom	2000 ft
width at bottom	907 ft
Cell dike information	
Dike side slopes	
exterior	3 horiz : 1 vert
interior	3 horiz : 1 vert
Average width at top of dike	20 ft
Total length of exterior dike	19200 ft

Disposal Cell Cross-Section
Wet Disposal Impoundment w/ Single Liner

NOTE: Datum is below existing ground surface an average of 15 feet at this site

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	724	[acres]	0.00	0.
clear and grub	17	[acres]	1,298	22,064
final grading	541	[acres]	538	291,012
cut & fill non-compacted	11,128,549	[cy]	1.50	16,695,494
on-site structural cut/fill	1,210,226	[cy]	2.36	2,854,838
sand collection zone placmt	1,312,941	[cy]	8.70	11,416,639
clay liner/cap placement	2,089,409	[cy]	4.64	9,692,559
synthetic membrane	48,040,827	[sf]	0.55	26,553,126
seeding and mulching -grass	2,618,627	[sy]	0.41	1,085,526
plastic filter fabric	2,702,354	[sy]	0.71	1,920,401
light duty bituminous road	35,660	[lf]	12.52	446,291
perimeter fencing	21,200	[ft]	11.84	251,093
groundwater monitoring wells	1,000	[lf]	11.84	21,319
CELL CONSTRUCTION COST SUBTOTAL				\$71,250,370.
Wet Disposal - No Leachate Treatment Plant				
No Wet-to-Dry Conversion for Fly Ash or Bottom Ash				
No Wet-to-Dry Conversion for FGD				
CONSTRUCTION COST TOTAL				\$71,250,370.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items = \$71,250,370. x 0.50 =				\$35,625,190.
Permitting Cost				\$250,000
TOTAL CAPITAL REQUIREMENT =				\$107,125,600.

* Site Cost Adjustment Factor (SCAF) = .987
 Site Unit Cost = SCAF x National-Average Unit Cost

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TABLE 4.4

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	15,517,940	1.0000	15,517,940
1985	15,267,940	0.8925	13,626,636
1990	15,267,940	0.7966	12,162,441
1995	15,267,940	0.7110	10,855,505
2000	15,267,940	0.6346	9,689,035
2005	15,267,940	0.5664	8,647,761
2010	15,267,940	0.5055	7,717,944
Total Cap. Exp	\$107,125,580		
Present Worth of all Capital Costs			\$78,217,262
Total Levelizing Factor (LF) =		0.0740	
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$5,788,077

[Plant # 10]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	174,999	2.47	431,810	Wet disposal
Bottom ash	73,160	2.47	180,522	Wet disposal
F6D	367,497	2.47	906,799	Wet disposal
Total handling			1,519,131	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Leachate Treatment Plant O and M			\$0	
Total non-administrative O and M			-----\$1,519,131-----	

Administrative O&M Cost Items

Manifesting	\$23,745
Groundwater monitoring	\$35,443
Inspection	\$8,647
Personnel training	\$1,184
Non-sudden occurrence insurance	\$44,912
General administration	\$71,191
Total Annual Administration cost	-----\$185,122-----
Total annual operation and maintenance cost	\$1,704,253

Post closure O&M costs

Existing site (1980-2010)	\$0
New site	
Groundwater monitoring	\$70,886
Inspection	\$17,293
Maintenance	\$63,393
Administrative services	\$5,527
Total annual post closure cost (2014-2044)	-----\$157,099-----

[10012-01-1982016:43:21]

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TABLE 4.6

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	1,704,253	1.0000	1,704,253	Begin post closure operation and maintenance of existing site
1981	1,704,253	0.9775	1,665,907	
1982	1,704,253	0.9555	1,628,414	
1983	1,704,253	0.9341	1,591,943	
1984	1,704,253	0.9131	1,556,153	
1985	1,704,253	0.8925	1,521,046	
1986	1,704,253	0.8725	1,486,961	
1987	1,704,253	0.8528	1,453,387	
1988	1,704,253	0.8337	1,420,836	
1989	1,704,253	0.8149	1,388,796	
1990	1,704,253	0.7966	1,357,608	
1991	1,704,253	0.7787	1,327,102	
1992	1,704,253	0.7612	1,297,277	
1993	1,704,253	0.7441	1,268,135	
1994	1,704,253	0.7273	1,239,503	
1995	1,704,253	0.7110	1,211,724	
1996	1,704,253	0.6950	1,184,456	
1997	1,704,253	0.6794	1,157,869	
1998	1,704,253	0.6641	1,131,794	
1999	1,704,253	0.6492	1,106,401	
2000	1,704,253	0.6346	1,081,519	
2001	1,704,253	0.6203	1,057,148	
2002	1,704,253	0.6064	1,033,459	
2003	1,704,253	0.5927	1,010,111	
2004	1,704,253	0.5794	987,444	
2005	1,704,253	0.5664	965,289	
2006	1,704,253	0.5536	943,474	
2007	1,704,253	0.5412	922,342	
2008	1,704,253	0.5290	901,550	
2009	1,704,253	0.5171	881,269	
2010	1,704,253	0.5055	861,500	
2011	1,704,253	0.4941	842,071	
2012	1,704,253	0.4830	823,154	End post closure operation and maintenance of existing site
2013	1,704,253	0.4722	804,748	
2014	1,704,253	0.4616	786,683	
2015	157,099	0.4512	70,883	
2016	157,099	0.4410	69,281	Begin post closure operation and maintenance
2017	157,099	0.4311	67,725	
2018	157,099	0.4214	66,202	
2019	157,099	0.4120	64,725	
2020	157,099	0.4027	63,264	
2021	157,099	0.3936	61,834	
2022	157,099	0.3848	60,452	
2023	157,099	0.3761	59,085	
2024	157,099	0.3677	57,765	
2025	157,099	0.3594	56,461	

(continued next page)

[Plant # 10]

TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$
2026	157,099	0.3513	55,189
2027	157,099	0.3434	53,948
2028	157,099	0.3357	52,738
2029	157,099	0.3282	51,560
2030	157,099	0.3208	50,397
2031	157,099	0.3136	49,266
2032	157,099	0.3065	48,151
2033	157,099	0.2996	47,067
2034	157,099	0.2929	46,014
2035	157,099	0.2863	44,977
2036	157,099	0.2799	43,972
2037	157,099	0.2736	42,982
2038	157,099	0.2674	42,008
2039	157,099	0.2614	41,066
2040	157,099	0.2555	40,139
2041	157,099	0.2498	39,243
2042	157,099	0.2442	38,364
2043	157,099	0.2387	37,500
2044	157,099	0.2333	36,651

End post closure operation
and maintenance

Total Present Worth of Future Costs :

\$43,160,236

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

\$1,257,092

[Plant # 10]

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 10

Levelized Capital Cost

\$5,788,077

Levelized Operation and Maintenance Costs

\$1,257,092

Total Levelized Revenue Requirement

\$7,045,169

Levelized Revenue Requirement per Ton of Waste Disposed

\$11.44

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$12.21

TABLE 4.8

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 10

Design Mode: Hazardous Max

Date 12-01-1982

Power Plant Information (1980)

Generating capacity of plant	1064 mw
Generating capacity of largest boiler	554 mw

Waste Production Information *

Fly ash	174999 dry ton/yr
Bottom Ash	73160 dry ton/yr
FGD sludge	367497 dry ton/yr
Waste densities (as disposed)	
Fly ash	60 lb/cu ft
Bottom ash	61 lb/cu ft
FGD sludge	100 lb/cu ft

General Disposal Site Information

Site area	724 acres
Percent heavily wooded	0 %
Percent lightly wooded	0 %
Site perimeter	21200 ft
Distance to plant	1.25 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	6600 ft
Thickness of soils above bedrock	150 ft
Thickness of topsoil at site	0 ft
Groundwater table depth	20 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	yes

Climatic Information

Maximum frost penetration	90 in
Total annual precipitation	28.41 in
10-yr, 24-hr rainfall event	3.6 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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Notes for Plant 10:

FGD SLUDGE: the annual sludge production quantity (367,497 tons) includes 117,642 tons of fly ash which is removed with the sludge in the wet venturi scrubber for Unit 3.

TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	7
Cell volume	2889996 cu yd
Depth of waste at edge of fill	31 ft
Cell dimensions	
length at top	2186 ft
width at top	1093 ft
length at bottom	2000 ft
width at bottom	907 ft
Cell dike information	
Dike side slopes	
exterior	3 horiz : 1 vert
interior	3 horiz : 1 vert
Average width at top of dike	20 ft
Total length of exterior dike	19200 ft

Disposal Cell Cross-Section
Wet Disposal Impoundment w/ Double Liner

NOTE: Datum is below existing ground surface an average of 15 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	724 [acres]		0.00	0.
clear and grub	17 [acres]		1,298	22,064
final grading	541 [acres]		538	291,012
cut & fill non-compacted	12,011,809 [cy]		1.50	18,020,596
on-site structural cut/fill	1,210,226 [cy]		2.36	2,854,838
sand collection zone placmt	2,196,201 [cy]		8.70	19,097,000
clay liner/cap placement	2,089,409 [cy]		4.64	9,692,559
synthetic membrane	72,395,038 [sf]		0.55	40,014,185
seeding and mulching -grass	2,618,637 [sy]		0.41	1,085,530
plastic filter fabric	2,702,354 [sy]		0.71	1,920,401
light duty bituminous road	35,660 [lf]		12.52	446,291
perimeter fencing	21,200 [ft]		11.84	251,093
plastic pipe, pvc-4"	138,100 [lf]		9.82	1,356,232
plastic pipe, pvc-6"	35,300 [lf]		14.14	499,273
leachate collect sumps	2,129 [lf]		92.78	197,524
groundwater monitoring wells	1,000 [lf]		11.84	21,319
CELL CONSTRUCTION COST SUBTOTAL				\$95,769,920.
Wet Disposal - No Leachate Treatment Plant No Wet-to-Dry Conversion for Fly Ash or Bottom Ash No Wet-to-Dry Conversion for FGD				
CONSTRUCTION COST TOTAL				\$95,769,920.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items = \$95,769,920. x 0.50 =				\$47,884,960.
Permitting Cost				\$500,000
TOTAL CAPITAL REQUIREMENT =				\$144,154,900.

* Site Cost Adjustment Factor (SCAF) = .987
 Site Unit Cost = SCAF x National-Average Unit Cost

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TABLE 4.11

HAZARDOUS MAX 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	21,022,130	1.0000	21,022,130
1985	20,522,130	0.8925	18,316,001
1990	20,522,130	0.7966	16,347,929
1995	20,522,130	0.7110	14,591,234
2000	20,522,130	0.6346	13,023,344
2005	20,522,130	0.5664	11,623,734
2010	20,522,130	0.5055	10,373,937

Total Cap Exp \$144,154,910

Present Worth of all Capital Costs

\$105,298,309

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$7,792,075

[Plant # 10]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS**Non-Administrative Annual O&M Costs**

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	174,999	2.47	431,810	Wet disposal
Bottom ash	73,160	2.47	180,522	Wet disposal
FGD	367,497	2.47	906,799	Wet disposal
Total handling			1,519,131	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Leachate Treatment Plant O and M			\$0	
Total non-administrative O and M			-----\$1,519,131-----	

Administrative O&M Cost Items

Manifesting	\$23,745
Groundwater monitoring	\$35,443
Inspection	\$8,647
Personnel training	\$1,184
Non-sudden occurrence insurance	\$44,912
General administration	\$71,191
Total Annual Administration cost	-----\$185,122-----
Total annual operation and maintenance cost	\$1,704,253

Post closure O&M costs

Existing site (1980-2010)	\$0
New site	
Groundwater monitoring	\$70,886
Inspection	\$17,293
Maintenance	\$63,393
Administrative services	\$5,527
Total annual post closure cost (2014-2044)	-----\$157,099-----

[10012-01-1982#16:15:50]

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TABLE 4.13
HAZARDOUS MAX 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	1,704,253	1.0000	1,704,253	Begin post closure operation and maintenance of existing site
1981	1,704,253	0.9775	1,665,907	
1982	1,704,253	0.9555	1,628,414	
1983	1,704,253	0.9341	1,591,943	
1984	1,704,253	0.9131	1,556,153	
1985	1,704,253	0.8925	1,521,046	
1986	1,704,253	0.8725	1,486,961	
1987	1,704,253	0.8528	1,453,387	
1988	1,704,253	0.8337	1,420,836	
1989	1,704,253	0.8149	1,388,796	
1990	1,704,253	0.7966	1,357,608	
1991	1,704,253	0.7787	1,327,102	
1992	1,704,253	0.7612	1,297,277	
1993	1,704,253	0.7441	1,268,135	
1994	1,704,253	0.7273	1,239,503	
1995	1,704,253	0.7110	1,211,724	
1996	1,704,253	0.6950	1,184,456	
1997	1,704,253	0.6794	1,157,869	
1998	1,704,253	0.6641	1,131,794	
1999	1,704,253	0.6492	1,106,401	
2000	1,704,253	0.6346	1,081,519	
2001	1,704,253	0.6203	1,057,148	
2002	1,704,253	0.6064	1,033,459	
2003	1,704,253	0.5927	1,010,111	
2004	1,704,253	0.5794	987,444	
2005	1,704,253	0.5664	965,289	
2006	1,704,253	0.5536	943,474	
2007	1,704,253	0.5412	922,342	
2008	1,704,253	0.5290	901,550	
2009	1,704,253	0.5171	881,269	
2010	1,704,253	0.5055	861,500	
2011	1,704,253	0.4941	842,071	
2012	1,704,253	0.4830	823,154	End post closure operation and maintenance of existing site
2013	1,704,253	0.4722	804,748	
2014	1,704,253	0.4616	786,683	
2015	157,099	0.4512	70,883	
2016	157,099	0.4410	69,281	Begin post closure operation and maintenance
2017	157,099	0.4311	67,725	
2018	157,099	0.4214	66,202	
2019	157,099	0.4120	64,725	
2020	157,099	0.4027	63,264	
2021	157,099	0.3936	61,834	
2022	157,099	0.3848	60,452	
2023	157,099	0.3761	59,085	
2024	157,099	0.3677	57,765	
2025	157,099	0.3594	56,461	

(continued next page)

[Plant # 10]

TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	157,099	0.3513	55,189	
2027	157,099	0.3434	53,948	
2028	157,099	0.3357	52,738	
2029	157,099	0.3282	51,560	
2030	157,099	0.3208	50,397	
2031	157,099	0.3136	49,266	
2032	157,099	0.3065	48,151	
2033	157,099	0.2996	47,067	
2034	157,099	0.2929	46,014	
2035	157,099	0.2863	44,977	
2036	157,099	0.2799	43,972	
2037	157,099	0.2736	42,982	
2038	157,099	0.2674	42,008	
2039	157,099	0.2614	41,066	
2040	157,099	0.2555	40,139	
2041	157,099	0.2498	39,243	
2042	157,099	0.2442	38,364	
2043	157,099	0.2387	37,500	
2044	157,099	0.2333	36,651	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$43,160,236	
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			\$1,257,092	

[Plant # 10]

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 10

Levelized Capital Cost

\$7,792,075

Levelized Operation and Maintenance Costs

\$1,257,092

Total Levelized Revenue Requirement

\$9,049,167

Levelized Revenue Requirement per Ton of Waste Disposed

\$14.78

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$15.68

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 247,000	\$ 1,672,000	\$ 1,919,000	\$ 3.15	\$ 3.37
Non-Hazardous	1,054,000	1,689,000	2,743,000	4.50	4.81
Hazardous Minimum	5,788,000	1,257,000	7,045,000	11.44	12.21
Hazardous Maximum	7,792,000	1,257,000	9,049,000	14.78	15.68

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data
1980, Kingston, MA.

RCRA Impact
Case Study of Plant 11

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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal in the utility industry. These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 11 is located in central North Dakota and has a current nameplate generating capacity of 674 MW as shown in Table 1.1. The plant has two (2) coal-fired, wet-bottom, cyclone boilers. Fuel oil is used only for start-up and combustion stabilization.

Lignite coal for the plant is transported by off-road trucks from an adjacent mine. Normally a 60-day stockpile is maintained at the power plant site. Coal consumption for 1980 was 3,601,000 tons. The average analysis of the coal consumed during 1980 was 0.58 percent sulfur, 8.8 percent ash, and 6,552 BTU's/lb. The projected coal burns for 1985 and 2000 are the same as for 1980 or a rate of 3,601,000 tons per year.

Each of the boilers is equipped with an electrostatic precipitator (ESP). Unit 2 has SO₂ scrubber equipment which utilizes a portion of the fly ash generated from Units 1 and 2 and a small quantity of lime as a slurry to condition 85 percent of the flue gas. Particulate removal is 99.8 percent and the units presently meet the Federal and state emission limits. Table 1.1 summarizes plant characteristics including year of boiler start-up, 1980 availability factor, coal used, and air pollution control equipment.

EXISTING DISPOSAL

A schematic flow diagram of the existing facilities of the plant is shown in Figure 1.2. The quantities of major waste materials generated at the plant are summarized in Table 1.2.

Fly ash from both units is collected dry in silos and incorporated into the scrubber slurry or conditioned before disposal at the mine site. The boiler slag from Unit 1 is sluiced to a settling pond for excavation and disposal at the mine site. Unit 2 boiler slag is pumped to dewatering bins. From there the sluicing water is recycled, and the dewatered slag is trucked to the mine disposal site. The scrubber sludge from Unit 2 is either pumped to a thickener which sends the underflow to a vacuum dewaterer or it is alternatively sluiced to one of two holding ponds for dewatering. After dewatering, the solids are loaded into trucks and hauled to the mine for disposal. Figure 1.3 shows the plant location and Figure 1.4 shows the mine disposal.

Fly ash and bottom slag have not been sold for commercial purposes but made available to local citizenry for stabilizing feed lots and road or deicing aggregate. Some of the bottom slag is used internally by the plant as road aggregate.

Solid wastes from the wastewater treatment plant are combined with thickener underflow and are disposed of with the scrubber sludge. These wastes result from treatment of roof runoff, floor drains, coal pile runoff, and other low-volume waste streams. Liquid wastes from the wastewater treatment plant are used as makeup to the lime slurry tank.

SCHEMATIC FLOW DIAGRAM

FIGURE 1.2

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PLANT 11 571

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PLANT 11

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PLANT 11 573

FIGURE 1.4

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 11

Boiler	Stack	MW (Nameplate)	Year of Start-up	1980 Availability Factor	1980 Coal Used (tons)	1985 Coal Projections (tons)	2000 Coal Projections (tons)	Type of Control	
								Particulate	SO ₂
1	1	234	1970	90%	1,364,000	1,364,000	1,364,000	ESP	NONE
2	2	440	1977	87%	2,237,000	2,237,000	2,237,000	ESP	SCRUBBERS
TOTALS		674			3,601,000	3,601,000	3,601,000		

TABLE 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 11

Waste Product	1980 Values	1985 Values	2000 Values	35-Year Average*
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	98,000	98,000	98,000	98,000
Tons Sold	<u>2,000</u>	<u>2,000</u>	<u>2,000</u>	<u>2,000</u>
Tons Disposed	96,000	96,000	96,000	96,000
<u>Bottom Slag (Dry Weight)</u>				
Tons Produced	186,000	186,000	186,000	186,000
Tons Sold	<u>6,000</u>	<u>6,000</u>	<u>6,000</u>	<u>6,000</u>
Tons Disposed	180,000	180,000	180,000	180,000
<u>Scrubber Sludge (Dry Weight)</u>				
Tons Produced**	134,000	134,000	134,000	134,000
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	134,000	134,000	134,000	134,000
<u>Other Wastes</u>				
Coal Pile Runoff (MG/yr)	1.0	1.0	1.0	

* Average is for 1980-2014, assuming that the 1990 values remain constant through 2014.

** Includes 26,000 ton of fly ash

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates.

The present mine disposal site is more than adequate in size to handle the 35 years of waste generation (See Figure 1.4). The site operations would continue as described under the existing disposal practice.

Fly ash, bottom slag and scrubber sludge would continue to be transported by a contractor to the mine disposal area in off-road trucks. A water truck would be used to control dust at the mine site. A dozer would be required to spread the ash, slag and sludge at the disposal area. A self-propelled compactor would be used to consolidate the waste material. This method of waste placement would minimize the waste volume, reduce the permeability of the waste fill, and increase stability. At closure, the mining plan requires that the land be brought back to original grade. These areas would then be seeded to establish a vegetative cover to control erosion.

