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# PREFEASIBILITY STUDY

# OIL SHALE UTILIZATION FOR POWER PRODUCTION IN THE HASHEMITE KINGDOM OF JORDAN

## VOLUME IV OF VI - APPENDIX 5
## MINING STUDY

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JORDAN OIL SHALE TO POWER
PREFEASIBILITY STUDY

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Appendix 5

# PREFEASIBILITY STUDY

# OIL SHALE UTILIZATION FOR POWER PRODUCTION IN THE HASHEMITE KINGDOM OF JORDAN

## THE MINING REPORT

Includes:

Mining Plans
Shale Processing (Crushing) Plans
Spent Shale Ash and Overburden Disposal Plans

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## 1.0 INTRODUCTION

This portion of the Oil Shale to Power Prefeasibility Study includes those studies for determining estimates of cost for the oil shale to be used as fuel in the 20 MW Demonstration Plant, the 50 MW Prototype Plant and the 400 MW Full Scale Power Plant. In making these determinations, conceptual plans were made for the development of the mine, and the oil shale processing plant to prepare proper sized fuel for the power plant. The cost estimates presented in this report are order of magnitude estimates with a range spread of minus 15 percent and plus 25 percent.

The report covers an evaluation of the reserves as to quantity and quality based on information provided by the Natural Resources Authority (NRA). This information included geologic maps of the Sultani deposit and a geological and core assay report prepared by the NRA project staff.

For each of the three plant sizes studied, a description of the mine development, the mining operation and the processing plant is included in the report. Based on these descriptions and design basis, capital and operating costs were determined.

The end product of this section of the report is the cost of producing fuel for each of the three different sized power plants. Cash flow analyses were made for each of the three plants for debt-equity financing ratios of 50:50 and 80:20. Included in these analyses are the capital expenditures for the mine development, the mining equipment and the oil shale processing facilities, spare parts, working capital, interest during construction for both debt-equity cases, the operating costs, interest expenses for both debt-equity cases, depreciation and amortization, a management fee, royalty, and a return on equity for both debt-equity cases. Excluded from these analyses are resource cost or depletion allowance, advalorem taxes, sales and use taxes, income taxes for expatriate employees and income taxes for project operation.

With the much larger volumes of materials to be handled for the 400 MW Full Scale Plant, different concepts from those used in the smaller plants were developed. The application of larger overburden removal equipment, the employment of continuous surface miners for selective mining of the oil shale, the use of a conveying system from the bottom of the pit to two large blending facilities, and a redundant crushing and screening plant for improved reliability of oil shale processing and supply are the main features of the larger plant.

Employing these new concepts sustantially decreases the cost of the processed oil shale which could not be achieved by factoring these costs from the smaller plants.

This report also includes a section on spent shale disposal for the three different sized plants. Capital and operating costs were determined for each plant as well as cash flow analysis to arrive at an estimated cost for the disposal of the spent shale. These estimates also are based on debt-equity ratios of 50:50 and 80:20.

Also included is a section on the infrastructure requirements for the mine and processing plant including electric power, water and housing for the employees.

In the last section of the report is a comparison of cost for mining the oil shale as prepared in this report with the quoted contractor's price.

Figure 1.1, Tenative Jordan Oil Shale Layout is located on the following page. This figure shows the relationship of the reserves, mine, process plant and power plant. It will be referred to in the text of the report.