CURRENT PRACTICE HANDLING & DISPOSAL

Operation Activity
Construction Activity

PLANT 11

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 11

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	674 MW
Generating capacity of largest boiler	440 MW

Waste Production Information*

Fly ash	96000 dry ton/yr
Bottom Ash	180000 dry ton/yr
FGD sludge	134000 dry ton/yr
Waste densities (as disposed)	
Fly ash	70 lb/cu ft
Bottom ash	75 lb/cu ft
FGD sludge	83.7 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

[11011-17-1982#15:54:01]

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TABLE 2.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 2014

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	\$0.
--------------	------

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)	\$0.
---	------

* Site cost adjustment factor (SCAF)= .987

Site Unit cost= SCAF x National Average Unit Cost

[11/17-1982#15:54:01]

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TABLE 2.3
CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	0	0	0.9131	0
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	0	0.4512	0

Total Present Worth of Future Capital Expenditures :

\$0

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$0

[Plant # 11]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	96,000	3.45	331,632	Dry disposal
Bottom ash	180,000	3.45	621,010	Dry disposal
F6D	134,000	2.47	330,645	Wet disposal
Total handling			1,284,087	
<u>Ash excavation</u>				
F6D	134,000	2.47	330,645	
Total excavation			180,253	
<u>Ash transportation</u>				
Flyash	96,000	0.76	72,643	open off road truck (30cy) 3 mi. hau
Bottom ash	180,000	0.76	136,206	open off road truck (30cy) 3 mi. hau
F6D	134,000	0.76	101,398	open off road truck (30cy) 3 mi. hau
Total transportation			310,247	
<u>Landfill costs</u>				
Flyash	96,000	1.12	107,285	
Bottom ash	180,000	1.04	187,749	
F6D	134,000	0.93	125,241	
Total landfill cost			420,276	

Annual operation and maintenance cost \$2,194,863

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TABLE 2.5
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	2,194,863	1.0000	2,194,863
1981	2,194,863	0.9775	2,145,479
1982	2,194,863	0.9555	2,097,192
1983	2,194,863	0.9341	2,050,222
1984	2,194,863	0.9131	2,004,129
1985	2,194,863	0.8925	1,958,915
1986	2,194,863	0.8725	1,915,018
1987	2,194,863	0.8528	1,871,779
1988	2,194,863	0.8337	1,829,857
1989	2,194,863	0.8149	1,788,594
1990	2,194,863	0.7966	1,748,428
1991	2,194,863	0.7787	1,709,140
1992	2,194,863	0.7612	1,670,730
1993	2,194,863	0.7441	1,633,198
1994	2,194,863	0.7273	1,596,324
1995	2,194,863	0.7110	1,560,548
1996	2,194,863	0.6950	1,525,430
1997	2,194,863	0.6794	1,491,190
1998	2,194,863	0.6641	1,457,609
1999	2,194,863	0.6492	1,424,905
2000	2,194,863	0.6346	1,392,860
2001	2,194,863	0.6203	1,361,474
2002	2,194,863	0.6064	1,330,965
2003	2,194,863	0.5927	1,300,895
2004	2,194,863	0.5794	1,271,704
2005	2,194,863	0.5664	1,243,170
2006	2,194,863	0.5536	1,215,076
2007	2,194,863	0.5412	1,187,860
2008	2,194,863	0.5290	1,161,083
2009	2,194,863	0.5171	1,134,964
2010	2,194,863	0.5055	1,109,503
2011	2,194,863	0.4941	1,084,482
2012	2,194,863	0.4830	1,060,119
2013	2,194,863	0.4722	1,036,414
2014	2,194,863	0.4616	1,013,149
Total Present Worth of Future Costs :			\$53,577,264
Sum of Present Worth Factors :			24.4103
Levelized O&M Cost = (Present Worth of all O&M Costs) / (Sum of Present Worth Factors)			
LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST			\$2,194,863

[Plant # 11]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 11

Levelized Capital Cost

\$0

Levelized Operation and Maintenance Costs

\$2,194,863

Total Levelized Revenue Requirement

\$2,194,863

Levelized Revenue Requirement per Ton of Waste Disposed

\$5.35

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$5.52

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of ground-water monitoring wells around the active mine disposal site. Closure of the disposal site will include the construction of a 12-inch clay cap to minimize leachate generation. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes, would continue to be recycled in the plant's water system.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge

NON-HAZARDOUS HANDLING & DISPOSAL

Operation Activity
Construction Activity

PLANT 11

rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5.

A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

TABLE 3.1

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 11

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	674 mw
Generating capacity of largest boiler	448 mw

Waste Production Information*

Fly ash	96000 dry ton/yr
Bottom Ash	180000 dry ton/yr
FGD sludge	134000 dry ton/yr
Waste densities (as disposed)	
Fly ash	70 lb/cu ft
Bottom ash	75 lb/cu ft
FGD sludge	83.7 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 3.2

NON-HAZARDOUS CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1984

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				\$0.
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
* Site cost adjustment factor (SCAF) = .987				
Site Unit cost = SCAF x National Average Unit Cost				
[11#11-17-1982#16:04:06]				PAGE 2

TABLE 3.2 (continued)

Construction Cost Items for Period 2
1985 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
groundwater monitoring wells	1,500 [1f]		11.84	17,766
CONSTRUCTION COST TOTAL				\$17,766
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items =	$\$17,766 \times 0.50 =$			\$8,883
CONSTRUCTION CAPITAL REQUIREMENT =				\$26,649
Closure Cost		\$28,623		
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$42,935
* Site cost adjustment factor (SCAF) = .987				
Site Unit cost = SCAF x National Average Unit Cost				

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TABLE 3.3
NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 % -
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	26,649	0	0.9131	24,333
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	42,935	0.4512	19,372

Total Present Worth of Future Capital Expenditures :

\$43,705

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$3,234

[Plant # 11]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTSO&M Costs for Period 1
1980 to 1984

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	96,000	3.45	331,632	Dry disposal
Bottom ash	180,000	3.45	621,810	Dry disposal
FGD	134,000	2.47	330,645	Wet disposal
Total handling			1,284,087	
Ash excavation				
FGD	134,000	2.47	330,645	
Total excavation			180,253	
Ash transportation				
Flyash	96,000	0.76	72,643	open off road truck (30cy) 3 mi. haul
Bottom ash	180,000	0.76	136,206	open off road truck (30cy) 3 mi. haul
FGD	134,000	0.76	101,393	open off road truck (30cy) 3 mi. haul
Total transportation			310,247	
Landfill costs				
Flyash	96,000	1.12	107,295	
Bottom ash	180,000	1.04	187,749	
FGD	134,000	0.93	125,241	
Total landfill cost			420,276	

Annual operation and maintenance cost \$2,194,863

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TABLE 3.4 (continued)

O&M Costs for Period 2
1985 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	96,000	3.45	331,632	Dry disposal
Bottom ash	180,000	3.45	621,810	Dry disposal
FGD	134,000	2.47	330,645	Wet disposal
Total handling			1,284,087	
Ash excavation				
FGD	134,000	2.47	330,645	
Total excavation			180,253	
Ash transportation				
Flyash	96,000	0.76	72,643	open off road truck (30cy) 3 mi. hau
Bottom ash	180,000	0.76	136,266	open off road truck (30cy) 3 mi. hau
FGD	134,000	0.76	101,398	open off road truck (30cy) 3 mi. hau
Total transportation			310,247	
Landfill costs				
Flyash	96,000	1.12	107,285	
Bottom ash	180,000	1.04	187,749	
FGD	134,000	0.93	125,241	
Total landfill cost			420,276	
Groundwater monitoring			26,050	
Annual operation and maintenance cost			\$2,220,913	

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TABLE 3.5
NON-HAZARDOUS 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	2,194,863	1.0000	2,194,863
1981	2,194,863	0.9775	2,145,479
1982	2,194,863	0.9555	2,097,192
1983	2,194,863	0.9341	2,050,222
1984	2,194,863	0.9131	2,004,129
1985	2,220,913	0.8925	1,982,165
1986	2,220,913	0.8725	1,937,747
1987	2,220,913	0.8528	1,893,995
1988	2,220,913	0.8337	1,851,575
1989	2,220,913	0.8149	1,809,822
1990	2,220,913	0.7966	1,769,179
1991	2,220,913	0.7787	1,729,425
1992	2,220,913	0.7612	1,690,559
1993	2,220,913	0.7441	1,652,581
1994	2,220,913	0.7273	1,615,270
1995	2,220,913	0.7110	1,579,069
1996	2,220,913	0.6950	1,543,535
1997	2,220,913	0.6794	1,508,888
1998	2,220,913	0.6641	1,474,908
1999	2,220,913	0.6492	1,441,817
2000	2,220,913	0.6346	1,409,391
2001	2,220,913	0.6203	1,377,632
2002	2,220,913	0.6064	1,346,762
2003	2,220,913	0.5927	0
2004	2,220,913	0.5794	1,286,797
2005	2,220,913	0.5664	1,257,925
2006	2,220,913	0.5536	1,229,497
2007	2,220,913	0.5412	1,201,958
2008	2,220,913	0.5290	1,174,863
2009	2,220,913	0.5171	1,148,434
2010	2,220,913	0.5055	1,122,672
2011	2,220,913	0.4941	1,097,353
2012	2,220,913	0.4830	1,072,701
2013	2,220,913	0.4722	1,048,715
2014	2,220,913	0.4616	1,025,173

Total Present Worth of Future Costs :

\$52,772,293

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$2,161,886

[Plant # 11]

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 11

Levelized Capital Cost

\$3,234

Levelized Operation and Maintenance Costs

\$2,161,886

Total Levelized Revenue Requirement

\$2,165,120

Levelized Revenue Requirement per Ton of Waste Disposed

\$5.28

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$5.44

SECTION 4

HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

The proposed design consists of utilizing a tract of land adjacent to the mine site. All ash and sludge will be trucked to the new landfill. Leachate treatment facilities are provided and were sized based on a 10-year, 24-hour rainfall event falling on half the area of one open cell. Internal cell diking will preclude contamination of all storm water runoff. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes would continue to be used as make-up water to the plants' recycle system.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities

Design FactorHazardous MinimumHazardous Maximum

2. Liner System

Use a single liner system as specified in the EPA guidance documents

Use a double liner system as specified in the EPA guidance documents

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. It was assumed that because of RCRA restrictions ash would no longer be able to be sold for other uses. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed cells on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Figure 4.1 is a layout of the nine cells which are proposed for ash disposal under the hazardous waste scenario. Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the

FIGURE 4.1

HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION ⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.2

HAZARDOUS MAXIMUM LANDFILL – TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 11

Design Mode: Hazardous Min

Date 11-18-1982

Power Plant Information (1980)

Generating capacity of plant	674 MW
Generating capacity of largest boiler	440 MW

Waste Production Information *

Fly ash	98000 dry ton/yr
Bottom Ash	186000 dry ton/yr
FGD sludge	134000 dry ton/yr
Waste densities (as disposed)	
Fly ash	84 lb/cu ft
Bottom ash	90 lb/cu ft
FGD sludge	100 lb/cu ft

General Disposal Site Information

Site area	937 acres
Percent heavily wooded	0 %
Percent lightly wooded	0 %
Site perimeter	23125 ft
Distance to plant	3 mi
Distance to main road	1000 ft
Distance from disposal site to leachate treatment plant	4000 ft
Thickness of soils above bedrock	1000 ft
Thickness of topsoil at site	0 ft
Groundwater table depth	100 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	10 mi

Climatic Information

Maximum frost penetration	80 in
Total annual precipitation	16.31 in
10-yr, 24-hr rainfall event	3.3 in

* note: Average for period 1960-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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TABLE 4.2

HAZARDOUS MIN CELL GEOMETRY

of cells	9
Cell volume	1320304 cu yd
Depth of waste at edge of fill	40 ft
Cell dimensions	
length at top	1728 ft
width at top	576 ft
length at bottom	1568 ft
width at bottom	416 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	14064 ft

Disposal Cell Cross-Section
Dry Landfill w/ Single Liner

NOTE: Datum is below existing ground surface an average of 20 feet at this site

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	937 [acres]		0.00	0.
clear and grub	778 [acres]		1,298	1,005,429
final grading	759 [acres]		538	408,261
cut & fill non-compacted	3,291,158 [cy]		1.50	4,937,527
on-site structural cut/fill	1,737,632 [cy]		2.36	4,098,952
sand collection zone plant	879,930 [cy]		8.70	7,651,404
sand import	879,930 [cy]		6.27	5,514,917
clay liner/cap placement	858,563 [cy]		4.64	3,982,787
synthetic membrane	19,250,890 [sf]		0.55	10,639,904
seeding and mulching -grass	3,673,415 [sy]		0.41	1,522,777
gravel stabilization	3,967 [sy]		0.69	2,741
plastic filter fabric	2,138,898 [sy]		0.71	1,519,986
light duty bituminous road	13,336 [lf]		12.52	166,902
heavy duty bituminous road	1,000 [lf]		16.42	16,424
perimeter fencing	23,125 [ft]		11.84	273,893
plastic pipe, pvc-4"	46,965 [lf]		9.82	461,224
plastic pipe, pvc-6"	35,104 [lf]		14.14	496,501
leachate collect sumps	1,000 [lf]		92.78	167,000
soil borings	45,538 [lf]		14.81	674,193
groundwater monitoring wells	3,094 [lf]		11.84	36,646
CELL CONSTRUCTION COST SUBTOTAL				\$43,581,470.
Leachate Treatment Plant Construction Cost				\$1,559,696.
No Wet-to-Dry Conversion for Fly Ash or Bottom Ash				
No Wet-to-Dry Conversion for FGD				
Construction Cost for Closure of Existing Disposal Site(s)				\$363,216
CONSTRUCTION COST TOTAL				\$45,504,390.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items = \$45,504,390. x 0.50 =				\$22,752,190.
Permitting Cost				\$250,000
TOTAL CAPITAL REQUIREMENT =				\$68,506,580.

* Site Cost Adjustment Factor (SCAF) = .987
 Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4

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	10,397,950	1.0000	10,397,950
1984	7,263,579	0.9131	6,632,374
1988	7,263,579	0.8337	6,055,646
1992	7,263,579	0.7612	5,529,036
1996	7,263,579	0.6950	5,048,187
1999	7,263,579	0.6492	4,715,515
2003	7,263,579	0.5927	4,305,123
2007	7,263,579	0.5412	3,931,049
2011	7,263,579	0.4941	3,588,934
Total Cap Exp	\$68,506,582		
Present Worth of all Capital Costs			\$50,203,816
Total Levelizing Factor (LF) =		0.0740	
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$3,715,082

[Plant # 11]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS**Non-Administrative Annual O&M Costs**

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	98,000	3.45	338,541	Dry disposal
Bottom ash	186,000	3.45	642,537	Dry disposal
FGD	134,000	10.74	1,439,631	Dry disposal
Total handling			2,420,709	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	98,000	0.76	74,157	open off road truck (30cy) 3 mi. hau
Bottom ash	186,000	0.76	140,746	open off road truck (30cy) 3 mi. hau
FGD	134,000	0.76	101,398	open off road truck (30cy) 3 mi. hau
Total transportation			316,300	
Landfill costs				
Flyash	98,000	0.93	91,267	
Bottom ash	186,000	0.87	161,673	
FGD	134,000	0.78	104,827	
Total landfill cost			357,767	
Leachate Treatment Plant O and M			\$182,117	
Total non-administrative O and M			-----\$3,276,544-----	

Administrative O&M Cost Items

Manifesting	\$18,478
Groundwater monitoring	\$26,116
Inspection	\$11,190
Personnel training	\$1,184
Non-sudden occurrence insurance	\$36,432
General administration	\$59,681
Total Annual Administration cost	-----\$153,081-----
Total annual operation and maintenance cost	\$3,430,025
Post closure O&M costs	
Existing site (1980-2010)	\$113,500
New site	
Groundwater monitoring	\$52,232
Inspection	\$22,361
Maintenance	\$74,110
Administrative services	\$5,527
Total annual post closure cost (2014-2044)	-----\$154,250-----

[11#11-18-1982#12135186]

TABLE 4.6
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	3,543,525	1.0000	3,543,525	Begin post closure operation and maintenance of existing site
1981	3,543,525	0.9775	3,463,796	
1982	3,543,525	0.9555	3,385,838	
1983	3,543,525	0.9341	3,310,007	
1984	3,543,525	0.9131	3,235,593	End post closure operation and maintenance of existing site
1985	3,543,525	0.8925	3,162,596	
1986	3,543,525	0.8725	3,091,726	
1987	3,543,525	0.8528	3,021,918	
1988	3,543,525	0.8337	2,954,237	
1989	3,543,525	0.8149	2,887,619	
1990	3,543,525	0.7966	2,822,772	
1991	3,543,525	0.7787	2,759,343	
1992	3,543,525	0.7612	2,697,331	
1993	3,543,525	0.7441	2,636,737	
1994	3,543,525	0.7273	2,577,206	
1995	3,543,525	0.7110	2,519,446	
1996	3,543,525	0.6950	2,462,750	Begin post closure operation and maintenance
1997	3,543,525	0.6794	2,407,471	
1998	3,543,525	0.6641	2,353,255	
1999	3,543,525	0.6492	2,300,456	
2000	3,543,525	0.6346	2,248,721	End post closure operation and maintenance of existing site
2001	3,543,525	0.6203	2,198,049	
2002	3,543,525	0.6064	2,148,794	
2003	3,543,525	0.5927	2,100,247	
2004	3,543,525	0.5794	2,053,118	Begin post closure operation and maintenance
2005	3,543,525	0.5664	2,007,053	
2006	3,543,525	0.5536	1,961,695	
2007	3,543,525	0.5412	1,917,756	
2008	3,543,525	0.5290	1,874,525	
2009	3,543,525	0.5171	1,832,357	
2010	3,543,525	0.5055	1,791,252	
2011	3,430,025	0.4941	1,694,775	
2012	3,430,025	0.4830	1,656,702	
2013	3,430,025	0.4722	1,619,658	
2014	3,430,025	0.4616	1,583,300	
2015	154,250	0.4512	69,598	
2016	154,250	0.4410	68,024	Begin post closure operation and maintenance
2017	154,250	0.4311	66,497	
2018	154,250	0.4214	65,001	
2019	154,250	0.4120	63,551	
2020	154,250	0.4027	62,116	Begin post closure operation and maintenance
2021	154,250	0.3936	60,713	
2022	154,250	0.3848	59,355	
2023	154,250	0.3761	58,013	
2024	154,250	0.3677	56,718	Begin post closure operation and maintenance
2025	154,250	0.3594	55,437	

(continued next page)

[Plant # 11]

TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	154,250	0.3513	54,188	
2027	154,250	0.3434	52,969	
2028	154,250	0.3357	51,782	
2029	154,250	0.3282	50,625	
2030	154,250	0.3208	49,483	
2031	154,250	0.3136	48,373	
2032	154,250	0.3065	47,278	
2033	154,250	0.2996	46,213	
2034	154,250	0.2929	45,180	
2035	154,250	0.2863	44,162	
2036	154,250	0.2799	43,175	
2037	154,250	0.2736	42,203	
2038	154,250	0.2674	41,246	
2039	154,250	0.2614	40,321	
2040	154,250	0.2555	39,411	
2041	154,250	0.2498	38,532	
2042	154,250	0.2442	37,668	
2043	154,250	0.2387	36,819	
2044	154,250	0.2333	35,987	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$87,812,259	
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			\$2,557,634	

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 11

Levelized Capital Cost

\$3,715,082

Levelized Operation and Maintenance Costs

\$2,557,634

Total Levelized Revenue Requirement

\$6,272,716

Levelized Revenue Requirement per Ton of Waste Disposed

\$15.01

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$18.52

TABLE 4.8

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 11

Design Mode: Hazardous Max

Date 11-18-1982

Power Plant Information (1980)

Generating capacity of plant	674 MW
Generating capacity of largest boiler	442 MW

Waste Production Information *

Fly ash	98000 dry ton/yr
Bottom Ash	186000 dry ton/yr
FGD sludge	134000 dry ton/yr
Waste densities (as disposed)	
Fly ash	84 lb/cu ft
Bottom ash	90 lb/cu ft
FGD sludge	100 lb/cu ft

General Disposal Site Information

Site area	937 acres
Percent heavily wooded	0 %
Percent lightly wooded	0 %
Site perimeter	23125 ft
Distance to plant	3 mi
Distance to main road	1000 ft
Distance from disposal site to leachate treatment plant	4000 ft
Thickness of soils above bedrock	1000 ft
Thickness of topsoil at site	0 ft
Groundwater table depth	100 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	10 mi

Climatic Information

Maximum frost penetration	80 in
Total annual precipitation	16.31 in
10-yr, 24-hr rainfall event	3.3 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	9
Volume	1320364 cu yd
Depth of waste at edge of fill	40 ft
Cell dimensions	
length at top	1728 ft
width at top	576 ft
length at bottom	1568 ft
width at bottom	416 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	14064 ft

Disposal Cell Cross-Section
Dry Landfill w/ Double Liner

NOTE: Datum is below existing ground surface an average of 22 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT+ COST	EXTENSION
real estate	937	[acres]	0.00	0.
clear and grub	761	[acres]	1,298	987,082
final grading	759	[acres]	538	408,261
cut & fill non-compacted	4,180,651	[cy]	1.50	6,271,980
on-site structural cut/fill	1,292,757	[cy]	2.36	3,049,523
sand collection zone p/cmt	1,074,857	[cy]	8.70	9,346,387
sand import	1,074,857	[cy]	6.27	6,736,613
clay liner/cap placement	1,723,452	[cy]	4.64	7,994,921
synthetic membrane	19,349,790	[sf]	0.55	10,695,016
seeding and mulching -grass	3,673,415	[sy]	0.41	1,522,777
gravel stabilization	3,967	[sy]	0.69	2,741
plastic filter fabric	2,149,976	[sy]	0.71	1,527,859
light duty bituminous road	6,304	[lf]	12.52	78,896
heavy duty bituminous road	400	[lf]	16.42	6,569
perimeter fencing	25,625	[ft]	11.84	303,503
plastic pipe, pvc-4"	93,929	[lf]	9.82	922,448
plastic pipe, pvc-6"	70,208	[lf]	14.14	993,002
leachate collect sumps	1,800	[lf]	92.78	167,000
soil borings	45,538	[lf]	14.81	674,193

CELL CONSTRUCTION COST SUBTOTAL

\$51,688,770.

Leachate Treatment Plant Construction Cost

\$1,559,696.

No Wet-to-Dry Conversion for Fly Ash or Bottom Ash

No Wet-to-Dry Conversion for FGD

Construction Cost for Closure of Existing Disposal Site(s)

\$1,066,947

CONSTRUCTION COST TOTAL

\$54,315,410.

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%

Other Capital Items = \$54,315,410. x 0.50 =

\$27,157,710.

Permitting Cost

\$500,000

TOTAL CAPITAL REQUIREMENT =

\$81,973,110.

* Site Cost Adjustment Factor (SCAF) = .987

Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.11

HAZARDOUS MAX 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	13,054,760	1.0000	13,054,760
1984	8,614,794	0.9131	7,866,168
1988	8,614,794	0.8337	7,182,154
1992	8,614,794	0.7612	6,557,581
1996	8,614,794	0.6950	5,987,282
1999	8,614,794	0.6492	5,592,724
2003	8,614,794	0.5927	5,105,988
2007	8,614,794	0.5412	4,662,327
2011	8,614,794	0.4941	4,256,570

Total Cap Exp \$81,973,112

Present Worth of all Capital Costs \$60,265,554

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST \$4,459,651

[Plant # 11]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	98,000	3.45	338,541	Dry disposal
Bottom ash	186,000	3.45	642,537	Dry disposal
FGD	134,000	10.74	1,439,681	Dry disposal
Total handling			2,420,759	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	98,000	0.76	74,157	open off road truck (30cy) 3 mi. hau
Bottom ash	186,000	0.76	140,746	open off road truck (30cy) 3 mi. hau
FGD	134,000	0.76	101,398	open off road truck (30cy) 3 mi. hau
Total transportation			316,300	
<u>Landfill costs</u>				
Flyash	98,000	0.93	91,267	
Bottom ash	186,000	0.87	161,673	
FGD	134,000	0.78	104,827	
Total landfill cost			357,767	
Leachate Treatment Plant O and M			\$182,117	
Total non-administrative O and M			\$3,276,544	

Administrative O&M Cost Items

Manifesting	\$18,478
Groundwater monitoring	\$0
Inspection	\$11,190
Personnel training	\$1,184
Non-sudden occurrence insurance	\$36,432
General administration	\$59,681
Total Annual Administration cost	\$126,965

Total annual operation and maintenance cost \$3,403,909

Post closure O&M costs

Existing site (1980-2010) \$113,500

New site

Groundwater monitoring	\$0
Inspection	\$22,361
Maintenance	\$74,100
Administrative services	\$5,527
Total annual post closure cost (2014-2044)	\$102,000

TABLE 4.13

HAZARDOUS MAX 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	3,517,409	1.0000	3,517,409	Begin post closure operation and maintenance of existing site
1981	3,517,409	0.9775	3,438,267	
1982	3,517,409	0.9555	3,360,884	
1983	3,517,409	0.9341	3,285,612	
1984	3,517,409	0.9131	3,211,746	Begin post closure operation and maintenance of existing site
1985	3,517,409	0.8925	3,139,288	
1986	3,517,409	0.8725	3,068,939	
1987	3,517,409	0.8528	2,999,646	
1988	3,517,409	0.8337	2,932,464	
1989	3,517,409	0.8149	2,866,337	
1990	3,517,409	0.7966	2,801,968	
1991	3,517,409	0.7787	2,739,006	
1992	3,517,409	0.7612	2,677,452	
1993	3,517,409	0.7441	2,617,304	
1994	3,517,409	0.7273	2,558,212	
1995	3,517,409	0.7110	2,500,878	
1996	3,517,409	0.6950	2,444,599	
1997	3,517,409	0.6794	2,389,728	
1998	3,517,409	0.6641	2,335,911	
1999	3,517,409	0.6492	2,283,502	
2000	3,517,409	0.6346	2,232,148	
2001	3,517,409	0.6203	2,181,849	
2002	3,517,409	0.6064	2,132,957	
2003	3,517,409	0.5927	2,084,768	
2004	3,517,409	0.5794	2,037,987	End post closure operation and maintenance of existing site
2005	3,517,409	0.5664	1,992,260	
2006	3,517,409	0.5536	1,947,238	
2007	3,517,409	0.5412	1,903,622	
2008	3,517,409	0.5290	1,860,709	
2009	3,517,409	0.5171	1,818,852	
2010	3,517,409	0.5055	1,778,050	
2011	3,403,909	0.4941	1,681,871	
2012	3,403,909	0.4830	1,644,088	Begin post closure operation and maintenance
2013	3,403,909	0.4722	1,607,326	
2014	3,403,909	0.4616	1,571,244	
2015	102,008	0.4512	46,026	
2016	102,008	0.4410	44,986	
2017	102,008	0.4311	43,976	
2018	102,008	0.4214	42,986	
2019	102,008	0.4120	42,027	
2020	102,008	0.4027	41,079	
2021	102,008	0.3936	40,150	
2022	102,008	0.3848	39,253	
2023	102,008	0.3761	38,365	
2024	102,008	0.3677	37,508	
2025	102,008	0.3594	36,662	

(continued next page)

[Plant # 11]

TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	102,008	0.3513	35,835	
2027	102,008	0.3434	35,030	
2028	102,008	0.3357	34,244	
2029	102,008	0.3282	33,479	
2030	102,008	0.3208	32,724	
2031	102,008	0.3136	31,990	
2032	102,008	0.3065	31,265	
2033	102,008	0.2996	30,562	
2034	102,008	0.2929	29,878	
2035	102,008	0.2863	29,205	
2036	102,008	0.2799	28,552	
2037	102,008	0.2736	27,909	
2038	102,008	0.2674	27,277	
2039	102,008	0.2614	26,665	
2040	102,008	0.2555	26,063	
2041	102,008	0.2498	25,482	
2042	102,008	0.2442	24,910	
2043	102,008	0.2387	24,349	
2044	102,008	0.2333	23,798	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$86,656,357	
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			\$2,523,967	

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 11

Levelized Capital Cost

\$4,459,651

Levelized Operation and Maintenance Costs

\$2,523,967

Total Levelized Revenue Requirement

\$6,983,618

Levelized Revenue Requirement per Ton of Waste Disposed

\$16.70

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$20.62

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 0	\$ 2,195,000	\$ 2,195,000	\$ 5.35	\$ 5.52
Non-Hazardous	3,000	2,162,000	2,165,000	5.28	5.44
Hazardous Minimum	3,715,000	2,558,000	6,273,000	15.01	18.52
Hazardous Maximum	4,460,000	2,524,000	6,984,000	16.70	20.62

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data 1980, Kingston, MA.

RCRA Impact
Case Study of Plant 12

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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal for utility wastes (fly ash, bottom ash, slag and FGD wastes). These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 12 is located on Tampa Bay in western Florida and has a nameplate generating capacity of 1,249 MW (Table 1.1). The plant has three wet bottom boilers fired with pulverized coal. These units generate boiler slag as a waste. Fuel oil is used only for start-up and combustion stabilization. An expansion at the facility consists of a new 425 MW unit scheduled to come online in 1985. The new boiler will be a dry bottom boiler which produces bottom ash.

Bituminous coal for the plant is obtained from western Kentucky and Oklahoma with delivery by barge. Normally, a 45-day stockpile of coal is maintained on-site, with another 45-day supply in transit. This results in a dynamic inventory of 90 days. Coal consumption for 1980

was 2,827,000 tons. The average analysis of the coal consumed during 1980 was 10 percent ash, 2.2 percent sulfur, and 11,050 BTU's/lb. Projected 1985 and 2000 rates of coal consumption are 3,799,000 tons and 3,657,000 tons, respectively.

Each of the boilers is equipped with an electrostatic precipitator (ESP). The fly ash is collected dry and stored in silos for sale or reinjection into the boiler to make additional saleable bottom boiler slag. Occasionally a flue gas conditioning chemical is used in Unit 3 to aid fly ash precipitation. The new unit (Unit 4) will have a dry bottom boiler with an ESP and flue gas desulfurization system. The FGD system is designed to produce a saleable gypsum by-product. Table 1.1 summarizes plant characteristics including year of boiler start-up, 1980 availability factor, coal used, and air pollution control equipment.

EXISTING DISPOSAL

The schematic flow diagram of the existing disposal facilities for the plant is shown in Figure 1.2. The quantities of major waste materials generated are summarized in Table 1.2.

Fly ash is transferred dry to overhead storage silos. The bottom boiler slag is sluiced to a pond where the material is reclaimed by loaders for truck shipping to a broker's processing plant for sale. An on-site diked disposal area is used in emergencies for the ash which is not sold or reinjected.

A waste water treatment plant with evaporation pond, spray irrigation system and recycle system is used for processing coal pile runoff and low volume waste streams. The settled solids are dredged periodically and deposited in the diked disposal site.

SCHEMATIC FLOW DIAGRAM

FIGURE 1.2

FIGURE 1.3

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 12

Boiler	Stack	MW (Nameplate)	Year of Start-up	1980 Availability Factor	1980 Coal Used (tons)	1985 Coal Projections (tons)	2000 Coal Projections (tons)	Type of Control	
								Particulate	SO ₂
1	1 ¹	417	1970	50%	656,000	964,000	926,000	ESP	NONE
2	1 ¹	417	1973	85%	1,044,000	990,000	904,000	ESP	NONE
3	2	415	1976	83%	1,127,000	966,000	863,000	ESP	NONE
4	3	444	1985	N/A	N/A	879,000	964,000	ESP	FGD
TOTALS		1,693			2,827,000	3,799,000	3,657,000		

¹ Common Stack for Units 1 & 2
N/A - not applicable

TABLE 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 12

Waste Product	1980 Values	1985 Values	2000 Values	35-Year Average*
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	149,000	169,000	164,000	162,758
Tons Sold	<u>136,600</u>	<u>150,000</u>	<u>150,000</u>	<u>148,850</u>
Tons Disposed	12,400	19,000	14,000	13,908
<u>Bottom Slag (Dry Weight)</u>				
Tons Produced	133,700	223,000	209,300	206,720
Tons Sold	<u>133,700</u>	<u>223,000</u>	<u>209,300</u>	<u>206,720</u>
Tons Disposed	0	0	0	0
<u>Bottom Ash (Dry Weight)</u>				
Tons Produced	0	23,700	26,000	21,769
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	0	23,700	26,000	21,769
<u>Scrubber Sludge (90% Solids)</u>				
Tons Produced	0	131,250	194,000	156,200
Tons Sold	<u>0</u>	<u>131,250</u>	<u>194,000</u>	<u>156,200</u>
Tons Disposed	0	0	0	0

*Average is for 1980-2014, assuming that the 2000 values remain constant through 2014.

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates. Incorporated into this design was the additional quantities to be generated by Unit 4 starting in April, 1985, along with its proposed ash handling and disposal systems.

The disposal and sale operation would remain the same for Units 1, 2 and 3. It was assumed that the sale of bottom slag would continue over the 35 year design period and no slag would have to be disposed on-site. Unsold fly ash would continue to be reinjected and only disposed on-site in the existing disposal area on an emergency basis. Sludge (primarily fly ash) is dredged periodically from the wastewater pond and also placed in the emergency disposal area. Sludge (primarily fly ash) is dredged periodically from the wastewater pond and also placed in the emergency disposal area. When Unit 4 is constructed in 1985, it was assumed that the fly ash would be disposed of on-site, the FGD by-product would be sold for the manufacture of wall board or cement and the bottom ash would be sluiced to a newly constructed bottom ash pond shown on Figure 2.2. For the purpose of this study, the abandoned

CURRENT PRACTICE HANDLING & DISPOSAL

▨ Operation Activity
■ Construction Activity

PLANT 12

FIGURE 2.1

FIGURE 2.2

CURRENT PRACTICE WASTE DISPOSAL SITES

horseshoe cooling pond will be modified to allow for disposal of bottom ash. The horseshoe design would be modified by extending the center dike to have two independent ponds. These ponds can then be operated in a standard fill and draw mode. Each of the new bottom ash ponds would have approximately 8 years capacity before excavation of the bottom ash to the land disposal area would be required. Miscellaneous wastes, e.g. coal pile runoff, currently generated by the plant would continue to be sent to the wastewater treatment plant.

The existing fly ash disposal area would have sufficient capacity to handle wastes through 1992. One additional landfill area would be required to dispose of fly ash and bottom ash for the remainder of the design period.

The proposed design consists of clearing and regrading the area as necessary before waste materials deposition, and providing a surface water drainage system. A perimeter dike would be constructed around the new disposal site to divert surface water around and away from the site. The perimeter dike would be constructed of compacted materials which would have to be imported to the site. A six-inch layer of topsoil would be placed and compacted on the slopes of the dikes. The slopes would be seeded to produce a thick ground cover which would provide erosion protection of the dike.

A dozer would be required to spread the fly ash and bottom ash at the proposed landfill. A self-propelled compactor would be used to consolidate the waste material. This method of waste placement would minimize the waste volume, reduce the permeability of the waste fill, and increase landfill stability. At closure, a proposed 12-inch layer of topsoil would be placed and compacted on the disposal areas. These areas would be seeded to establish a vegetative cover to control erosion.

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs

based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extentions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 12

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	1249 MW
Generating capacity of largest boiler	417 MW

Waste Production Information*

Fly ash	13908 dry ton/yr
Bottom Ash	21769 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	48 lb/cu ft
Bottom ash	81.7 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 2.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1992

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
<hr/>				
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.
<hr/>				
Closure Cost			\$0.	
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
<hr/>				
Site cost adjustment factor (SCAF) = 1.017				
Site Unit cost = SCAF x National Average Unit Cost				
<hr/>				
[12011-26-1982001:31:49]				PAGE 2

TABLE 2.2 (continued)

Construction Cost Items for Period 2

1993 - 1997

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
clear and grub	50 [acres]		1,337	66,850
final grading	50 [acres]		554	27,713
borrow material import	125,791 [cy]		7.53	946,678
topsoil removal & stockpile	77,440 [cy]		1.55	119,710
seeding and mulching -grass	49,835 [sy]		0.43	21,287
riprap, grouted	3,520 [sy]		77.98	274,502
soil borings	250 [lf]		15.26	3,814
CONSTRUCTION COST TOTAL				\$1,460,571.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
50%				
Other Capital Items = \$1,460,571. x 0.50 =				\$730,286
CONSTRUCTION CAPITAL REQUIREMENT =				\$2,190,857.
Closure Cost			\$78,309	
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$117,464
* Site cost adjustment factor (SCAF)= 1.017				
Site Unit cost= SCAF x National Average Unit Cost				
[12#11-26-1982#01:31:49]				PAGE 3

TABLE 2.2 (continued)

Construction Cost Items for Period 3
 1998 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
------	----------	------	---------------	-----------

CONSTRUCTION COST TOTAL				\$0.
-------------------------	--	--	--	------

Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
<hr/>				
	50%			

Other Capital Items =	\$0. x 0.50 =		\$0.
-----------------------	---------------	--	------

CONSTRUCTION CAPITAL REQUIREMENT =		\$0.
------------------------------------	--	------

Closure Cost	\$336,627	
--------------	-----------	--

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)	\$504,941
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* Site cost adjustment factor (SCAF) = 1.017
 Site Unit cost = SCAF x National Average Unit Cost

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TABLE 2.3
CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	0	0	0.9131	0
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	2,190,857	0	0.7612	1,667,680
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	117,464	0.6641	78,008
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	504,941	0.4512	227,829

Total Present Worth of Future Capital Expenditures :

\$1,973,518

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$146,040

[Plant # 12]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1992

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	13,908	3.56	49,506	Dry disposal
Bottom ash	21,769	2.54	55,348	Wet disposal
Total handling			104,853	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	13,908	0.50	6,931	open on road truck (load) 1 mi. haul
Total transportation			6,931	
Landfill costs				
Flyash	13,908	1.68	23,356	
Total landfill cost			23,356	
Annual operation and maintenance cost			\$135,140	

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TABLE 2.4 (continued)

O&M Costs for Period 2
1993 to 1997

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	13,908	3.56	49,506	Dry disposal
Bottom ash	21,769	2.54	55,348	Wet disposal
Total handling			104,853	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	13,908	0.50	6,951	open on road truck (16cy) 1 mi. haul
Total transportation			6,951	
Landfill costs				
Flyash	13,908	1.68	23,356	
Total landfill cost			23,356	

Annual operation and maintenance cost

\$135,140

Non-annual ash excavation cost 207240 c.y. @ \$ 3.1527 /c.y = \$ 653365.5 in year 1993

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TABLE 2.4 (continued)

O&M Costs for Period 3
1998 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	13,908	3.56	49,506	Dry disposal
Bottom ash	21,769	2.54	55,348	Wet disposal
Total handling			104,853	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	13,908	0.50	6,931	open on road truck (16cy) 1 mi. haul
Total transportation			6,931	
Landfill costs				
Flyash	13,908	1.68	23,356	
Total landfill cost			23,356	

Annual operation and maintenance cost \$135,140
 Non-annual ash excavation cost 115132 c.y. @ \$ 2.35944 /c.y. = \$ 271647 in year 1999
 Non-annual ash excavation cost 115132 c.y. @ \$ 2.35944 /c.y. = \$ 271647 in year 2004
 Non-annual ash excavation cost 23026 c.y. @ \$ 2.35944 /c.y. = \$ 54328.46 in year 2009

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TABLE 2.5
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	135,140	1.0000	135,140
1981	135,140	0.9775	132,099
1982	135,140	0.9555	129,126
1983	135,140	0.9341	126,234
1984	135,140	0.9131	123,396
1985	135,140	0.8925	120,612
1986	135,140	0.8725	117,910
1987	135,140	0.8528	115,247
1988	135,140	0.8337	112,666
1989	135,140	0.8149	110,126
1990	135,140	0.7966	107,653
1991	135,140	0.7787	105,234
1992	135,140	0.7612	102,869
1993	788,505	0.7441	586,727
1994	135,140	0.7273	98,287
1995	135,140	0.7110	96,085
1996	135,140	0.6950	93,922
1997	135,140	0.6794	91,814
1998	135,140	0.6641	89,746
1999	406,787	0.6492	264,086
2000	135,140	0.6346	85,760
2001	135,140	0.6203	83,827
2002	135,140	0.6064	81,949
2003	135,140	0.5927	80,097
2004	406,787	0.5794	235,692
2005	135,140	0.5664	76,545
2006	135,140	0.5536	74,814
2007	135,140	0.5412	73,138
2008	135,140	0.5290	71,489
2009	189,468	0.5171	97,974
2010	135,140	0.5055	68,313
2011	135,140	0.4941	66,773
2012	135,140	0.4830	65,273
2013	135,140	0.4722	63,813
2014	135,140	0.4616	62,381

Total Present Worth of Future Costs :			\$4,146,815
Sum of Present Worth Factors :			24.4103
Levelized O&M Cost = (Present Worth of all O&M Costs) / (Sum of Present Worth Factors)			
LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST			\$169,880

[Plant # 12]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 12

Levelized Capital Cost

\$146,040

Levelized Operation and Maintenance Costs

\$169,880

Total Levelized Revenue Requirement

\$315,920

Levelized Revenue Requirement per Ton of Waste Disposed

\$8.86

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$7.67

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of ground-water monitoring wells around the emergency fly ash disposal area. Once the existing disposal area is filled, a one foot clay cap will be placed over the area. The new ash landfill (Figure 2.2) would be constructed with a clay liner and cap to minimize leachate migration. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes, would continue to be discharged to the wastewater treatment plant.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge

FIGURE 3.1

NON-HAZARDOUS HANDLING & DISPOSAL

▨ Operation Activity
■ Construction Activity

PLANT 12

rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5.

A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

TABLE 3.1

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 12

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	1249 MW
Generating capacity of largest boiler	417 MW

Waste Production Information*

Fly ash	13986 dry ton/yr
Bottom Ash	21769 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	48 lb/cu ft
Bottom ash	61.7 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 3.2

NON-HAZARDOUS CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1984

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
<hr/>				
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.
<hr/>				
Closure Cost			\$0.	
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
<hr/>				
* Site cost adjustment factor (SCAF)= 1.017				
Site Unit cost= SCAF x National Average Unit Cost				
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TABLE 3.2 (continued)

Construction Cost Items for Period 2 1985 - 1992				
ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
<hr/>				
groundwater monitoring wells	405 (14)		12.20	4,943
CONSTRUCTION COST TOTAL				\$4,943
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items =	\$4,943 x 0.50 =			\$2,471
CONSTRUCTION CAPITAL REQUIREMENT =				\$7,414
<hr/>				
Closure Cost			\$0.	
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
<hr/>				
* Site cost adjustment factor (SCAF) = 1.017				
Unit cost = SCAF x National Average Unit Cost				
<hr/>				

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TABLE 3.2 (continued)

Construction Cost Items for Period 3
1993 - 1997

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
clear and grub	50	[acres]	1,337	66,868
final grading	50	[acres]	554	27,713
borrow material import	125,791	[cy]	7.53	946,678
topsoil removal & stockpile	77,440	[cy]	1.55	119,710
clay liner/cap placement	96,800	[cy]	4.78	462,694
clay import	96,800	[cy]	5.09	492,228
seeding and mulching -grass	49,835	[sy]	0.43	21,287
riprap, grouted	3,520	[sy]	77.98	274,582
soil borings	500	[lf]	15.26	7,628
groundwater monitoring wells	200	[lf]	12.20	2,441

CONSTRUCTION COST TOTAL**\$2,421,746.**

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%

Other Capital Items = \$2,421,746. x 0.50 =

\$1,210,874.