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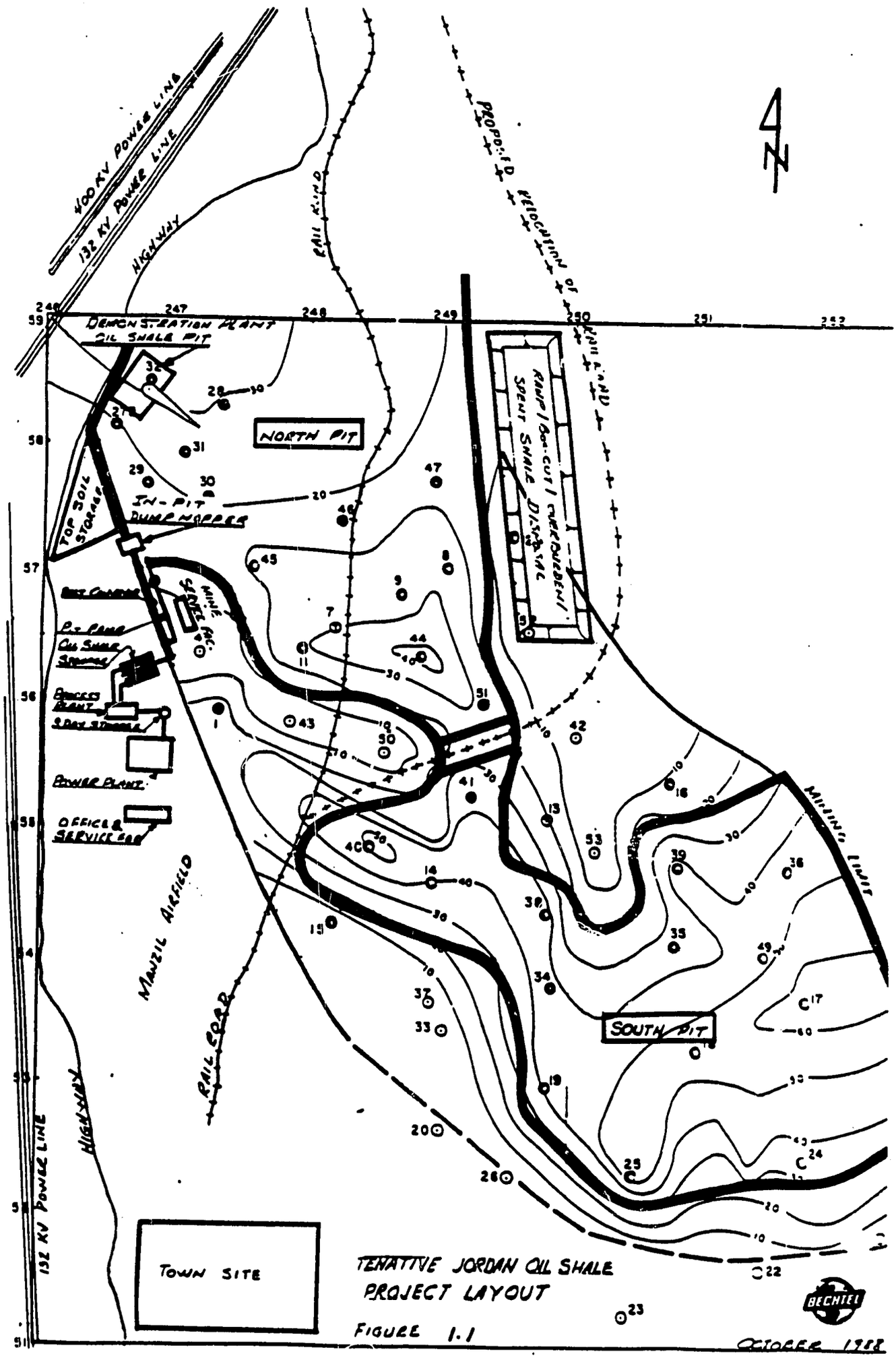


TENATIVE JORDAN OIL SHALE PROJECT LAYOUT

FIGURE 1.1

OCTOBER 1988

14'

## 2.0 SUMMARY AND CONCLUSION

### 2.1 Reserves

2.1.1 A total of 53 drill holes were drilled in previous programs to delineate the reserves at Sultani. In a recent drill program 25 drill holes were drilled on 150 metre spacings to define the reserves in the northwest section of these reserves. In excess of 6000 metres were drilled in total of which nearly 20 percent was cored for analytical determinations. The oil content was determined in 67 of these holes and analyses for minerals and carbon content were determined for 15 drill holes.

2.1.2 Based on the mineable reserve criteria of using reserves with five percent oil content or greater and a stripping ratio of overburden volume to oil shale volume of less than 3:1, the findings of this investigation are summarized as follows:

Table 2-1

SULTANI OIL SHALE RESERVES

| AREA | OIL SHALE TONNE X $10^6$ | OIL CONTENT PERCENT | OVERBURDEN $m^3$ X $10^6$ | STRIP RATIO $m^3 : m^3$ |
|---|---|---|---|---|
| North | 320 | 7.44 | 384 | 2.16:1 |
| South | 658 | 7.61 | 627 | 1.71:1 |
| Total | 978 | 7.65 | 1011 | 1.86:1 |

When the mining criteria is applied to these reserves, the deposit has two distinct mining areas: one in the north and one in the south separated by a narrow throat of low grade oil shale in the central part of the deposit.

2.1.3 The mineable reserves as determined from the criteria were classified into reserves by their oil content and these results are summarized as follows:

Table 2-2

SULTANI OIL SHALE RESERVES BY OIL CONTENT

| AREA | 5% OIL T X $10^6$ | 6% OIL T X $10^6$ | 7% OIL T X $10^6$ | 8% OIL T X $10^6$ | 9% OIL T X $10^6$ | 10% OIL T X $10^6$ | TOTAL T X $10^6$ |
|---|---|---|---|---|---|---|---|
| North | NIL | 24.440 | 158.075 | 114.407 | 23.407 | -- | 320.329 |
| South | 2.075 | 82.416 | 238.067 | 186.870 | 144.420 | 4.750 | 658.598 |
| TOTAL | 2.075 | 106.856 | 396.142 | 301.277 | 167.827 | 4.750 | 978.927 |

2.1.4 Other findings of this investigation of importance are listed below:

- The overburden thickness ranges between 34 metres and 86 metres. The minimum thickness is found in the northwest part of the deposit and the maximum is in the southeast.

- Oil shale thickness varies between 1.5 metres and 65 metres with the greatest thickness occurring in the southeast section of the reserves.

- The thicker oil shale beds contain a higher percentage of oil.