CONSTRUCTION CAPITAL REQUIREMENT =**\$3,632,623.****Closure Cost****\$484,766****CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)****\$527,149**

* Site cost adjustment factor (SCAF)= 1.017

Site Unit cost= SCAF x National Average Unit Cost

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TABLE 3.2 (continued)

Construction Cost Items for Period 4
 1998 - 2014

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	\$1,789,926.			
--------------	--------------	--	--	--

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)	\$2,684,889.			
---	--------------	--	--	--

* Site cost adjustment factor (SCAF) = 1.017
 Site Unit cost = SCAF x National Average Unit Cost

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TABLE 3.3
NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations
 Nominal Return : 8.4 %
 Inflation Rate : 6.0 %
 Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	7,414	0	0.9131	6,770
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	3,632,623	0	0.7612	2,765,153
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	607,149	0.6641	403,208
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	2,684,880	0.4512	1,211,418

Total Present Worth of Future Capital Expenditures :

\$4,386,548

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$324,605

[Plant # 12]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTS

Costs for Period 1
1980 to 1984

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	13,908	3.56	49,506	Dry disposal
Bottom ash	21,769	2.54	55,348	Wet disposal
Total handling			104,853	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	13,908	2.52	6,931	open on road truck (16cy) 1 mi. haul
Total transportation			6,931	
Landfill costs				
Flyash	13,908	1.68	23,356	
Total landfill cost			23,356	
Annual operation and maintenance cost			\$135,140	

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TABLE 3.4 (continued)

O&M Costs for Period 2
1985 to 1992

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	13,908	3.56	49,506	Dry disposal
Bottom ash	21,769	2.54	55,348	Wet disposal
Total handling			104,853	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	13,908	0.50	6,931	open on road truck (16cy) 1 mi. haul
Total transportation			6,931	
Landfill costs				
Flyash	13,908	1.68	23,356	
Total landfill cost			23,356	
Groundwater monitoring			9,954	
Annual operation and maintenance cost			\$145,093	

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TABLE 3.4 (continued)

O&M Costs for Period 3
1993 to 1997

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	13,908	3.56	49,506	Dry disposal
Bottom ash	21,769	2.54	55,348	Wet disposal
Total handling			104,853	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	13,908	0.50	6,931	open on road truck (16cy) 1 mi. haul
Total transportation			6,931	
Landfill costs				
Flyash	13,908	1.68	23,356	
Total landfill cost			23,356	
Groundwater monitoring			12,894	

Annual operation and maintenance cost \$148,033
 Non-annual ash excavation cost 287240 c.y. @ \$ 3.1527 /c.y = \$ 653365.5 in year 1993

[12011-26-1982001:42:20]

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TABLE 3.4 (continued)

O&M Costs for Period 4
1998 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	13,908	3.56	49,506	Dry disposal
Bottom ash	21,769	2.54	55,348	Wet disposal
Total handling			104,853	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	13,908	0.50	6,931	open on road truck (16cy) 1 mi. haul
Total transportation			6,931	
<u>Landfill costs</u>				
Flyash	13,908	1.68	23,356	
Total landfill cost			23,356	
Groundwater monitoring			12,894	

Annual operation and maintenance cost \$148,033
 Non-annual ash excavation cost 115132 c.y. @ \$ 2.35944 /c.y = \$ 271647 in year 1999
 Non-annual ash excavation cost 115132 c.y. @ \$ 2.35944 /c.y = \$ 271647 in year 2004
 Non-annual ash excavation cost 23026 c.y. @ \$ 2.35944 /c.y = \$ 54328.46 in year 2009

[12011-26-1982021:42:20]

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TABLE 3.5
NON-HAZARDOUS 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	135,140	1.0000	135,140
1981	135,140	0.9775	132,099
1982	135,140	0.9555	129,126
1983	135,140	0.9341	126,234
1984	135,140	0.9131	123,396
1985	145,093	0.8925	129,496
1986	145,093	0.8725	126,594
1987	145,093	0.8528	123,735
1988	145,093	0.8337	120,964
1989	145,093	0.8149	118,236
1990	145,093	0.7966	115,581
1991	145,093	0.7787	112,984
1992	145,093	0.7612	110,445
1993	801,399	0.7441	596,321
1994	148,033	0.7273	107,664
1995	148,033	0.7110	105,251
1996	148,033	0.6950	102,883
1997	148,033	0.6794	100,574
1998	148,033	0.6641	98,309
1999	419,680	0.6492	272,456
2000	148,033	0.6346	93,942
2001	148,033	0.6203	91,825
2002	148,033	0.6064	89,767
2003	148,033	0.5927	87,739
2004	419,680	0.5794	243,163
2005	148,033	0.5664	83,846
2006	148,033	0.5536	81,951
2007	148,033	0.5412	80,115
2008	148,033	0.5290	78,309
2009	202,362	0.5171	104,641
2010	148,033	0.5055	74,831
2011	148,033	0.4941	73,143
2012	148,033	0.4830	71,500
2013	148,033	0.4722	69,901
2014	148,033	0.4616	68,332

Total Present Worth of Future Costs :

\$4,380,495

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$179,453

[Plant # 12]

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 12

Levelized Capital Cost

\$324,605

Levelized Operation and Maintenance Costs

\$179,453

Total Levelized Revenue Requirement

\$504,058

Levelized Revenue Requirement per Ton of Waste Disposed

\$14.13

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$12.23

SECTION 4

HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

The proposed design consists of acquiring a tract of land approximately five miles from the power plant. For the purpose of this analysis, it has been determined that it will be most cost effective in the future if dry handling systems are utilized for the disposal of the bottom ash from Units 1, 2 and 3. In the future, all fly ash, bottom slag and ash, and FGD sludge will be trucked to the new landfill. Leachate treatment facilities are provided and were sized based on a 10-year, 24-hour rainfall event falling on half the area of one open cell. Internal cell diking will preclude contamination of all storm water runoff. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes could be used to moisture condition the ash before placement in the landfill or could continue to be discharged to the wastewater treatment plant.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

Design FactorHazardous MinimumHazardous Maximum

1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities
2. Liner System	Use a single liner system as specified in the EPA guidance documents	Use a double liner system as specified in the EPA guidance documents

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. It was assumed that because of RCRA restrictions ash, slag and sludge would no longer be able to be sold for other uses. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed cells on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Figure 4.1 is a layout of the eight cells which are proposed for ash disposal under the hazardous waste scenario. Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980

PROPOSED HAZARDOUS WASTE DISPOSAL SITES

HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION ⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.2

HAZARDOUS MAXIMUM LANDFILL - TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FROST/THAW PROTECTION.

dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life. "levelized" estimate of annual revenue requirements.

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 12

Design Mode: Hazardous Min

Date 101-19-1982

Power Plant Information (1980)

Generating capacity of plant	1249 mw
Generating capacity of largest boiler	417 mw

Waste Production Information *

Fly ash	162758 dry ton/yr
** Bottom Ash	228489 dry ton/yr
FGD sludge	156200 dry ton/yr
Waste densities (as disposed)	
Fly ash	58 lb/cu ft
Bottom ash	98 lb/cu ft
FGD sludge	90 lb/cu ft

General Disposal Site Information

Site area	856 acres
Percent heavily wooded	10 %
Percent lightly wooded	30 %
Site perimeter	25200 ft
Distance to plant	5 mi
Distance to main road	2000 ft
Distance from disposal site to leachate treatment plant	4000 ft
Thickness of soils above bedrock	65 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	10 ft

Construction Materials

Clay availability on-site	no
Clay import distance	10 mi
Sand availability on-site	yes

Climatic Information

Maximum frost penetration	0 in
Total annual precipitation	52.38 in
10-yr, 24-hr rainfall event	8 in

* note: Average for period 1980- 2014 . If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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** Note: Bottom ash quantity includes 206,720 tons of boiler slag.

TABLE 4.2

HAZARDOUS MIN CELL GEOMETRY

Number of cells	8
Cell volume	2229231 cu yd
Depth of waste at edge of fill	35 ft
Cell dimensions	
length at top	2283 ft
width at top	761 ft
length at bottom	2143 ft
width at bottom	621 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	14900 ft

**Disposal Cell Cross-Section
Dry Landfill w/ Single Liner**

NOTE: Datum is below existing ground surface an average of 5 feet at this site

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980- 2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	856	[acres]	4,000	3,424,000
clear and grub	682	[acres]	1,337	912,673
heavy stump removal	68	[acres]	915	62,464
light stump removal	205	[acres]	549	112,436
final grading	514	[acres]	554	284,671
cut & fill non-compacted	2,650,132	[cy]	1.55	4,096,680
borrow material import	4,438,364	[cy]	7.53	33,402,240
topsoil removal & stockpile	1,188,519	[cy]	1.55	1,837,260
sand collection zone p/cant	1,343,109	[cy]	8.96	12,033,948
clay liner/cap placement	1,307,023	[cy]	4.78	6,247,439
clay import	1,307,023	[cy]	5.09	6,646,212
synthetic membrane	29,260,450	[sf]	0.57	16,664,411
seeding and mulching -grass	2,485,824	[sy]	0.43	1,061,795
gravel stabilization	3,967	[sy]	0.71	2,824
plastic filter fabric	3,251,161	[sy]	0.73	2,380,630
light duty bituminous road	14,494	[lf]	12.90	186,900
heavy duty bituminous road	2,000	[lf]	16.92	33,846
perimeter fencing	25,200	[ft]	12.20	307,541
plastic pipe, pvc-4"	85,171	[lf]	10.12	861,862
plastic pipe, pvc-6"	40,528	[lf]	14.57	590,639
leachate collect sumps	2,160	[lf]	95.60	206,492
soil borings	7,704	[lf]	15.26	117,525
groundwater monitoring wells	596	[lf]	12.20	7,274
CELL CONSTRUCTION COST SUBTOTAL				\$91,481,700.
Leachate Treatment Plant Construction Cost				\$3,011,531.
Wet-to-dry conversion cost of bottom ash				\$2,475,120.
No Wet-to-Dry Conversion for FGD				
Construction Cost for Closure of Existing Disposal Site(s)				\$678,339
CONSTRUCTION COST TOTAL				\$97,646,760.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
50%				
Other Capital Items = \$97,646,760. x 0.50 =				\$48,823,380.
Permitting Cost				\$250,000
TOTAL CAPITAL REQUIREMENT =				\$146,720,100.

* Site Cost Adjustment Factor (SCAF) = 1.017
 Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.4

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

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YEAR OF EXPENDITURE	EXPENDITURE IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH EXPRESSED IN 1980 \$
1980	26,650,320	1.0000	26,650,320
1984	17,152,830	0.9131	15,662,249
1989	17,152,830	0.8149	13,977,841
1993	17,152,830	0.7441	12,763,421
1998	17,152,830	0.6641	11,391,194
2002	17,152,830	0.6064	10,401,476
2006	17,152,830	0.5536	9,495,807
2011	17,152,830	0.4941	8,475,213
Total Cap Exp	\$146,720,130		
Present Worth of all Capital Costs			\$108,817,522
Total Levelizing Factor (LF) =		0.0740	
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$8,052,497

[Plant # 12]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	162,758	3.56	579,337	Dry disposal
Bottom ash	228,489	3.56	813,307	Dry disposal
F6D	156,200	10.12	1,581,440	Dry disposal
Total handling			2,974,084	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	162,758	1.24	201,756	open on road truck (16cy) 5 mi. haul
Bottom ash	228,489	1.24	283,237	open on road truck (16cy) 5 mi. haul
F6D	156,200	1.24	193,627	open on road truck (16cy) 5 mi. haul
Total transportation			678,621	
Landfill costs				
Flyash	162,758	1.37	222,979	
Bottom ash	228,489	0.82	187,361	
F6D	156,200	0.90	140,580	
Total landfill cost			550,920	
Leachate Treatment Plant O and M			\$264,826	
Total non-administrative O and M			\$4,471,568	

Administrative O&M Cost Items

Manifesting	\$22,594
Groundwater monitoring	\$28,832
Inspection	\$10,534
Personnel training	\$1,220
Non-sudden occurrence insurance	\$41,985
General administration	\$69,262
Total Annual Administration cost	\$174,427
Total annual operation and maintenance cost	\$4,645,987

Post closure O&M costs

Existing site (1980-2010)	\$22,400
New site	
Groundwater monitoring	\$57,664
Inspection	\$21,067
Maintenance	\$73,450
Administrative services	\$5,695
Total annual post closure cost (2014 - 2044)	\$157,876

TABLE 4.6

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	4,668,387	1.0000	4,668,387	Begin post closure operation and maintenance of existing site
1981	4,668,387	0.9775	4,563,348	
1982	4,668,387	0.9555	4,460,644	
1983	4,668,387	0.9341	4,360,740	
1984	4,668,387	0.9131	4,262,704	End post closure operation and maintenance of existing site
1985	4,668,387	0.8925	4,166,535	
1986	4,668,387	0.8725	4,073,168	
1987	4,668,387	0.8528	3,981,200	
1988	4,668,387	0.8337	3,892,034	
1989	4,668,387	0.8149	3,804,269	
1990	4,668,387	0.7966	3,718,837	
1991	4,668,387	0.7787	3,635,273	
1992	4,668,387	0.7612	3,553,576	
1993	4,668,387	0.7441	3,473,747	
1994	4,668,387	0.7273	3,395,318	
1995	4,668,387	0.7110	3,319,223	
1996	4,668,387	0.6950	3,244,529	
1997	4,668,387	0.6794	3,171,702	
1998	4,668,387	0.6641	3,100,276	
1999	4,668,387	0.6492	3,030,717	Begin post closure operation and maintenance
2000	4,668,387	0.6346	2,962,558	
2001	4,668,387	0.6203	2,895,800	
2002	4,668,387	0.6064	2,830,910	
2003	4,668,387	0.5927	2,766,953	
2004	4,668,387	0.5794	2,704,863	
2005	4,668,387	0.5664	2,644,174	
2006	4,668,387	0.5536	2,584,419	
2007	4,668,387	0.5412	2,526,531	
2008	4,668,387	0.5290	2,469,577	
2009	4,668,387	0.5171	2,414,023	End post closure operation and maintenance of existing site
2010	4,668,387	0.5055	2,359,870	
2011	4,645,987	0.4941	2,295,582	
2012	4,645,987	0.4830	2,244,012	
2013	4,645,987	0.4722	2,193,835	Begin post closure operation and maintenance
2014	4,645,987	0.4616	2,144,588	
2015	157,876	0.4512	71,234	
2016	157,876	0.4410	69,623	
2017	157,876	0.4311	68,060	
2018	157,876	0.4214	66,529	
2019	157,876	0.4120	65,045	End post closure operation and maintenance of existing site
2020	157,876	0.4027	63,577	
2021	157,876	0.3936	62,140	
2022	157,876	0.3848	60,751	
2023	157,876	0.3761	59,377	
2024	157,876	0.3677	58,051	
2025	157,876	0.3594	56,741	

(continued next page)

[Plant # 12]

TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$
2026	157,876	0.3513	55,462
2027	157,876	0.3434	54,215
2028	157,876	0.3357	52,999
2029	157,876	0.3282	51,815
2030	157,876	0.3208	50,647
2031	157,876	0.3136	49,510
2032	157,876	0.3065	48,389
2033	157,876	0.2996	47,300
2034	157,876	0.2929	46,242
2035	157,876	0.2863	45,200
2036	157,876	0.2799	44,189
2037	157,876	0.2736	43,195
2038	157,876	0.2674	42,216
2039	157,876	0.2614	41,269
2040	157,876	0.2555	40,337
2041	157,876	0.2498	39,437
2042	157,876	0.2442	38,553
2043	157,876	0.2387	37,685
2044	157,876	0.2333	36,832

End post closure operation
and maintenance

Total Present Worth of Future Costs :

\$115,480,542

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

\$3,363,504

[Plant # 12]

Page 2

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 12

Levelized Capital Cost

\$8,052,497

Levelized Operation and Maintenance Costs

\$3,363,504

Total Levelized Revenue Requirement

\$11,416,001

Levelized Revenue Requirement per Ton of Waste Disposed

\$20.85

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$22.43

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 12

Design Mode: Hazardous Max

Date 101-19-1982

Power Plant Information (1980)

Generating capacity of plant	1249 MW
Generating capacity of largest boiler	417 MW

Waste Production Information *

Fly ash	162758 dry ton/yr
Bottom Ash **	228489 dry ton/yr
FGD sludge	156200 dry ton/yr
Waste densities (as disposed)	
Fly ash	58 lb/cu ft
Bottom ash	98 lb/cu ft
FGD sludge	90 lb/cu ft

General Disposal Site Information

Site area	856 acres
Percent heavily wooded	10 %
Percent lightly wooded	30 %
Site perimeter	25200 ft
Distance to plant	5 mi
Distance to main road	2000 ft
Distance from disposal site to leachate treatment plant	4000 ft
Thickness of soils above bedrock	65 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	10 ft

Construction Materials

Clay availability on-site	no
Clay import distance	10 mi
Sand availability on-site	yes

Climatic Information

Maximum frost penetration	0 in
Total annual precipitation	52.38 in
10-yr, 24-hr rainfall event	8 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

[12001-19-1982018:45:42]

page 1 of 7

** note: Bottom ash quantity includes 206,720 tons of boiler slag.

TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	8
Cell volume	2229231 cu yd
Depth of waste at edge of fill	35 ft
Cell dimensions	
length at top	2283 ft
width at top	761 ft
length at bottom	2143 ft
width at bottom	621 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	14900 ft

**Disposal Cell Cross-Section
Dry Landfill w/ Double Liner**

NOTE: Datum is below existing ground surface an average of 5 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS

Construction Cost Items (1980- 2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	856 [acres]		4,000	3,424,000
clear and grub	682 [acres]		1,337	912,673
heavy stump removal	68 [acres]		915	62,464
light stump removal	205 [acres]		549	112,436
final grading	514 [acres]		554	284,671
cut & fill non-compacted	2,971,521 [cy]		1.55	4,593,496
borrow material import	5,069,127 [cy]		7.53	38,149,236
topsoil removal & stockpile	1,209,115 [cy]		1.55	1,869,098
sand collection zone p/cmt	1,639,783 [cy]		8.96	14,692,079
clay liner/cap placement	2,633,609 [cy]		4.78	12,586,388
clay import	2,633,609 [cy]		5.07	13,391,902
synthetic membrane	29,540,290 [sf]		0.57	16,823,786
seeding and mulching -grass	2,485,824 [sy]		0.43	1,061,795
gravel stabilization	3,967 [sy]		0.71	2,824
plastic filter fabric	3,282,254 [sy]		0.73	2,403,398
light duty bituminous road	14,494 [lf]		12.90	186,908
heavy duty bituminous road	2,000 [lf]		16.92	33,846
perimeter fencing	25,200 [ft]		12.20	307,541
plastic pipe, pvc-4"	170,343 [lf]		10.12	1,723,724
plastic pipe, pvc-6"	81,056 [lf]		14.57	1,181,279
leachate collect sumps	2,160 [lf]		95.60	206,492
soil borings	7,704 [lf]		15.26	117,525
groundwater monitoring wells	596 [lf]		12.20	7,274
CELL CONSTRUCTION COST SUBTOTAL				\$114,136,900.
Leachate Treatment Plant Construction Cost				\$3,011,531.
Wet-to-dry conversion cost of Bottom ash				\$2,475,120.
No Wet-to-Dry Conversion for FGD				
Construction Cost for Closure of Existing Disposal Site(s)				\$1,313,964.
CONSTRUCTION COST TOTAL				\$120,937,500.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
50%				
Other Capital Items = \$120,937,500. x 0.50 =				\$60,468,750.
Permitting Cost				\$500,000
TOTAL CAPITAL REQUIREMENT =				\$181,906,200.

* Site Cost Adjustment Factor (SCAF) = 1.017
 Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.11

HAZARDOUS MAX 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	32,101,580	1.0000	32,101,580
1984	21,400,660	0.9131	19,540,943
1989	21,400,660	0.8149	17,439,398
1993	21,400,660	0.7441	15,924,231
1998	21,400,660	0.6641	14,212,178
2002	21,400,660	0.6064	12,977,360
2006	21,400,660	0.5536	11,847,405
2011	21,400,660	0.4941	10,574,066

Total Cap Exp \$181,906,200

Present Worth of all Capital Costs \$134,617,162

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST \$9,961,670

[Plant # 12]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	162,758	3.56	579,337	Dry disposal
Bottom ash	228,489	3.56	813,307	Dry disposal
FGD	156,200	10.12	1,581,440	Dry disposal
Total handling			2,974,084	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	162,758	1.24	201,756	open on road truck (16cy) 5 mi. haul
Bottom ash	228,489	1.24	283,237	open on road truck (16cy) 5 mi. haul
FGD	156,200	1.24	193,627	open on road truck (16cy) 5 mi. haul
Total transportation			678,621	
<u>Landfill costs</u>				
Flyash	162,758	1.39	226,196	
Bottom ash	228,489	0.62	187,936	
FGD	156,200	0.90	139,897	
Total landfill cost			554,030	
Leachate Treatment Plant O and M			\$264,826	
Total non-administrative O and M			\$4,471,568	

Administrative O&M Cost Items

Manifesting	\$22,594
Groundwater monitoring	\$28,832
Inspection	\$10,534
Personnel training	\$1,220
Non-sudden occurrence insurance	\$41,985
General administration	\$69,262
Total Annual Administration cost	\$174,427
Total annual operation and maintenance cost	\$4,645,987

Post closure O&M costs

Existing site (1980-2010)	\$22,400
New site	
Groundwater monitoring	\$57,664
Inspection	\$21,067
Maintenance	\$73,450
Administrative services	\$5,695
Total annual post closure cost (2014 - 2044)	\$157,676

TABLE 4.13
HAZARDOUS MAX 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	4,668,387	1.0000	4,668,387	Begin post closure operation and maintenance of existing site
1981	4,668,387	0.9775	4,563,348	
1982	4,668,387	0.9555	4,460,644	
1983	4,668,387	0.9341	4,360,740	
1984	4,668,387	0.9131	4,262,704	
1985	4,668,387	0.8925	4,166,535	
1986	4,668,387	0.8725	4,073,168	
1987	4,668,387	0.8528	3,981,200	
1988	4,668,387	0.8337	3,892,034	
1989	4,668,387	0.8149	3,804,269	
1990	4,668,387	0.7966	3,718,837	
1991	4,668,387	0.7787	3,635,273	
1992	4,668,387	0.7612	3,553,576	
1993	4,668,387	0.7441	3,473,747	
1994	4,668,387	0.7273	3,395,318	
1995	4,668,387	0.7110	3,319,223	
1996	4,668,387	0.6950	3,244,529	
1997	4,668,387	0.6794	3,171,702	
1998	4,668,387	0.6641	3,100,276	
1999	4,668,387	0.6492	3,030,717	End post closure operation and maintenance of existing site
2000	4,668,387	0.6346	2,962,558	
2001	4,668,387	0.6203	2,895,800	
2002	4,668,387	0.6064	2,830,910	
2003	4,668,387	0.5927	2,766,953	
2004	4,668,387	0.5794	2,704,863	
2005	4,668,387	0.5664	2,644,174	
2006	4,668,387	0.5536	2,584,419	
2007	4,668,387	0.5412	2,526,531	
2008	4,668,387	0.5290	2,469,577	
2009	4,668,387	0.5171	2,414,023	
2010	4,668,387	0.5055	2,359,870	
2011	4,645,987	0.4941	2,295,582	Begin post closure operation and maintenance
2012	4,645,987	0.4830	2,244,012	
2013	4,645,987	0.4722	2,193,835	
2014	4,645,987	0.4616	2,144,588	
2015	157,876	0.4512	71,234	
2016	157,876	0.4410	69,623	
2017	157,876	0.4311	68,060	
2018	157,876	0.4214	66,529	
2019	157,876	0.4120	65,045	
2020	157,876	0.4027	63,577	
2021	157,876	0.3936	62,140	
2022	157,876	0.3848	60,751	
2023	157,876	0.3761	59,377	
2024	157,876	0.3677	58,051	
2025	157,876	0.3594	56,741	

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TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	157,876	0.3513	55,462	
2027	157,876	0.3434	54,215	
2028	157,876	0.3357	52,999	
2029	157,876	0.3282	51,815	
2030	157,876	0.3208	50,647	
2031	157,876	0.3136	49,510	
2032	157,876	0.3065	48,389	
2033	157,876	0.2996	47,300	
2034	157,876	0.2929	46,242	
2035	157,876	0.2863	45,200	
2036	157,876	0.2799	44,189	
2037	157,876	0.2736	43,195	
2038	157,876	0.2674	42,216	
2039	157,876	0.2614	41,269	
2040	157,876	0.2555	40,337	
2041	157,876	0.2498	39,437	
2042	157,876	0.2442	38,553	
2043	157,876	0.2387	37,685	
2044	157,876	0.2333	36,832	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$115,480,542	
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			\$3,363,504	

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 12

Levelized Capital Cost

\$9,961,670

Levelized Operation and Maintenance Costs

\$3,363,504

Total Levelized Revenue Requirement

\$13,325,174

Levelized Revenue Requirement per Ton of Waste Disposed

\$24.34

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$26.17

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 146,000	\$ 170,000	\$ 316,000	\$ 8.86	\$ 7.67
Non-Hazardous	325,000	179,000	504,000	14.13	12.23
Hazardous Minimum	8,052,000	3,363,000	11,416,000	20.85	22.43
Hazardous Maximum	9,962,000	3,363,000	13,325,000	24.34	26.17

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data 1980, Kingston, MA.

RCRA Impact
Case Study of Plant 13

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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal in the utility industry. These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 13 is located in northwest Georgia and has a current nameplate generating capacity of 3,160 MW. The plant has four pulverized coal-fired, dry-bottom boilers. Fuel oil is used for start-up and combustion stabilization.

Bituminous coal for the plant is obtained from Kentucky. Coal is transported to the facility by unit train. Normally a 120-day supply of coal is maintained on-site. Coal consumption for 1980 was 7,171,107 tons. The average analysis of the coal consumed during 1980 was 1.7 percent sulfur, 11.0 percent ash, and 11,980 BTU's/lb. The projected 1985 and 2000 rates of coal consumption are 7,200,000 tons per year.

Each of the boilers is equipped with an electrostatic precipitator (ESP). Particulate removal for these units is estimated to fall between 98.5 and 99.0 percent. The units are to be upgraded by 1983 so that all units will meet the Federal and state emission limits. Table 1.1 summarizes plant characteristics including year of boiler start-up, 1980 capacity factor, coal used, and air pollution control equipment.

EXISTING DISPOSAL

The schematic flow diagram of the existing disposal facilities for the plant is shown in Figure 1.2. The quantities of major waste materials generated are summarized in Table 1.2.

Fly ash from all units is collected dry and transferred pneumatically to storage silos or is slurried and wet sluiced to ash disposal pond (See Figure 1.3). The bottom ash is sluiced to the ash pond. To optimize the life of the pond, ash periodically is relocated to the far reaches of the pond by dredging.

Fly ash has been sold commercially. Bottom ash has been used internally and is scheduled to be sold in the future.

In addition to the fly ash and bottom ash, the ash pond receives direct discharge from the coal pile runoff collection system, domestic sewage treatment plant, floor and roof drains. Blowdown from the cooling towers goes directly to the plant discharge drain where it passes through a neutralization and monitoring system. The decant water from the ash pond is recycled.

SCHEMATIC FLOW DIAGRAM

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 13

Boiler	Stack	MW (Nameplate)	Year of Start-up	1980 Capacity Factor	1980 Coal Used (tons)	1985 Coal Projections (tons)	2000 Coal Projections (tons)	Type of Control	
								Particulate	SO ₂
1	1	700	1971	87.5	1,585,287	1,600,000	1,600,000	ESP	None
2	1	700	1972	73.5	1,357,423	1,600,000	1,600,000	ESP	None
3	2	880	1974	73.1	2,123,786	2,000,000	2,000,000	ESP	None
4	2	880	1975	73.0	2,104,611	2,000,000	2,000,000	ESP	None
TOTALS		3,160			7,171,107	7,200,000	7,200,000		

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TABLE 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 13

Waste Product	1980 Values	1985 Values	2000 Values	35-Year Average*
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	631,000	634,000	634,000	633,740
Tons Sold	<u>147,100</u>	<u>150,000</u>	<u>150,000</u>	<u>149,750</u>
Tons Disposed	493,900	484,000	484,000	483,990
<u>Bottom Ash (Dry Weight)</u>				
Tons Produced	157,760	158,000	158,000	157,980
Tons Sold	<u>0</u>	<u>126,000</u>	<u>126,000</u>	<u>115,200</u>
Tons Disposed	157,760	32,000	32,000	42,780

* Average is for 1980 - 2014, assuming that the 2000 values remain constant through 2014.

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates.

In 1980, the existing ash pond had a remaining life of 10 years. To provide sufficient ash disposal capacity over the 35 year design period, it was necessary to construct a new ash pond at a location approximately one half mile from the power plant.

The proposed design consists of acquiring a tract of land and clearing and regrading the area as necessary before waste materials deposition. Figure 2.2 illustrates the location of the new disposal pond which would be constructed in 1989. The perimeter dike (Figure 2.3) would be constructed entirely of compacted clay soils which are available on-site. A six-inch layer of topsoil would be placed and compacted on the slopes of the dikes. The slopes would be seeded to produce a thick ground cover which would provide erosion protection of the dike. Site grading would allow runoff from the surrounding area to drain around the ash pond. Construction of the new pond will require rerouting of the piping systems for the various water collection systems

CURRENT PRACTICE HANDLING & DISPOSAL

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PROPOSED PERIMETER DIKE - TYPICAL SECTION

2-4

PLANT 13

Not To Scale

FIGURE 2.3

and ash conveying lines. Miscellaneous low volume wastes, e.g. coal pile runoff, etc., currently generated by the plant would continue to be sent to the ash pond.

At closure, a proposed 6-inch layer of topsoil would be placed and compacted on the disposal areas. These areas would be seeded to establish a vegetative cover to control erosion.

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 13

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	3160 MW
Generating capacity of largest boiler	880 MW

Waste Production Information*

Fly ash	483990 dry ton/yr
Bottom Ash	42780 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	65 lb/cu ft
Bottom ash	65 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 2.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1989

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 \$1,205,381.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items) \$1,808,072.

* Site cost adjustment factor (SCAF) = .99

Site Unit cost = SCAF x National Average Unit Cost

[13#11-15-1982#02:51:21]

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TABLE 2.2 (continued)

Construction Cost Items for Period 2 1990 - 2014

ITEM	QUANTITY	UNIT	UNIT+ COST	EXTENSION
real estate	602	[acres]	2,970	1,787,940
clear and grub	50	[acres]	1,302	65,093
light stump removal	50	[acres]	535	26,730
cut & fill non-compacted	50,300	[cy]	1.50	75,450
on-site structural cut/fill	1,046,476	[cy]	2.37	2,476,067
topsoil placement & grading	116,000	[cy]	1.67	194,000
topsoil removal & stockpile	116,000	[cy]	1.50	174,557
seeding and mulching -grass	310,000	[sy]	0.42	128,898
gravel stabilization	23,335	[sy]	0.69	16,171
gravel roadways	16,000	[lf]	2.99	47,837
drainage cap-48"	704	[lf]	46.98	33,071
fibercast pipe 8"	77,627	[lf]	36.23	2,812,737
steel pipe -12"	80,411	[lf]	45.34	3,661,717
miscellaneous structures	896,490	[ls]	0.55	867,525
miscellaneous concrete	119,530	[ls]	0.99	118,433
soil borings	1,300	[lf]	14.85	19,305

CONSTRUCTION COST TOTAL

\$12,526,100.

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%

Other Capital Items = \$12,526,100. x 0.50 =

\$6,263,051.

CONSTRUCTION CAPITAL REQUIREMENT =

\$18,789,150.

Closure Cost

\$2,493,889.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$3,740,834.

* Site cost adjustment factor (SCAF) = .99

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 2.3
CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	0	0	0.9131	0
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	18,789,150	0	0.8149	15,311,278
1990	0	1,808,072	0.7966	1,440,310
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	3,740,834	0.4512	1,687,864

Total Present Worth of Future Capital Expenditures :

\$18,439,453

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$1,364,520

[Plant # 13]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1989

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	483,990	2.48	1,197,875	Wet disposal
Bottom ash	42,780	2.48	105,881	Wet disposal
Total handling			1,303,756	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Annual operation and maintenance cost			\$1,303,756	

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TABLE 2.4 (continued)

O&M Costs for Period 2
1990 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	483,990	2.48	1,197,875	Wet disposal
Bottom ash	42,780	2.48	105,881	Wet disposal
Total handling			1,303,756	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Total transportation			none	
<u>Landfill costs</u>				
Total landfill cost			none	
Annual operation and maintenance cost			\$1,303,756	

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TABLE 2.5
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	1,303,756	1.0000	1,303,756
1981	1,303,756	0.9775	1,274,421
1982	1,303,756	0.9555	1,245,739
1983	1,303,756	0.9341	1,217,838
1984	1,303,756	0.9131	1,190,460
1985	1,303,756	0.8925	1,163,602
1986	1,303,756	0.8725	1,137,527
1987	1,303,756	0.8528	1,111,843
1988	1,303,756	0.8337	1,086,941
1989	1,303,756	0.8149	1,062,431
1990	1,303,756	0.7966	1,038,572
1991	1,303,756	0.7787	1,015,235
1992	1,303,756	0.7612	992,419
1993	1,303,756	0.7441	970,125
1994	1,303,756	0.7273	948,222
1995	1,303,756	0.7110	926,971
1996	1,303,756	0.6950	906,110
1997	1,303,756	0.6794	885,772
1998	1,303,756	0.6641	865,824
1999	1,303,756	0.6492	846,398
2000	1,303,756	0.6346	827,364
2001	1,303,756	0.6203	808,720
2002	1,303,756	0.6064	790,598
2003	1,303,756	0.5927	772,736
2004	1,303,756	0.5794	755,396
2005	1,303,756	0.5664	738,447
2006	1,303,756	0.5536	721,759
2007	1,303,756	0.5412	705,523
2008	1,303,756	0.5290	689,687
2009	1,303,756	0.5171	674,172
2010	1,303,756	0.5055	659,049
2011	1,303,756	0.4941	644,186
2012	1,303,756	0.4830	629,714
2013	1,303,756	0.4722	615,534
2014	1,303,756	0.4615	601,814

Total Present Worth of Future Costs :

\$31,825,075

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$1,303,756

[Plant # 13]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 13

Levelized Capital Cost

\$1,364,520

Levelized Operation and Maintenance Costs

\$1,303,756

Total Levelized Revenue Requirement

\$2,668,276

Levelized Revenue Requirement per Ton of Waste Disposed

\$5.06

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$4.44

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of ground-water monitoring wells around the existing ash pond. The new ash pond (Figure 2.2) would be constructed with a clay liner and cap to minimize leachate migration. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes, would continue to be discharged to the ash pond.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

NON-HAZARDOUS HANDLING & DISPOSAL

FIGURE 3.1

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5. A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

TABLE 3.1

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 13

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	3160 mw
Generating capacity of largest boiler	880 mw

Waste Production Information*

Fly ash	483990 dry ton/yr
Bottom Ash	42780 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	65 lb/cu ft
Bottom ash	65 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 3.2

NON-HAZARDOUS CAPITAL COSTSConstruction Cost Items for Period 1
1980 - 1984

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				\$0.
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
* Site cost adjustment factor (SCAF)= .99				
Site Unit cost= SCAF x National Average Unit Cost				
[13011-15-1982002:50:35]				PAGE 2

TABLE 3.2 (continued)

Construction Cost Items for Period 2 1985 - 1989

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
groundwater monitoring wells	1,600 [1f]		11.88	19,008
CONSTRUCTION COST TOTAL				\$19,008
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
	50%			
Other Capital Items =	\$19,008 x 0.50 =			\$9,504
CONSTRUCTION CAPITAL REQUIREMENT =				\$28,512
Closure Cost	\$5,774,266.			
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$8,661,399.
Site cost adjustment factor (SCAF) = .99 Unit cost = SCAF x National Average Unit Cost				

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TABLE 3.2 (continued)

Construction Cost Items for Period 3 1990 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	602	[acres]	2,970	1,787,940
clear and grub	50	[acres]	1,302	65,093
light stump removal	50	[acres]	535	26,730
cut & fill non-compacted	1,215,772	[cy]	1.50	1,829,494
on-site structural cut/fill	1,046,476	[cy]	2.37	2,476,067
topsoil placement & grading	116,000	[cy]	1.67	194,880
topsoil removal & stockpile	116,000	[cy]	1.50	174,557
seeding and mulching -grass	310,000	[sy]	0.42	128,898
gravel stabilization	23,335	[sy]	0.69	16,171
gravel roadways	16,000	[lf]	2.99	47,837
drainage cap-48"	704	[lf]	46.98	33,071
fibercast pipe 8"	77,627	[lf]	36.23	2,812,737
steel pipe -12"	80,411	[lf]	45.54	3,661,917
miscellaneous structures	896,490	[ls]	0.99	887,525
miscellaneous concrete	119,680	[ls]	0.99	118,483
soil borings	2,600	[lf]	14.85	38,610
groundwater monitoring wells	2,000	[lf]	11.88	23,760

CONSTRUCTION COST TOTAL

\$14,322,970.

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%

Other Capital Items = \$14,322,970. x 0.50 =

\$7,161,484.

CONSTRUCTION CAPITAL REQUIREMENT =

\$21,484,450.

Closure Cost

\$11,946,760.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$17,920,140.

* Site cost adjustment factor (SCAF) = .99

Site Unit cost = SCAF x National Average Unit Cost

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TABLE 3.3
NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9773	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	28,512	0	0.9131	26,034
1985	0	0	0.8923	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	0	0	0.8337	0
1989	21,484,450	0	0.8149	17,507,678
1990	0	8,661,399	0.7966	6,899,670
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	17,920,140	0.4512	8,085,567

Total Present Worth of Future Capital Expenditures :

\$32,518,950

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$2,406,402

[Plant # 13]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTSO&M Costs for Period 1
1980 to 1984

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	483,990	2.48	1,197,875	Wet disposal
Bottom ash	42,780	2.48	105,981	Wet disposal
Total handling			1,303,756	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	

Annual operation and maintenance cost	\$1,303,756
---------------------------------------	-------------

[13#11-15-1982#02:58:35]

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TABLE 3.4 (continued)

O&M Costs for Period 2
1985 to 1989

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	483,998	2.48	1,197,875	Wet disposal
Bottom ash	42,788	2.48	105,881	Wet disposal
Total handling			1,303,756	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Groundwater monitoring			27,528	
Annual operation and maintenance cost			\$1,331,276	

[13011-15-1982#02:58:35]

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TABLE 3.4 (continued)

O&M Costs for Period 3
1990 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	483,990	2.48	1,197,875	Wet disposal
Bottom ash	42,780	2.48	105,881	Wet disposal
Total handling			1,303,756	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Groundwater monitoring			56,920	
Annual operation and maintenance cost			\$1,360,676	

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TABLE 3.5
NON-HAZARDOUS 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	1,303,756	1.0000	1,303,756
1981	1,303,756	0.9775	1,274,421
1982	1,303,756	0.9555	1,245,739
1983	1,303,756	0.9341	1,217,838
1984	1,303,756	0.9131	1,190,460
1985	1,331,276	0.8925	1,188,164
1986	1,331,276	0.8725	1,161,538
1987	1,331,276	0.8528	1,135,312
1988	1,331,276	0.8337	1,109,885
1989	1,331,276	0.8149	1,084,857
1990	1,360,676	0.7966	1,083,915
1991	1,360,676	0.7787	1,059,558
1992	1,360,676	0.7612	1,035,747
1993	1,360,676	0.7441	1,012,479
1994	1,360,676	0.7273	989,620
1995	1,360,676	0.7110	967,441
1996	1,360,676	0.6950	945,670
1997	1,360,676	0.6794	924,443
1998	1,360,676	0.6641	903,625
1999	1,360,676	0.6492	883,351
2000	1,360,676	0.6346	863,485
2001	1,360,676	0.6203	844,027
2002	1,360,676	0.6064	825,114
2003	1,360,676	0.5927	806,473
2004	1,360,676	0.5794	788,376
2005	1,360,676	0.5664	770,687
2006	1,360,676	0.5536	753,270
2007	1,360,676	0.5412	736,398
2008	1,360,676	0.5290	719,798
2009	1,360,676	0.5171	703,606
2010	1,360,676	0.5055	687,822
2011	1,360,676	0.4941	672,310
2012	1,360,676	0.4830	657,207
2013	1,360,676	0.4722	642,511
2014	1,360,676	0.4616	628,088

Total Present Worth of Future Costs :

\$32,816,988

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$1,344,391

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 13

Levelized Capital Cost

\$2,406,402

Levelized Operation and Maintenance Costs

\$1,344,391

Total Levelized Revenue Requirement

\$3,750,793

Levelized Revenue Requirement per Ton of Waste Disposed

\$7.12

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$6.25

SECTION 4

HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

The proposed design consists of acquiring a tract of land adjacent to the power plant. For the purpose of this analysis, it has been determined that it will continue to be most cost effective in the future if wet handling systems are utilized for the disposal of the fly ash and bottom ash. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes would continue to be sent to the surface impoundment.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities

Design FactorHazardous MinimumHazardous Maximum

2. Liner System

Use a single liner system as specified in the EPA guidance documents

Use a double liner system as specified in the EPA guidance documents

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. It was assumed that because of RCRA restrictions ash would no longer be able to be sold for other uses. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed surface impoundments on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Figure 4.1 is a layout of the cells which are proposed for ash disposal under the hazardous waste scenario. Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the

FIGURE 4.1

HAZARDOUS MINIMUM SURFACE IMPOUNDMENT – TYPICAL CELL HALF SECTION⁽¹⁾

FIGURE 4.2

HAZARDOUS MAXIMUM SURFACE IMPOUNDMENT – TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.3

construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 13

Design Mode: Hazardous Min

Date 11-15-1982

Power Plant Information (1980)

Generating capacity of plant	3160 kw
Generating capacity of largest boiler	880 kw

Waste Production Information *

Fly ash	633740 dry ton/yr
Bottom Ash	157980 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	65 lb/cu ft
Bottom ash	65 lb/cu ft

General Disposal Site Information

Site area	1328 acres
Percent heavily wooded	25 %
Percent lightly wooded	25 %
Site perimeter	45000 ft
Distance to plant	1 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	5300 ft
Thickness of soils above bedrock	50 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	40 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	10 mi

Climatic Information

Maximum frost penetration	10 in
Total annual precipitation	52.56 in
10-yr, 24-hr rainfall event	6.5 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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TABLE 4.2

HAZARDOUS MIN CELL GEOMETRY

Number of cells	7
Cell volume	4519508 cu yd
Depth of waste at edge of fill	35 ft
Cell dimensions	
length at top	3138 ft
width at top	1846 ft
length at bottom	2998 ft
width at bottom	986 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	39640 ft

Disposal Cell Cross-Section
Wet Disposal Impoundment w/ Single Liner

NOTE: Datum is below existing ground surface an average of 12 feet at this site

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS**Construction Cost Items (1980-2014)**

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	1,328	[acres]	2,970	3,944,160
clear and grub	1,018	[acres]	1,302	1,325,391
heavy stump removal	255	[acres]	891	226,778
light stump removal	255	[acres]	535	136,067
final grading	1,023	[acres]	540	551,722
cut & fill non-compacted	4,271,564	[cy]	1.50	6,427,850
on-site structural cut/fill	4,637,676	[cy]	2.37	10,973,205
topsoil removal & stockpile	1,986,257	[cy]	1.50	2,988,920
sand collection zone plant	1,324,743	[cy]	8.72	11,554,276
sand import	1,324,743	[cy]	6.29	8,327,997
clay liner/cap placement	2,135,782	[cy]	4.65	9,937,794
synthetic membrane	47,790,370	[sf]	0.55	26,494,981
seeding and mulching -grass	4,949,191	[sy]	0.42	2,057,874
plastic filter fabric	2,702,693	[sy]	0.71	1,926,480
light duty bituminous road	29,304	[lf]	12.55	367,859
heavy duty bituminous road	300	[lf]	16.47	4,942
perimeter fencing	45,000	[ft]	11.80	534,600
soil borings	25,564	[lf]	14.85	379,625
groundwater monitoring wells	3,964	[lf]	11.80	47,092
CELL CONSTRUCTION COST SUBTOTAL				\$88,207,610.
Wet Disposal - No Leachate Treatment Plant				
No Wet-to-Dry Conversion for Fly Ash or Bottom Ash				
Construction Cost for Closure of Existing Disposal Site(s)				\$6,224,130
CONSTRUCTION COST TOTAL				\$94,431,730.
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
50%				
Other Capital Items = \$94,431,730. x 0.50 =				\$47,215,870.
Permitting Cost				\$250,000
TOTAL CAPITAL REQUIREMENT =				\$141,897,600.

* Site Cost Adjustment Factor (SCAF) = .990
 Site Unit Cost = SCAF x National-Average Unit Cost

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TABLE 4.4

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	28,487,830	1.0000	28,487,830
1985	18,901,630	0.8925	16,869,705
1990	18,901,630	0.7966	15,057,038
1995	18,901,630	0.7110	13,439,059
2000	18,901,630	0.6346	11,994,974
2005	18,901,630	0.5664	10,705,883
2010	18,901,630	0.5055	9,554,774
Total Cap Exp	\$141,897,610		
Present Worth of all Capital Costs			\$106,109,264
Total Levelizing Factor (LF) =		0.0740	
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$7,852,086

[Plant # 13]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	633,740	2.48	1,568,567	Wet disposal
Bottom ash	157,988	2.48	391,801	Wet disposal
Total handling			1,959,567	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Leachate Treatment Plant O and M			\$0	
Total non-administrative O and M			-----\$1,959,567-----	

Administrative O&M Cost Items

Manifesting	\$28,523
Groundwater monitoring	\$73,908
Inspection	\$15,988
Personnel training	\$1,188
Non-sudden occurrence insurance	\$52,465
General administration	\$81,691
Total Annual Administration cost	-----\$253,664-----
Total annual operation and maintenance cost	\$2,213,191

Post closure O&M costs

Existing site (1980-2010)	\$38,067
New site	
Groundwater monitoring	\$147,817
Inspection	\$31,816
Maintenance	\$111,807
Administrative services	\$5,544
Total annual post closure cost (2014-2044)	-----\$296,984-----

[13011-15-1982#02:03:58]

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TABLE 4.6
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	2,251,258	1.0000	2,251,258	Begin post closure operation and maintenance of existing site
1981	2,251,258	0.9775	2,200,605	
1982	2,251,258	0.9555	2,151,077	
1983	2,251,258	0.9341	2,102,900	
1984	2,251,258	0.9131	2,055,624	
1985	2,251,258	0.8925	2,009,248	
1986	2,251,258	0.8725	1,964,223	
1987	2,251,258	0.8528	1,919,873	
1988	2,251,258	0.8337	1,876,874	
1989	2,251,258	0.8149	1,834,550	
1990	2,251,258	0.7966	1,793,352	
1991	2,251,258	0.7787	1,753,055	
1992	2,251,258	0.7612	1,713,658	
1993	2,251,258	0.7441	1,675,161	
1994	2,251,258	0.7273	1,637,340	
1995	2,251,258	0.7110	1,600,644	
1996	2,251,258	0.6950	1,564,624	
1997	2,251,258	0.6794	1,529,505	
1998	2,251,258	0.6641	1,495,060	
1999	2,251,258	0.6492	1,461,517	
2000	2,251,258	0.6346	1,428,648	
2001	2,251,258	0.6203	1,396,455	
2002	2,251,258	0.6064	1,365,163	
2003	2,251,258	0.5927	1,334,321	
2004	2,251,258	0.5794	1,304,379	
2005	2,251,258	0.5664	1,275,113	
2006	2,251,258	0.5536	1,246,296	
2007	2,251,258	0.5412	1,218,381	
2008	2,251,258	0.5290	1,190,915	
2009	2,251,258	0.5171	1,164,126	
2010	2,251,258	0.5055	1,138,011	End post closure operation and maintenance of existing site
2011	2,213,191	0.4941	1,093,538	
2012	2,213,191	0.4830	1,068,971	
2013	2,213,191	0.4722	1,045,069	
2014	2,213,191	0.4616	1,021,609	
2015	296,984	0.4512	133,999	Begin post closure operation and maintenance
2016	296,984	0.4410	130,970	
2017	296,984	0.4311	128,030	
2018	296,984	0.4214	125,149	
2019	296,984	0.4120	122,357	
2020	296,984	0.4027	119,395	
2021	296,984	0.3936	116,893	
2022	296,984	0.3848	114,279	
2023	296,984	0.3761	111,696	
2024	296,984	0.3677	109,201	
2025	296,984	0.3594	106,736	

(continued next page)

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TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	296,984	0.3513	104,330	
2027	296,984	0.3434	101,984	
2028	296,984	0.3357	99,698	
2029	296,984	0.3282	97,470	
2030	296,984	0.3208	95,272	
2031	296,984	0.3136	93,134	
2032	296,984	0.3065	91,026	
2033	296,984	0.2996	88,976	
2034	296,984	0.2929	86,987	
2035	296,984	0.2863	85,027	
2036	296,984	0.2799	83,126	
2037	296,984	0.2736	81,255	
2038	296,984	0.2674	79,414	
2039	296,984	0.2614	77,632	
2040	296,984	0.2555	75,879	
2041	296,984	0.2498	74,187	
2042	296,984	0.2442	72,523	
2043	296,984	0.2387	70,890	
2044	296,984	0.2333	69,286	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$57,828,143	
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			\$1,684,312	

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 13

Levelized Capital Cost

\$7,852,086

Levelized Operation and Maintenance Costs

\$1,684,312

Total Levelized Revenue Requirement

\$9,536,398

Levelized Revenue Requirement per Ton of Waste Disposed

\$12.05

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$10.57

TABLE 4.8

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 13

Design Mode: Hazardous Max

Date 11-15-1982

Power Plant Information (1980)

Generating capacity of plant	3160 mw
Generating capacity of largest boiler	880 mw

Waste Production Information *

Fly ash	633740 dry ton/yr
Bottom Ash	157980 dry ton/yr

No FGD

Waste densities (as disposed)

Fly ash	65 lb/cu ft
Bottom ash	65 lb/cu ft

General Disposal Site Information

Site area	1328 acres
Percent heavily wooded	25 %
Percent lightly wooded	25 %
Site perimeter	45000 ft
Distance to plant	1 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	5300 ft
Thickness of soils above bedrock	50 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	40 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	10 mi

Climatic Information

Maximum frost penetration	10 in
Total annual precipitation	52.56 in
10-yr, 24-hr rainfall event	6.5 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	7
Cell volume	4519508 cu yd
Depth of waste at edge of fill	35 ft
Cell dimensions	
length at top	3138 ft
width at top	1846 ft
length at bottom	2998 ft
width at bottom	986 ft
Cell dike information	
Dike side slopes	
exterior	3 horiz : 1 vert
interior	2 horiz : 1 vert
Average width at top of dike	28 ft
Total length of exterior dike	39648 ft

Disposal Cell Cross-Section
Wet Disposal Impoundment w/ Double Liner

NOTE: Datum is below existing ground surface an average of 11 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	1,328	[acres]	2,970	3,944,160
clear and grub	1,018	[acres]	1,302	1,325,391
heavy stump removal	255	[acres]	891	226,778
light stump removal	255	[acres]	535	136,067
final grading	1,023	[acres]	540	551,722
cut & fill non-compacted	4,259,884	[cy]	1.50	6,410,153
on-site structural cut/fill	4,528,376	[cy]	2.37	10,714,590
topsoil removal & stockpile	1,982,737	[cy]	1.50	2,983,623
sand collection zone plant	2,183,888	[cy]	8.72	19,047,653
sand import	2,183,888	[cy]	6.29	13,729,012
clay liner/cap placement	2,129,902	[cy]	4.65	9,910,434
synthetic membrane	71,190,040	[sf]	0.55	39,467,758
seeding and mulching -grass	4,949,191	[sy]	0.42	2,057,874
plastic filter fabric	2,695,309	[sy]	0.71	1,921,216
light duty bituminous road	29,304	[lf]	12.55	367,859
heavy duty bituminous road	300	[lf]	16.47	4,942
perimeter fencing	45,000	[ft]	11.88	534,600
plastic pipe, pvc-4"	152,107	[lf]	9.85	1,498,325
plastic pipe, pvc-6"	49,232	[lf]	14.19	698,440
leachate collect sumps	2,520	[lf]	93.06	234,511
soil borings	25,564	[lf]	14.85	379,625
groundwater monitoring wells	3,964	[lf]	11.88	47,092

CELL CONSTRUCTION COST SUBTOTAL

\$116,191,800.

Wet Disposal - No Leachate Treatment Plant

No Wet-to-Dry Conversion for Fly Ash or Bottom Ash

Construction Cost for Closure of Existing Disposal Site(s) \$14,724,270

CONSTRUCTION COST TOTAL

\$130,916,100.

Contractor Overhead	15%
Contractor Profit	10%
Engineering & Legal Costs	10%
Contingency	15%

50%

Other Capital Items = \$130,916,100. x 0.50 =

\$65,458,050.

Permitting Cost

\$500,000

TOTAL CAPITAL REQUIREMENT =

\$196,874,200.

* Site Cost Adjustment Factor (SCAF) = .990

Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.11

HAZARDOUS MAX 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	47,484,650	1.0000	47,484,650
1985	24,898,250	0.8925	22,221,688
1990	24,898,250	0.7966	19,833,946
1995	24,898,250	0.7110	17,702,656
2000	24,898,250	0.6346	15,800,429
2005	24,898,250	0.5664	14,102,369
2010	24,898,250	0.5055	12,586,065

Total Cap Exp \$196,874,150

Present Worth of all Capital Costs

\$149,731,803

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$11,080,153

[Plant # 13]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	633,740	2.48	1,568,507	Wet disposal
Bottom ash	157,980	2.48	391,801	Wet disposal
Total handling			1,959,507	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Leachate Treatment Plant O and M			\$0	
Total non-administrative O and M			\$1,959,507	

Administrative O&M Cost Items

Manifesting	\$28,523
Groundwater monitoring	\$73,908
Inspection	\$15,908
Personnel training	\$1,188
Non-sudden occurrence insurance	\$52,465
General administration	\$81,691
Total Annual Administration cost	\$253,684
Total annual operation and maintenance cost	\$2,213,191

Post closure O&M costs

Existing site (1980-2010)	\$38,067
New site	
Groundwater monitoring	\$147,817
Inspection	\$31,816
Maintenance	\$111,807
Administrative services	\$5,544
Total annual post closure cost (2014-2044)	\$296,984

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TABLE 4.13
HAZARDOUS MAX 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	2,251,258	1.0000	2,251,258	Begin post closure operation and maintenance of existing site
1981	2,251,258	0.9775	2,200,605	
1982	2,251,258	0.9555	2,151,077	
1983	2,251,258	0.9341	2,102,900	
1984	2,251,258	0.9131	2,055,624	End post closure operation and maintenance of existing site
1985	2,251,258	0.8925	2,009,248	
1986	2,251,258	0.8725	1,964,223	
1987	2,251,258	0.8528	1,919,873	
1988	2,251,258	0.8337	1,876,874	
1989	2,251,258	0.8149	1,834,550	
1990	2,251,258	0.7966	1,793,352	
1991	2,251,258	0.7787	1,753,055	
1992	2,251,258	0.7612	1,713,658	
1993	2,251,258	0.7441	1,675,161	
1994	2,251,258	0.7273	1,637,340	
1995	2,251,258	0.7110	1,600,644	
1996	2,251,258	0.6950	1,564,624	
1997	2,251,258	0.6794	1,529,505	
1998	2,251,258	0.6641	1,495,060	
1999	2,251,258	0.6492	1,461,517	Begin post closure operation and maintenance
2000	2,251,258	0.6346	1,428,648	
2001	2,251,258	0.6203	1,396,455	
2002	2,251,258	0.6064	1,365,163	
2003	2,251,258	0.5927	1,334,321	End post closure operation and maintenance of existing site
2004	2,251,258	0.5794	1,304,379	
2005	2,251,258	0.5664	1,275,113	
2006	2,251,258	0.5536	1,246,296	
2007	2,251,258	0.5412	1,218,381	Begin post closure operation and maintenance
2008	2,251,258	0.5290	1,190,915	
2009	2,251,258	0.5171	1,164,126	
2010	2,251,258	0.5055	1,138,011	
2011	2,213,191	0.4941	1,093,538	End post closure operation and maintenance of existing site
2012	2,213,191	0.4830	1,068,971	
2013	2,213,191	0.4722	1,045,069	
2014	2,213,191	0.4616	1,021,609	
2015	296,984	0.4512	133,999	Begin post closure operation and maintenance
2016	296,984	0.4410	130,970	
2017	296,984	0.4311	128,030	
2018	296,984	0.4214	125,149	
2019	296,984	0.4120	122,357	End post closure operation and maintenance of existing site
2020	296,984	0.4027	119,595	
2021	296,984	0.3936	116,893	
2022	296,984	0.3848	114,279	
2023	296,984	0.3761	111,696	Begin post closure operation and maintenance
2024	296,984	0.3677	109,201	
2025	296,984	0.3594	106,736	

(continued next page)

[Plant # 13]

TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	296,984	0.3513	104,330	
2027	296,984	0.3434	101,984	
2028	296,984	0.3357	99,698	
2029	296,984	0.3282	97,470	
2030	296,984	0.3208	95,272	
2031	296,984	0.3136	93,134	
2032	296,984	0.3065	91,026	
2033	296,984	0.2996	88,976	
2034	296,984	0.2929	86,987	
2035	296,984	0.2863	85,027	
2036	296,984	0.2799	83,126	
2037	296,984	0.2736	81,255	
2038	296,984	0.2674	79,414	
2039	296,984	0.2614	77,632	
2040	296,984	0.2555	75,879	
2041	296,984	0.2498	74,187	
2042	296,984	0.2442	72,523	
2043	296,984	0.2387	70,890	
2044	296,984	0.2333	69,286	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$57,828,143	
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			\$1,684,312	

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 13

Levelized Capital Cost

\$11,080,153

Levelized Operation and Maintenance Costs

\$1,684,312

Total Levelized Revenue Requirement

\$12,764,465

Levelized Revenue Requirement per Ton of Waste Disposed

\$16.12

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$14.15

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 1,364,000	\$ 1,304,000	\$ 2,668,000	\$ 5.06	\$ 4.44
Non-Hazardous	2,406,000	1,344,000	3,751,000	7.12	6.25
Hazardous Minimum	7,852,000	1,684,000	9,536,000	12.05	10.57
Hazardous Maximum	11,080,000	1,684,000	12,764,000	16.12	14.15

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data 1980, Kingston, MA.

RCRA Impact
Case Study of Plant 14

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SECTION 1

INTRODUCTION

BACKGROUND

The U.S. Department of Energy (DOE) retained Engineering-Science (ES) to provide services which include the estimation of the costs associated with implementation of the Resource Conservation and Recovery Act (RCRA) regulations for non-hazardous and hazardous material disposal in the utility industry. These costs are based on engineering studies at a number of coal-fired power plants in which the costs for hazardous and non-hazardous disposal are compared to the costs developed for the current practice design for each utility. The relationship of the three costs is displayed in Figure 1.1. The emphasis of this study is on the determination of incremental costs rather than the absolute costs for each case (current practice, non-hazardous, or hazardous). For the purpose of this project, the hazardous design cost was determined for two situations:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulation.
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulation.

During a February, 1982 meeting in Atlanta of this project's Utility Advisory Task Force, the following criteria were designated to be incorporated into the engineering analyses for the three cost estimates:

- o The designs should be based on a 35 year life
- o Conversion costs of wet ash handling to dry handling should be included in the current practice design if it is cost effective over the design life.
- o Current practice cost estimates will not include "sunk costs" for existing capital equipment and land.

RCRA ECONOMIC IMPACT

- o Hazardous and non-hazardous landfill designs should have a cell life of not greater than five years.
- o Leachate treatment should be provided as required.
- o For the hazardous waste design, miscellaneous wastes such as coal pile runoff and boiler cleaning waste will be used for ash conditioning, bottom ash make-up water or other uses whenever practical.
- o All economic analyses should use present worth and levelized annual cost procedures.

The cost values for the current practice, non-hazardous and hazardous designs must be prepared on the same basis in order to compare the results. To accomplish this, it was necessary to differentiate between the existing disposal practices and a "current practice" design. Existing disposal practices refer to the present methods for handling and disposal of fly ash, bottom ash and FGD sludge. The existing disposal practices were determined by conducting site visits at the plant. The information gathered was summarized and sent to the plant for verification. Resultant site visit summary forms were utilized as a basis for this report. "Current practice" design describes a disposal plan, developed for this study, which would be feasible for the design period of 1980 through 2014, assuming that the utility were not constrained by RCRA requirements or guidelines.

PLANT DESCRIPTION

Case Study Plant 14 is located in southeastern North Carolina. The plant has a current nameplate generating capacity of 1,155 MW. Construction of additional boilers is not presently planned. The plant has five boilers, each are dry-bottom, pulverized coal-fired units. Fuel oil is used for start-up and combustion stabilization.

Bituminous coal for the plant is obtained from Virginia with smaller quantities from Kentucky, Tennessee and West Virginia. Coal is transported to the facility by rail. Normally a 60-day stockpile is maintained on-site. Coal consumption for 1980 was 2,396,600 tons. The average analysis of the coal consumed during 1980 was 1.0 percent sulfur, 12.09 percent ash, and 12,297 BTU's/lb. Projected 1985 and 1990

rates of coal consumption are 1,443,500 and 1,912,500 tons, respectively.

Units 1 and 2 are equipped with mechanical collectors followed by electrostatic precipitators with flue-gas conditioning. Units 3, 4, and 5 are equipped with electrostatic precipitators. The plant has an average particulate efficiency of 97.59 percent which meets state and Federal emission limits. Table 1.1 summarizes the plant characteristics including year of boiler start-up, 1980 availability factor, coal used, and air pollution control equipment.

EXISTING DISPOSAL

The current practice schematic flow diagram at the plant is illustrated in Figure 1.2. The quantities of major waste materials generated are summarized in Table 1.2.

Fly ash and bottom ash from all the units are sluiced to an on-site disposal pond (Figure 1.3). Fly ash and bottom ash are not being sold. In addition to ash, this ash pond receives discharges of coal pile runoff, boiler blowdown and cleaning waste, floor and yard drainage, and water treatment waste. Decant water from the ash pond is discharged to the river.

SCHEMATIC FLOW DIAGRAM

FIGURE 1.2

TABLE 1.1
PLANT OPERATING CHARACTERISTICS
PLANT 14

Boiler	MW Stack	Year of (Nameplate)	1980 Start-up	1980 Availability Factor	1980 Coal Used (tons)	1985 Coal Projections (tons)	2000 Coal Projections (tons)	Type of Control	
								Particulate	SO ₂
1	1	165	1957	70%	207,300	197,500	253,200	COMBINATION ¹	None
2	2	165	1957	46%	196,600	177,200	221,700	COMBINATION ¹	None
3	3	275	1959	86%	760,300	374,500	491,500	ESP	None
4	4	275	1960	89%	595,900	353,500	475,800	ESP	None
5	5	<u>275</u>	1961	90%	<u>635,500</u>	<u>340,800</u>	<u>470,300</u>	ESP	None
TOTALS		1,155			2,395,600	1,443,500	1,912,500		

¹ Combination - mechanical collectors and electrostatic precipitators

TABLE 1.2
QUANTITIES OF WASTE PRODUCTS
PLANT 14

Waste Product	1980 Values	1985 Values	2000 Values	35-Year Average*
<u>Fly Ash (Dry Weight)</u>				
Tons Produced	210,800	130,889	173,416	171,000
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	210,800	130,889	173,416	171,000
<u>Bottom Ash (Dry Weight)</u>				
Tons Produced	54,200	43,630	57,805	56,500
Tons Sold	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Tons Disposed	54,200	43,630	57,805	56,500
<u>Other Wastes</u>				
Coal Pile Runoff (MG/yr)	22.35	22.35	22.35	
Boiler Cleaning Waste (MG/yr)	0.64	0.64	0.64	

- * Average is for 1980-2014, assuming that the 1990 values remain constant through 2014.

SECTION 2

CURRENT PRACTICE DESIGN

Current practice costs are compared with non-hazardous and hazardous capital and operating costs for comparably sized facilities. For this project, a design period of 35 years, from 1980 through 2014, was selected as the basis for all capital and operating cost estimates and supporting designs.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal using the project definition of current practice as described in Section 1. Current disposal practices for the selected periods are described in Figure 2.1, based on the 35-year average values for waste disposal from Table 1.2. This simplifying assumption will affect the year that certain activities are projected to occur, but will have an insignificant effect on total cost estimates.

The proposed modification of the waste disposal procedures consists of placing the fly ash in a landfill and continued sluicing of the bottom ash to the ash pond. The landfilling of fly ash would require the installation of a dry ash handling system for all units and modification of the old ash pond. The plant's inactive ash pond would be re-designed to provide the additional fly ash storage capacity until 2014. The inactive pond has been divided by a crest embankment. This dike serves as the foundation for sluice pipes leading to the active ash basin. The two areas are designated as sites 'A' and 'B' as shown in Figure 2.2.

Site 'A' appears to be best suited for the development of a landfill. Before fly ash deposition, it would be necessary to do some light construction within the area. Existing haul roads would have to be upgraded to handle the volume and loads of the hauling trucks. This would require a base and surface of six inches of crushed aggregate,

CURRENT PRACTICE HANDLING & DISPOSAL

Operation Activity

Construction Activity

PLANT 14

FIGURE 2.2

CURRENT PRACTICE WASTE DISPOSAL SITES

SCALE 1/2 1 MILE

assuming the existing subgrade will support the load. A drainage system, including diversion channels and a sedimentation basin would be constructed to control the drainage from the area. The existing drainage tower at the site would be utilized for discharge of runoff. The existing cover material (topsoil) of the area would be removed and stockpiled for future use.

The disposal method would entail the placing of the fly ash in a controlled fill with minimum compactive effort. The fly ash would be brought up to optimum moisture and placed in one to two foot lifts. Loaded trucks would be used to obtain the necessary compaction. This method of disposal would minimize waste volume, reduce permeability and increase landfill stability. On-site material would be used for intermediate and final cover and/or dust control during operation. A final cover of twelve (12) inches of topsoil would be placed and compacted on the disposal area during closure. This area would be seeded to establish a vegetative cover for erosion control.

Bottom ash would continue to be disposed of by sluicing to the existing pond through the year 2014. A final cover of six (6) inches of topsoil would be placed and compacted on the disposal area. This area would be seeded to establish a vegetative cover for erosion control.

COST ESTIMATES

The cost estimating approach presented is based directly on the current practice waste disposal site modifications as described in this section. Material and labor quantities were estimated for the current practice construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs based on published 1980 construction cost indices (Means, 1979). Capital and operating costs were then used to calculate revenue requirements. The methodology used estimates of future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

Waste volumes and densities are presented in Table 2.1 for the current practice design. These quantities represent the average values over the 35 year design period (1980-2014). Construction cost items,

quantity take-off information, regional unit costs (1980 dollars), and extensions for the current practice design periods are presented in Table 2.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the current practice design. Closure costs are treated in the same manner.

On Table 2.3 the construction and closure capital expenditures are levelized by an annual fixed charge rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35 year design life are presented in Table 2.4. These costs are levelized in Table 2.5.

A cost summary of the levelized revenue requirements is displayed in Table 2.6. The cost of waste disposed is identified on a per ton and per cubic yard basis.

TABLE 2.1

CURRENT PRACTICE SUMMARY OF INPUT INFORMATION

Site Code: 14

Design Mode: Current Practice

Power Plant Information (1980)

Generating capacity of plant	1155 mw
Generating capacity of largest boiler	275 mw

Waste Production Information*

Fly ash	171000 dry ton/yr
Bottom Ash	56500 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	54.4 lb/cu ft
Bottom ash	51.6 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

[14011-11-1982#09:02:15]

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TABLE 2.2

CURRENT PRACTICE CAPITAL COSTS

Construction Cost Items for Period 1
1980 - 1988

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 \$0.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items) \$0.

Site cost adjustment factor (SCAF) = .916

Site Unit cost = SCAF x National Average Unit Cost

[14#11-11-1982#09:02:15]

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TABLE 2.2 (continued)

Construction Cost Items for Period 2
1989 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
cut & fill non-compacted	6,953 [cy]		1.39	9,681
on-site structural cut/fill	39,415 [cy]		2.19	86,289
topsoil placement & grading	4,504 [cy]		1.55	6,972
topsoil removal & stockpile	4,504 [cy]		1.39	6,271
seeding and mulching -grass	13,511 [sy]		0.38	5,198
gravel roadways	5,067 [lf]		2.77	14,017
miscellaneous structures	2,887,400 [ls]		0.92	2,644,858

CONSTRUCTION COST TOTAL

\$2,773,287.

Contractor Overhead 15%
Contractor Profit 10%
Engineering & Legal Costs 10%
Contingency 15%

50%

Other Capital Items = \$2,773,287. x 0.50 =

\$1,386,643.

CONSTRUCTION CAPITAL REQUIREMENT =

\$4,159,930.

Closure Cost

\$1,854,721.

CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)

\$2,782,082.

* Site cost adjustment factor (SCAF) = .916

Site Unit cost = SCAF x National Average Unit Cost

[14#11-11-1982#09:02:15]

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TABLE 2.3
CURRENT PRACTICE CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
Inflation Rate : 6.0 %
Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	0	0	0.9131	0
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	4,159,930	0	0.8337	3,468,134
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	2,782,082	0.4512	1,255,275

Total Present Worth of Future Capital Expenditures :

\$4,723,409

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$349,532

[Plant # 14]

TABLE 2.4

CURRENT PRACTICE OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1988

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	171,000	2.29	391,590	Wet disposal
Bottom ash	56,500	2.29	129,385	Wet disposal
Total handling			520,975	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Annual operation and maintenance cost			\$520,975	

[14#11-11-1982#09:02:15]

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TABLE 2.4 (continued)

Y.M. Costs for Period 2
1989 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	171,000	3.21	548,226	Dry disposal
Bottom ash	56,500	2.29	129,385	Wet disposal
Total handling			677,611	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	171,000	0.45	76,752	open on road truck (16cy) 1 mi. haul
Total transportation			76,752	
Landfill costs				
Flyash	171,000	1.33	228,214	
Total landfill cost			228,214	

Annual operation and maintenance cost \$982,577

[14011-11-1982#09:02:15]

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TABLE 2.5
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	520,975	1.0000	520,975
1981	520,975	0.9775	509,253
1982	520,975	0.9555	497,792
1983	520,975	0.9341	486,643
1984	520,975	0.9131	475,702
1985	520,975	0.8925	464,970
1986	520,975	0.8725	454,551
1987	520,975	0.8528	444,287
1988	520,975	0.8337	434,337
1989	982,577	0.8149	800,702
1990	982,577	0.7966	782,721
1991	982,577	0.7787	765,133
1992	982,577	0.7612	747,938
1993	982,577	0.7441	731,136
1994	982,577	0.7273	714,628
1995	982,577	0.7110	698,612
1996	982,577	0.6950	682,891
1997	982,577	0.6794	667,563
1998	982,577	0.6641	652,529
1999	982,577	0.6492	637,989
2000	982,577	0.6346	623,543
2001	982,577	0.6203	609,493
2002	982,577	0.6064	595,835
2003	982,577	0.5927	582,373
2004	982,577	0.5794	569,305
2005	982,577	0.5664	556,532
2006	982,577	0.5536	543,955
2007	982,577	0.5412	531,771
2008	982,577	0.5290	519,782
2009	982,577	0.5171	508,091
2010	982,577	0.5055	496,693
2011	982,577	0.4941	485,491
2012	982,577	0.4830	474,585
2013	982,577	0.4722	463,973
2014	982,577	0.4616	453,558

Total Present Worth of Future Costs :

\$20,185,230

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
 (Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$826,914

[Plant # 14]

TABLE 2.6

CURRENT PRACTICE COST SUMMARY FOR PLANT NO. 14

Levelized Capital Cost

\$349,532

Levelized Operation and Maintenance Costs

\$826,914

Total Levelized Revenue Requirement

\$1,176,446

Levelized Revenue Requirement per Ton of Waste Disposed

\$5.17

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$3.75

SECTION 3
NON-HAZARDOUS DESIGN

This section describes conceptual disposal practices and costs which would be involved with the application of the Federal non-hazardous guidelines contained in Title 40 Code of Federal Regulations - Part 241, "Guidelines for the Disposal of Solid Wastes" and Part 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices". The implementation of the non-hazardous guidelines could result in the following impacts on "current" disposal practices:

- o Ground-water observation wells would be required around the periphery of "current" waste disposal sites by 1985.
- o A clay or membrane liner and cap would be required on any new ash or FGD disposal facility. Existing permitted ash disposal facilities would not be lined over their design life. However a clay cap would be required during closure.
- o Leachate detection layers would not be required for lined ash disposal facilities.
- o Groundwater observation wells would be required on all newly permitted ash disposal facilities.

At the time of this report's preparation, methods and policies have not been defined for the implementation of the Federal non-hazardous guidelines by state and local regulatory agencies. The above impacts cited are interpretations by ES of how the existing non-hazardous guidelines might be implemented. When applied to this plant, ES had to make a number of further judgements as to how a "reasonable" regulator would approach these issues in the future. The following is a presentation of these judgements.

CONCEPTUAL DESIGN AND OPERATION

A conceptual engineering design was developed for waste disposal under the scenario of classifying ash and sludge as non-hazardous wastes. Conceptual disposal practices for the selected periods are described in Figure 3.1.

Current disposal practices described in Section 2 were incorporated into Figure 3.1 along with interpretations of how the non-hazardous guidelines might affect disposal. A modification, judged to be reasonable under the non-hazardous guidelines, was the installation of ground-water monitoring wells around the existing fly ash and bottom ash facilities. The fly ash landfill (Figure 2.2) would be constructed with a clay liner and cap to minimize leachate migration. Since the bottom ash pond will be in continuous use until the year 2014 and represents a large ash volume, it was decided that a clay cap would be a reasonable safeguard against possible future leachate generation. Miscellaneous wastes, e.g. coal pile runoff and boiler cleaning wastes, would continue to be discharged to the bottom ash pond.

COST ESTIMATES

The cost estimating approach used to quantify the impact of the non-hazardous regulations is based on the site and operational modifications described in the above section. Material and labor quantities were estimated for each time period. Capital and operating costs were developed and used to calculate levelized revenue requirements.

The non-hazardous design volumes and densities are presented in Table 3.1 and are the same as the current practice design. These quantities represent the average values over the 35-year design period (1980-2014). The construction cost items, quantity take-off information, regional unit costs (1980 dollars), and extensions for the non-hazardous design periods are presented in Table 3.2. This information was generated by the LFDESIGN Model (See Appendix C). Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the construction capital requirement for the non-hazardous design. Closure costs are treated in the same manner. On Table 3.3 the construction and closure capital expenditures are levelized by an annual fixed charge

NON-HAZARDOUS HANDLING & DISPOSAL

FIGURE 3 1

rate using the previously discussed levelizing procedure. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Operation and maintenance costs for the 35-year design life are presented in Table 3.4. These costs are levelized in Table 3.5.

A cost summary of the levelized revenue requirements is displayed in Table 3.6. The cost of non-hazardous waste disposed is identified on a per ton and per cubic yard basis.

TABLE 3.1

NON-HAZARDOUS SUMMARY OF INPUT INFORMATION

Site Code: 14

Design Mode: Non-Hazardous

Power Plant Information (1980)

Generating capacity of plant	1155 MW
Generating capacity of largest boiler	275 MW

Waste Production Information*

Fly ash	171000 dry ton/yr
Bottom Ash	56500 dry ton/yr
No FGD	
Waste densities (as disposed)	
Fly ash	54.4 lb/cu ft
Bottom ash	51.6 lb/cu ft

* Average for design period, 1980-2014.
Does not include wastes being sold
or reused (if applicable).

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TABLE 3.2

NON-HAZARDOUS CAPITAL COSTSConstruction Cost Items for Period 1
1980 - 1984

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				\$0.
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
* Site cost adjustment factor (SCAF) = .916				
Site Unit cost = SCAF x National Average Unit Cost				
[14#11-11-1982#08:49:42]				PAGE 2

TABLE 3.2 (continued)

 Construction Cost Items for Period 2
 1985 - 1988

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
<hr/>				
groundwater monitoring wells	720 (1f)		10.99	7,914
CONSTRUCTION COST TOTAL				\$7,914
Contractor Overhead	15%			
Contractor Profit	10%			
Engineering & Legal Costs	10%			
Contingency	15%			
<hr/>				
	50%			
Other Capital Items =	\$7,914 x 0.50 =			\$3,957
CONSTRUCTION CAPITAL REQUIREMENT =				\$11,871
<hr/>				
Closure Cost			\$0.	
CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items)				\$0.
<hr/>				
Site cost adjustment factor (SCAF) = .916				
Unit cost = SCAF x National Average Unit Cost				
<hr/>				

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TABLE 3.2 (continued)

Construction Cost Items for Period 3
1989 - 2014

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
cut & fill non-compacted	6,953 [cy]		1.39	9,681
on-site structural cut/fill	39,415 [cy]		2.19	86,289
topsoil placement & grading	4,504 [cy]		1.55	6,972
topsoil removal & stockpile	4,504 [cy]		1.39	6,271
synthetic membrane	3,267,000 [sf]		0.51	1,675,840
seeding and mulching -grass	13,511 [sy]		0.38	5,198
gravel roadways	5,067 [lf]		2.77	14,017
miscellaneous structures	2,887,400 [ls]		0.92	2,644,858
groundwater monitoring wells	600 [lf]		10.99	6,595

CONSTRUCTION COST TOTAL**\$4,455,722.**

Contractor Overhead 15%
 Contractor Profit 10%
 Engineering & Legal Costs 10%
 Contingency 15%

50%

Other Capital Items = $\$4,455,722. \times 0.50 =$ **\$2,227,861.****CONSTRUCTION CAPITAL REQUIREMENT =****\$6,683,583.****Closure Cost****\$8,549,263.****CLOSURE CAPITAL REQUIREMENT (Closure Cost +50% for Other Capital Items) \$12,823,090.**

* Site cost adjustment factor (SCAF) = .916
 Site Unit cost = SCAF x National Average Unit Cost

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TABLE 3.3

NON-HAZARDOUS CAPITAL COST LEVELIZING SUMMARY

Basis of Cost Levelizing Calculations

Nominal Return : 8.4 %
 Inflation Rate : 6.0 %
 Real Return : 2.3 %

YEAR OF EXPENDITURE	CONSTRUCTION CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	CLOSURE CAPITAL EXPENDITURE EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF EXPENDITURE IN 1980 \$
1980	0	0	1.0000	0
1981	0	0	0.9775	0
1982	0	0	0.9555	0
1983	0	0	0.9341	0
1984	11,871	0	0.9131	10,839
1985	0	0	0.8925	0
1986	0	0	0.8725	0
1987	0	0	0.8528	0
1988	6,683,583	0	0.8337	5,572,103
1989	0	0	0.8149	0
1990	0	0	0.7966	0
1991	0	0	0.7787	0
1992	0	0	0.7612	0
1993	0	0	0.7441	0
1994	0	0	0.7273	0
1995	0	0	0.7110	0
1996	0	0	0.6950	0
1997	0	0	0.6794	0
1998	0	0	0.6641	0
1999	0	0	0.6492	0
2000	0	0	0.6346	0
2001	0	0	0.6203	0
2002	0	0	0.6064	0
2003	0	0	0.5927	0
2004	0	0	0.5794	0
2005	0	0	0.5664	0
2006	0	0	0.5536	0
2007	0	0	0.5412	0
2008	0	0	0.5290	0
2009	0	0	0.5171	0
2010	0	0	0.5055	0
2011	0	0	0.4941	0
2012	0	0	0.4830	0
2013	0	0	0.4722	0
2014	0	0	0.4616	0
2015	0	12,823,890	0.4512	5,786,139

Total Present Worth of Future Capital Expenditures :

\$11,369,082

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST

\$841,312

[Plant # 14]

TABLE 3.4

NON-HAZARDOUS OPERATION AND MAINTENANCE COSTS

O&M Costs for Period 1
1980 to 1984

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	171,000	2.29	391,590	Wet disposal
Bottom ash	56,500	2.29	129,385	Wet disposal
Total handling			520,975	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Annual operation and maintenance cost			\$520,975	

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TABLE 3.4 (continued)

O&M Costs for Period 2
1985 to 1988

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	171,000	2.29	391,590	Wet disposal
Bottom ash	56,500	2.29	129,385	Wet disposal
Total handling			520,975	
Ash excavation				
Total excavation			none	
Ash transportation				
Total transportation			none	
Landfill costs				
Total landfill cost			none	
Groundwater monitoring			14,564	
Annual operation and maintenance cost			\$535,559	

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TABLE 3.4 (continued)

O&M Costs for Period 3
1989 to 2014

	quantity (tons)	unit cost (\$)	total annual \$	comments
<u>Ash handling</u>				
Flyash	171,000	3.21	548,226	Dry disposal
Bottom ash	56,500	2.29	129,385	Wet disposal
Total handling			677,611	
<u>Ash excavation</u>				
Total excavation			none	
<u>Ash transportation</u>				
Flyash	171,000	0.45	76,752	open on road truck (16cy) 1 mi. haul
Total transportation			76,752	
<u>Landfill costs</u>				
Flyash	171,000	1.33	228,214	
Total landfill cost			228,214	
Groundwater monitoring			23,404	
Annual operation and maintenance cost			\$1,665,981	

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TABLE 3.5
NON-HAZARDOUS 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	520,975	1.0000	520,975
1981	520,975	0.9775	509,253
1982	520,975	0.9555	497,792
1983	520,975	0.9341	486,643
1984	520,975	0.9131	475,702
1985	535,559	0.8925	477,986
1986	535,559	0.8725	467,275
1987	535,559	0.8528	456,725
1988	535,559	0.8337	446,496
1989	1,005,981	0.8149	819,774
1990	1,005,981	0.7966	801,364
1991	1,005,981	0.7787	783,357
1992	1,005,981	0.7612	765,753
1993	1,005,981	0.7441	748,550
1994	1,005,981	0.7273	731,650
1995	1,005,981	0.7110	715,252
1996	1,005,981	0.6950	699,157
1997	1,005,981	0.6794	683,463
1998	1,005,981	0.6641	668,072
1999	1,005,981	0.6492	653,083
2000	1,005,981	0.6346	638,396
2001	1,005,981	0.6203	624,010
2002	1,005,981	0.6064	610,027
2003	1,005,981	0.5927	596,245
2004	1,005,981	0.5794	582,865
2005	1,005,981	0.5664	569,788
2006	1,005,981	0.5536	556,911
2007	1,005,981	0.5412	544,437
2008	1,005,981	0.5290	532,164
2009	1,005,981	0.5171	520,193
2010	1,005,981	0.5055	508,523
2011	1,005,981	0.4941	497,055
2012	1,005,981	0.4830	485,889
2013	1,005,981	0.4722	475,024
2014	1,005,981	0.4616	464,361

Total Present Worth of Future Costs :

\$20,614,211

Sum of Present Worth Factors :

24.4103

Levelized O&M Cost = (Present Worth of all O&M Costs) /
(Sum of Present Worth Factors)

LEVELIZED ANNUAL OPERATION AND MAINTENANCE COST

\$844,488

TABLE 3.6

NON-HAZARDOUS COST SUMMARY FOR PLANT NO. 14

Levelized Capital Cost

\$841,312

Levelized Operation and Maintenance Costs

\$844,488

Total Levelized Revenue Requirement

\$1,685,800

Levelized Revenue Requirement per Ton of Waste Disposed

\$7.41

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$5.37

SECTION 4

HAZARDOUS DESIGN

On July 26, 1982 EPA published in the Federal Register its interim final hazardous waste treatment, storage and disposal regulations. These regulations superseded the February 5, 1981 regulations which called for a site-specific risk assessment approach including detailed site data and predictions concerning possible ground-water contamination.

The new regulations address both storage surface impoundments and landfills. EPA has determined that landfills must have liners designed to prevent migration of leachate during their active life. This condition requires installation of a synthetic liner and leachate collection system. Closure of a landfill will require that the cap must be as impermeable as the unit's liner. This will require in many cases that both synthetic and clay layers be used.

Owners of storage surface impoundments have the option of using either clay or a synthetic liner. If clay is used, the owner must remove the contents of the impoundment; if a synthetic liner is used, the owner must remove free liquids and stabilize the waste so that it has sufficient bearing capacity to support a final cover.

The scheme proposed in the regulations relies on a ground-water monitoring program to measure the effectiveness of the facility's design. If the owner should voluntarily install a double liner equipped with leak detection systems, the facility is exempt from ground-water monitoring requirements.

EPA has adopted the position that flexible design and operating performance standards be made specific by publication of permit guidelines which are referred to as "guidance documents". These documents contain examples of design specifications which EPA expects will lead to compliance with its current performance standards. ES has reviewed

these "guidance documents" and applied these specifications to this plant as described in the following section.

CONCEPTUAL DESIGN AND OPERATION

A hazardous waste conceptual engineering design was developed for waste disposal incorporating the design specifications presented in EPA's "guidance documents". ES evaluated two design conditions:

- o Hazardous Minimum - Probable least cost of complying with EPA's regulations
- o Hazardous Maximum - Probable maximum cost of complying with EPA's regulations

The proposed design consists of acquiring a tract of land located 10 miles west of the plant site. For the purpose of this analysis, it has been determined that it will be most cost effective in the future if dry handling systems are utilized for the disposal of the fly ash and bottom ash. In the future, all fly ash and bottom ash will be trucked to the new landfill. Leachate treatment facilities are provided and were sized based on a 10-year, 24-hour rainfall event falling on half the area of one open cell. Internal cell diking will preclude contamination of all storm water runoff. Miscellaneous wastes, eg. coal pile runoff and boiler cleaning wastes could be used to moisture condition the ash before placement in the landfill.

In reviewing the newly published hazardous waste regulations, it was obvious that the application of the regulations to existing disposal facilities would have major financial ramifications because of the extensive cap requirements. Similarly, the criteria governing liner design would also have a major impact. To address this situation, we have prepared two hazardous cost estimates - minimum and maximum - each with differing assumptions. The following is a listing of various assumptions for each design estimate:

<u>Design Factor</u>	<u>Hazardous Minimum</u>	<u>Hazardous Maximum</u>
1. Closure of existing disposal facility	Use the same closure requirements as specified under the non-hazardous scenario	Use the same closure requirements for the existing facilities as being utilized for the newly constructed facilities

Design FactorHazardous MinimumHazardous Maximum

2. Liner System

Use a single liner system
as specified in the EPA
guidance documents

Use a double liner
system as specified in
the EPA guidance
documents

Site-specific information for the plant disposal site was input into the LFDESIGN Model. Table 4.1 contains a copy of the plant input information under the hazardous minimum scenario. The ash quantities in Table 4.1 are 35 year average generation rates. Using the plant input information and a U.S. Geologic Survey quadrant sheet, the designer uses the LFDESIGN Model to perform iterative cell geometry calculations in order to balance cut and fill earthwork quantities and to lay out the proposed cells on the site map. The proposed cell geometry for the land disposal facility is shown in Table 4.2. Figure 4.1 is a layout of the cells which are proposed for ash disposal under the hazardous waste scenario. Figures 4.2 and 4.3 show typical cell cross sections which are proposed for the hazardous-minimum and hazardous-maximum designs. These cell sections were prepared based on information contained in EPA's guidance documents.

COST ESTIMATES

The cost estimating approach presented is based directly on the hazardous waste disposal site modifications as described in the previous section. Material and labor quantities were estimated for the hazardous waste construction, operation and closure activities. Regional unit costs for material and labor were developed by adjusting national costs by published construction cost indices. Capital and operating costs were then used to calculate revenue requirements. This methodology estimates future revenue requirements in terms of present worth in 1980 dollars, and then averages them into a "levelized" estimate of annual revenue requirements in terms of average inflated dollars over the 35-year design life.

The construction cost items are identified in Table 4.3. Construction costs are adjusted by factors for contractor overhead and profit, engineering and legal costs, and contingency monies to provide the

FIGURE 4.1

HAZARDOUS MINIMUM LANDFILL – TYPICAL CELL HALF SECTION ⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

FIGURE 4.2

HAZARDOUS MAXIMUM LANDFILL – TYPICAL CELL HALF SECTION⁽¹⁾

NOTES:

(1) SEE APPENDIX C FOR MORE DETAIL ON CONSTRUCTION SPECIFICATIONS.

(2) 24" IS A MINIMUM. MAY BE THICKER WHERE NECESSARY FOR FREEZE/THAW PROTECTION.

construction capital requirement for the hazardous design. Closure costs are treated in the same manner. In Table 4.4 the construction and closure capital expenditures are levelized by an annual fixed charge rate. Expenditures levelized over the facility life are projected by using factors for the escalation rate, cost of capital, taxes and personnel benefits.

Table 4.5 contains O&M costs for the proposed hazardous design which are divided between administrative and non-administrative cost. The administrative costs include insurance premiums, manifesting, sampling and analytical costs. Table 4.6 contains the levelized revenue requirement for the O&M costs. Table 4.7 presents a cost summary of the total levelized revenue requirements for the hazardous waste disposal facility. Tables 4.8 through 4.14 contain capital and O&M costs for the other design condition of interest namely hazardous maximum - the probable maximum cost of complying with the regulations. The major difference between hazardous minimum and maximum is the use of a double liner and stringent closure requirements as shown in Table 4.9. The maximum levelized revenue for this case is presented in Table 4.14.

TABLE 4.1

HAZARDOUS MIN SUMMARY OF INPUT INFORMATION

Site Code: 14

Design Mode: Hazardous Min

Date 11-11-1982

Power Plant Information (1980)

Generating capacity of plant	1155 mw
Generating capacity of largest boiler	275 mw

Waste Production Information *

Fly ash	171000 dry ton/yr
Bottom Ash	56500 dry ton/yr

No FGD

Waste densities (as disposed)

Fly ash	65.3 lb/cu ft
Bottom ash	62 lb/cu ft

General Disposal Site Information

Site area	660 acres
Percent heavily wooded	45 %
Percent lightly wooded	45 %
Site perimeter	21250 ft
Distance to plant	10 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	2800 ft
Thickness of soils above bedrock	50 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	20 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	10 mi

Climatic Information

Maximum frost penetration	10 in
Total annual precipitation	46.12 in
10-yr, 24-hr rainfall event	5.2 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

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TABLE 4.2

HAZARDOUS MIN CELL GEOMETRY

Number of cells	8
Cell volume	1144939 cu yd
Depth of waste at edge of fill	40 ft
Cell dimensions	
length at top	1623 ft
width at top	541 ft
length at bottom	1463 ft
width at bottom	381 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	11140 ft

Disposal Cell Cross-Section
Dry Landfill w/ Single Liner

NOTE: Datum is below existing ground surface an average of 15 feet at this site

TABLE 4.3

HAZARDOUS MIN CAPITAL COSTS

Construction Cost Items (1980-2014)

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	660	[acres]	2,748	1,813,680
clear and grub	514	[acres]	1,285	618,712
heavy stump removal	231	[acres]	824	190,554
light stump removal	231	[acres]	495	114,332
final grading	416	[acres]	499	207,576
cut & fill non-compacted	1,351,791	[cy]	1.39	1,882,126
on-site structural cut/fill	1,611,129	[cy]	2.19	3,527,148
borrow material import	792,317	[cy]	6.78	5,370,640
topsoil removal & stockpile	625,135	[cy]	1.39	870,388
sand collection zone plant	692,265	[cy]	8.87	5,586,550
sand import	692,265	[cy]	5.82	4,026,628
clay liner/cap placement	675,695	[cy]	4.31	2,909,865
synthetic membrane	15,137,750	[sf]	0.51	7,765,060
seeding and mulching -grass	2,012,472	[sq]	0.38	774,238
gravel stabilization	3,967	[sq]	0.64	2,544
plastic filter fabric	1,681,973	[sq]	0.66	1,109,295
light duty bituminous road	10,534	[lf]	11.61	122,351
heavy duty bituminous road	300	[lf]	15.24	4,573
perimeter fencing	21,250	[ft]	10.99	233,580
plastic pipe, pvc-4"	35,674	[lf]	9.11	325,138
plastic pipe, pvc-6"	28,768	[lf]	13.13	377,617
leachate collect sumps	1,600	[lf]	86.10	137,766
soil borings	8,316	[lf]	13.74	114,262
groundwater monitoring wells	668	[lf]	10.99	7,347

CELL CONSTRUCTION COST SUBTOTAL

\$38,091,980.

Leachate Treatment Plant Construction Cost \$1,839,443.
Wet-to-dry conversion cost of Fly ash and Bottom ash \$4,580,805.
Construction Cost for Closure of Existing Disposal Site(s) \$2,236,872

CONSTRUCTION COST TOTAL

\$46,749,100.

Contractor Overhead 15%
Contractor Profit 10%
Engineering & Legal Costs 10%
Contingency 15%

50%

Other Capital Items = \$46,749,100. x 0.50 =

\$23,374,550.

Permitting Cost

\$250,000

TOTAL CAPITAL REQUIREMENT =

\$70,373,650.

* Site Cost Adjustment Factor (SCAF) = .916
Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.4

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	20,377,930	1.0000	20,377,930
1984	7,142,246	0.9131	6,521,585
1989	7,142,246	0.8149	5,820,216
1993	7,142,246	0.7441	5,314,545
1998	7,142,246	0.6641	4,743,166
2002	7,142,246	0.6064	4,331,058
2006	7,142,246	0.5536	3,953,947
2011	7,142,246	0.4941	3,528,984
Total Cap Exp	\$70,373,652		
Present Worth of all Capital Costs			\$54,591,431
Total Levelizing Factor (LF) =		0.0740	
Levelized Capital Cost = LF x Present Worth of all Capital Costs			
LEVELIZED ANNUAL CAPITAL COST			\$4,039,766

[Plant # 14]

TABLE 4.5

HAZARDOUS MIN OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	171,000	3.21	548,226	Dry disposal
Bottom ash	56,500	3.21	181,139	Dry-disposal
Total handling			729,365	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	171,000	1.95	333,635	open on road truck (16cy) 10 mi. hau
Bottom ash	56,500	1.95	110,236	open on road truck (16cy) 10 mi. hau
Total transportation			443,871	
Landfill costs				
Flyash	171,000	1.11	190,120	
Bottom ash	56,500	1.17	66,161	
Total landfill cost			256,281	
Leachate Treatment Plant O and M			\$169,000	
Total non-administrative O and M			\$1,618,597	

Administrative O&M Cost Items

Manifesting	\$12,437
Groundwater monitoring	\$19,044
Inspection	\$7,315
Personnel training	\$1,099
Non-sudden occurrence insurance	\$28,260
General administration	\$45,092
Total Annual Administration cost	\$113,247

Total annual operation and maintenance cost \$1,731,844

Post closure O&M costs

Existing site (1980-2010)	\$48,562
New site	
Groundwater monitoring	\$38,007
Inspection	\$14,630
Maintenance	\$48,866
Administrative services	\$5,130
Total annual post closure cost (2014-2044)	\$106,713

TABLE 4.6
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	1,780,406	1.0000	1,780,406	Begin post closure operation and maintenance of existing site
1981	1,780,406	0.9775	1,740,347	
1982	1,780,406	0.9555	1,701,178	
1983	1,780,406	0.9341	1,663,077	
1984	1,780,406	0.9131	1,625,689	
1985	1,780,406	0.8925	1,589,012	
1986	1,780,406	0.8725	1,553,404	
1987	1,780,406	0.8528	1,518,330	
1988	1,780,406	0.8337	1,484,324	
1989	1,780,406	0.8149	1,450,853	
1990	1,780,406	0.7966	1,418,271	
1991	1,780,406	0.7787	1,386,402	
1992	1,780,406	0.7612	1,355,245	
1993	1,780,406	0.7441	1,324,800	
1994	1,780,406	0.7273	1,294,889	
1995	1,780,406	0.7110	1,265,869	
1996	1,780,406	0.6950	1,237,382	
1997	1,780,406	0.6794	1,209,608	
1998	1,780,406	0.6641	1,182,368	
1999	1,780,406	0.6492	1,155,840	
2000	1,780,406	0.6346	1,129,846	
2001	1,780,406	0.6203	1,104,386	
2002	1,780,406	0.6064	1,079,638	
2003	1,780,406	0.5927	1,055,247	
2004	1,780,406	0.5794	1,031,567	
2005	1,780,406	0.5664	1,008,422	
2006	1,780,406	0.5536	985,633	
2007	1,780,406	0.5412	963,556	
2008	1,780,406	0.5290	941,835	
2009	1,780,406	0.5171	920,648	
2010	1,780,406	0.5055	899,995	
2011	1,731,844	0.4941	879,704	
2012	1,731,844	0.4830	859,481	End post closure operation and maintenance of existing site
2013	1,731,844	0.4722	839,777	
2014	1,731,844	0.4616	819,419	
2015	106,713	0.4512	48,149	
2016	106,713	0.4410	47,060	Begin post closure operation and maintenance
2017	106,713	0.4311	46,004	
2018	106,713	0.4214	44,969	
2019	106,713	0.4120	43,966	
2020	106,713	0.4027	42,973	
2021	106,713	0.3936	42,002	
2022	106,713	0.3848	41,063	
2023	106,713	0.3761	40,135	
2024	106,713	0.3677	39,238	
2025	106,713	0.3594	38,353	

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[Plant # 14]

TABLE 4.6 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$
2026	106,713	0.3513	37,488
2027	106,713	0.3434	36,645
2028	106,713	0.3357	35,824
2029	106,713	0.3282	35,023
2030	106,713	0.3208	34,234
2031	106,713	0.3136	33,465
2032	106,713	0.3065	32,708
2033	106,713	0.2996	31,971
2034	106,713	0.2929	31,256
2035	106,713	0.2863	30,552
2036	106,713	0.2799	29,869
2037	106,713	0.2736	29,197
2038	106,713	0.2674	28,535
2039	106,713	0.2614	27,895
2040	106,713	0.2555	27,265
2041	106,713	0.2498	26,657
2042	106,713	0.2442	26,059
2043	106,713	0.2387	25,472
2044	106,713	0.2333	24,896

End post closure operation
and maintenance

Total Present Worth of Future Costs :

\$44,426,371

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

\$1,293,969

[Plant # 14]

TABLE 4.7

HAZARDOUS MIN COST SUMMARY FOR PLANT NO. 14

Levelized Capital Cost

\$4,039,766

Levelized Operation and Maintenance Costs

\$1,293,969

Total Levelized Revenue Requirement

\$5,333,735

Levelized Revenue Requirement per Ton of Waste Disposed

\$23.44

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$20.40

TABLE 4.8

HAZARDOUS MAX SUMMARY OF INPUT INFORMATION

Site Code: 14

Design Mode: Hazardous Max

Date 11-11-1982

Power Plant Information (1980)

Generating capacity of plant	1155 mw
Generating capacity of largest boiler	275 mw

Waste Production Information *

Fly ash	171000 dry ton/yr
Bottom ash	56500 dry ton/yr
No FGD	

Waste densities (as disposed)

Fly ash	65.3 lb/cu ft
Bottom ash	62 lb/cu ft

General Disposal Site Information

Site area	666 acres
Percent heavily wooded	45 %
Percent lightly wooded	45 %
Site perimeter	21250 ft
Distance to plant	10 mi
Distance to main road	300 ft
Distance from disposal site to leachate treatment plant	2800 ft
Thickness of soils above bedrock	50 ft
Thickness of topsoil at site	2 ft
Groundwater table depth	20 ft

Construction Materials

Clay availability on-site	yes
Sand availability on-site	no
Sand import distance	10 mi

Climatic Information

Maximum frost penetration	10 in
Total annual precipitation	46.12 in
10-yr, 24-hr rainfall event	5.2 in

* note: Average for period 1980-2014. If dry disposal is utilized, densities reflect a 1.2 compaction factor.

[14011-11-1982#00:31:53]

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TABLE 4.9

HAZARDOUS MAX CELL GEOMETRY

Number of cells	8
Cell volume	1144939 cu yd
Depth of waste at edge of fill	48 ft
Cell dimensions	
length at top	1623 ft
width at top	541 ft
length at bottom	1463 ft
width at bottom	381 ft
Cell dike information	
Dike side slopes	
exterior	3 horiz : 1 vert
interior	2 horiz : 1 vert
Average width at top of dike	28 ft
Total length of exterior dike	11140 ft

Disposal Cell Cross-Section
Dry Landfill w/ Double Liner

NOTE: Datum is below existing ground surface an average of 15 feet at this site

TABLE 4.10

HAZARDOUS MAX CAPITAL COSTS**Construction Cost Items (1980-2014)**

ITEM	QUANTITY	UNIT	UNIT* COST	EXTENSION
real estate	660	[acres]	2,748	1,813,680
clear and grub	514	[acres]	1,285	618,712
heavy stump removal	231	[acres]	824	190,554
light stump removal	231	[acres]	495	114,332
final grading	416	[acres]	499	207,576
cut & fill non-compacted	2,061,537	[cy]	1.39	2,870,319
on-site structural cut/fill	920,460	[cy]	2.19	2,015,109
borrow material import	1,882,838	[cy]	6.78	12,762,629
topsoil removal & stockpile	639,900	[cy]	1.39	890,946
sand collection zone p/cmt	850,931	[cy]	8.07	6,866,975
sand import	850,931	[cy]	5.82	4,949,522
clay liner/cap placement	1,367,524	[cy]	4.31	5,889,186
synthetic membrane	15,338,870	[sf]	0.51	7,868,227
seeding and mulching -grass	2,012,472	[sy]	0.38	774,238
gravel stabilization	3,967	[sy]	0.64	2,544
plastic filter fabric	1,704,319	[sy]	0.66	1,124,832
light duty bituminous road	10,534	[lf]	11.61	122,351
heavy duty bituminous road	300	[lf]	15.24	4,573
perimeter fencing	21,250	[ft]	10.99	233,580
plastic pipe, pvc-4"	71,348	[lf]	9.11	650,276
plastic pipe, pvc-6"	57,536	[lf]	13.13	755,234
leachate collect sumps	1,600	[lf]	86.10	137,766
soil borings	8,316	[lf]	13.74	114,262
groundwater monitoring wells	668	[lf]	16.99	7,347

CELL CONSTRUCTION COST SUBTOTAL

\$50,983,980.

Leachate Treatment Plant Construction Cost \$1,839,443.
Wet-to-dry conversion cost of Fly ash and Bottom ash \$4,580,805.
Construction Cost for Closure of Existing Disposal Site(s) \$5,949,420

CONSTRUCTION COST TOTAL

\$63,353,650.

Contractor Overhead 15%
Contractor Profit 10%
Engineering & Legal Costs 10%
Contingency 15%

50%

Other Capital Items = \$63,353,650. x 0.50 =

\$31,676,820.

Permitting Cost

\$500,000

TOTAL CAPITAL REQUIREMENT =

\$95,530,460.

* Site Cost Adjustment Factor (SCAF) = .916
Site Unit Cost = SCAF x National-Average Unit Cost

TABLE 4.11

HAZARDOUS MAX 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	28,614,000	1.0000	28,614,000
1984	9,559,496	0.9131	8,728,776
1989	9,559,496	0.8149	7,790,033
1993	9,559,496	0.7441	7,113,221
1998	9,559,496	0.6641	6,348,461
2002	9,559,496	0.6064	5,796,878
2006	9,559,496	0.5536	5,292,137
2011	9,559,496	0.4941	4,723,347

Total Cap Exp \$95,530,472

Present Worth of all Capital Costs \$74,406,854

Total Levelizing Factor (LF) = 0.0740

Levelized Capital Cost = LF x Present Worth of all Capital Costs

LEVELIZED ANNUAL CAPITAL COST \$5,506,107

[Plant # 14]

TABLE 4.12

HAZARDOUS MAX OPERATION AND MAINTENANCE COSTS

Non-Administrative Annual O&M Costs

	quantity (tons)	unit cost (\$)	total annual \$	comments
Ash handling				
Flyash	171,000	3.21	548,226	Dry disposal
Bottom ash	56,500	3.21	181,139	Dry disposal
Total handling			729,365	
Ash excavation				
Total excavation			none	
Ash transportation				
Flyash	171,000	1.95	333,635	open on road truck (16cy) 10 mi. hau
Bottom ash	56,500	1.95	110,236	open on road truck (16cy) 10 mi. hau
Total transportation			443,871	
Landfill costs				
Flyash	171,000	1.11	190,120	
Bottom ash	56,500	1.17	66,161	
Total landfill cost			256,281	
Leachate Treatment Plant O and M			\$189,080	
Total non-administrative O and M			-----\$1,618,597-----	

Administrative O&M Cost Items

Manifesting	\$12,437
Groundwater monitoring	\$19,844
Inspection	\$7,315
Personnel training	\$1,099
Non-sudden occurrence insurance	\$28,260
General administration	\$45,092
Total Annual Administration cost	-----\$113,247-----
Total annual operation and maintenance cost	\$1,731,844

Post closure O&M costs

Existing site (1980-2010)	\$48,562
New site	
Groundwater monitoring	\$38,087
Inspection	\$14,630
Maintenance	\$48,866
Administrative services	\$5,130
Total annual post closure cost (2014-2044)	-----\$106,713-----

TABLE 4.13
HAZARDOUS MAX 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	1,780,406	1.0000	1,780,406	Begin post closure operation and maintenance of existing site
1981	1,780,406	0.9775	1,740,347	
1982	1,780,406	0.9555	1,701,178	
1983	1,780,406	0.9341	1,663,077	
1984	1,780,406	0.9131	1,625,689	End post closure operation and maintenance of existing site
1985	1,780,406	0.8925	1,589,012	
1986	1,780,406	0.8725	1,553,404	
1987	1,780,406	0.8528	1,518,330	
1988	1,780,406	0.8337	1,484,324	
1989	1,780,406	0.8149	1,450,853	
1990	1,780,406	0.7966	1,418,271	
1991	1,780,406	0.7787	1,386,402	
1992	1,780,406	0.7612	1,355,245	
1993	1,780,406	0.7441	1,324,800	
1994	1,780,406	0.7273	1,294,889	
1995	1,780,406	0.7110	1,265,869	
1996	1,780,406	0.6950	1,237,382	Begin post closure operation and maintenance
1997	1,780,406	0.6794	1,209,608	
1998	1,780,406	0.6641	1,182,368	
1999	1,780,406	0.6492	1,155,840	
2000	1,780,406	0.6346	1,129,846	End post closure operation and maintenance of existing site
2001	1,780,406	0.6203	1,104,386	
2002	1,780,406	0.6064	1,079,638	
2003	1,780,406	0.5927	1,055,247	
2004	1,780,406	0.5794	1,031,567	Begin post closure operation and maintenance
2005	1,780,406	0.5664	1,008,422	
2006	1,780,406	0.5536	985,633	
2007	1,780,406	0.5412	963,556	
2008	1,780,406	0.5290	941,835	
2009	1,780,406	0.5171	920,648	
2010	1,780,406	0.5055	899,995	
2011	1,731,844	0.4941	855,704	
2012	1,731,844	0.4830	836,481	
2013	1,731,844	0.4722	817,777	
2014	1,731,844	0.4616	799,419	
2015	106,713	0.4512	48,149	
2016	106,713	0.4410	47,060	End post closure operation and maintenance of existing site
2017	106,713	0.4311	46,004	
2018	106,713	0.4214	44,969	
2019	106,713	0.4120	43,966	
2020	106,713	0.4027	42,973	Begin post closure operation and maintenance
2021	106,713	0.3936	42,002	
2022	106,713	0.3848	41,063	
2023	106,713	0.3761	40,135	
2024	106,713	0.3677	39,238	End post closure operation and maintenance of existing site
2025	106,713	0.3594	38,353	

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[Plant # 14]

TABLE 4.13 (continued)

YEAR	O&M COST EXPRESSED IN 1980 \$	PRESENT WORTH FACTOR	PRESENT WORTH OF O&M COST IN 1980 \$	
2026	106,713	0.3513	37,488	
2027	106,713	0.3434	36,645	
2028	106,713	0.3357	35,824	
2029	106,713	0.3282	35,023	
2030	106,713	0.3208	34,234	
2031	106,713	0.3136	33,465	
2032	106,713	0.3065	32,708	
2033	106,713	0.2996	31,971	
2034	106,713	0.2929	31,256	
2035	106,713	0.2863	30,552	
2036	106,713	0.2799	29,869	
2037	106,713	0.2736	29,197	
2038	106,713	0.2674	28,535	
2039	106,713	0.2614	27,895	
2040	106,713	0.2555	27,265	
2041	106,713	0.2498	26,657	
2042	106,713	0.2442	26,059	
2043	106,713	0.2387	25,472	
2044	106,713	0.2333	24,896	End post closure operation and maintenance
Total Present Worth of Future Costs :			\$44,426,371	
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			\$1,293,969	

TABLE 4.14

HAZARDOUS MAX COST SUMMARY FOR PLANT NO. 14

Levelized Capital Cost

\$5,506,107

Levelized Operation and Maintenance Costs

\$1,293,969

Total Levelized Revenue Requirement

\$6,800,076

Levelized Revenue Requirement per Ton of Waste Disposed

\$29.89

Levelized Revenue Requirement per Cubic Yard of Waste Disposed

\$26.01

SECTION 5

SUMMARY

The current practice, non-hazardous and hazardous cost information is summarized in the following chart:

<u>Design Mode</u>	<u>Levelized Capital Cost</u>	<u>Levelized Operating Cost</u>	<u>Total Levelized Revenue</u>	<u>Levelized Revenue Per ton</u>	<u>Levelized Revenue Per CuYd</u>
Current Practice	\$ 349,000	\$ 827,000	\$ 1,176,000	\$ 5.17	\$ 3.75
Non-Hazardous	841,000	844,000	1,686,000	7.41	5.37
Hazardous Minimum	4,040,000	1,294,000	5,334,000	23.44	20.40
Hazardous Maximum	5,506,000	1,294,000	6,800,000	29.89	26.01

As mentioned in the Introduction of this report, ES is interested in determining the incremental costs between each design mode which was examined. As such, the above costs for the plant will be combined with information from a number of other utilities. As is evident, all of the design modes were obtained by making a number of assumptions. ES will perform a sensitivity analysis on these assumptions and explore them in a report which will be issued to DOE.

REFERENCES

R. S. Means Company, Inc., 1979, Building Construction Cost Data 1980, Kingston, MA.

★U.S. GOVERNMENT PRINTING OFFICE:1987 .748 -172/ 40168