- Average organic carbon content of the oil shale tested ranged between 8 and 11 percent by weight.

- The sulfur content varies between 1.6 and 4.3 percent with most values between 2 and 3 percent.



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2.1.5 It appears that sufficient oil reserves are available to support a 400 MW plant in the north area of the reserves. With indications that the reserves in the south area are twice as large, the Sultani oil reserves have a potential of supporting as much as 1200 MW of power generation for 30 years.

## 2.2 Mine Planning

### 2.2.1 Environmental

For each of the three power plants, the mine planning considers measures to mitigate surface and ground water contamination and the fugitive dust from the mine operation. Prior to commencement of any on-site operations, environmental baseline studies should be conducted to develop data in all environmental media areas.

### 2.2.2. Mine Development Plans

The mine development plans for the 20 MW and 50 MW projects differ from those of the 400 MW plant because of the large volumes of material handled in the latter. For the two smaller projects the expansion of the existing trial mine into a loader and truck operation is considered. At the base of the incline a box-cut will be excavated to expose the oil shale reserves. Working benches and a system of roads and ramps in the overburden and oil shale will be developed in preparation for the production stage. Three haulroads will be constructed for transporting the following materials:

- Overburden from the pit to an out-of-pit waste pile.
- Oil shale from the pit to the process plant storage piles.

- Spent shale ash from the power plant to the out-of-pit waste pile.

The mine opening for the 400 MW plant will be located in the north area. This development will consist of a new incline and box-cut, the development of the working faces for electric shovels and trucks and the in-pit-system of roads and ramps. When the oil shale is mined, it will be fed onto a belt conveyor for conveying to the surface via the incline. In the first several years of operation, the incline will be used for haulage of overburden from the pit to the out-of-pit waste pile, until the backfill of the pit can be started. This operation will require haulroads for the disposal of the overburden and the spent shale.

The estimated volumes of materials to be excavated during the development stage of these mines are as follows:

Table 2-3

MINE DEVELOPMENT EXCAVATION

| MINE | BANK CUBIC METRES |
|---|---|
| 20 MW Plant | 500,000 |
| 50 MW Plant | 1,000,000 |
| 400 MW Plant | 8,455,000 |

### 2.2.3 Mine Service Facilities

The mine service facilities are provided for each of the three mines to maintain and warehouse parts

for the mining equipment and the oil shale processing plant. The overhaul and repair of equipment components will be let to local contractors. In addition to these services, the facilities will include offices, training rooms, a change house and cafeteria. A water well will supply the water needs of these facilities, including fire protection, as well as water for dust suppression of the haulroads.

### 2.2.4 Mine Operations

After the top-soil is removed from the mining area the overburden benches are individually drilled and blasted. The overburden for the mines of the 20 MW and 50 MW plants are loaded by front end loaders with bucket capacities of 10 cubic metres into 77 tonne trucks, whereas the overburden of the mine for the 400 MW plant will be loaded by 20 cubic metre electric power shovels into 136 tonne trucks. Overburden will be hauled to the out-of-pit waste pile until sufficient space is available in the mine to start backfilling. Mining of the oil shale for the two smaller mines will be by bulldozers ripping the oil shale and scrapers loading the ripped shale for delivery to the portable crusher. Mining of the shale in the larger mine will be by surface miners which load the broken shale, minus 150 mm, into trucks for delivery to the truck dump hoppers. Selective mining will be practiced in each of the mines.

The operating and production schedules for these mines are as follows:



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Table 2-4

MINE OPERATING AND PRODUCTION SCHEDULES

| MINE | OPERATING SCHEDULE SHIFTS/YR. | PRODUCTION SCHEDULE TONNES/YR |
|---|---|---|
| 20 MW Plant | 300 | 390,000 |
| 50 MW Plant | 900 | 973,000 |
| 400 MW Plant | 900 | 7,783,000 |

### 2.2.5 Oil Shale Handling

Oil shale at the mines for the 20 MW and 50 MW plants will be placed in stockpiles by the scrapers according to grade. A front end loader will feed a portable crusher from these stockpiles. The crushed material is loaded directly from the crusher into 77 tonne trucks for transport to the surface oil shale process plant stockpiles. While one stockpile is being built and tested, the second is being reclaimed and loaded by front end loader into the processing system. The performance specification of the oil shale is approximated in three steps before it enters the process plant for crushing; namely, selective mining, mixing at the portable crusher and reclaiming from stock pile.

Oil shale from the mine supporting the 400 MW plant is selectively mined and loaded by two surface miners, each with a capacity of 2000 tonnes per hour, for delivery by 136 tonne trucks to the truck dump hoppers. The surface miners produce a product that is less than 200 mm, and therefore, a primary crusher is not required. From the hoppers the oil shale is moved to the surface via belt conveyor where it enters an automatic sampler before it is placed on a traveling stacker for stockpiling into two 'V' slot storages. While one stockpile is being built and tested, the second is reclaimed by



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two variable speed plow feeders for delivery to the process plant. This system has the capability of providing the process plant with large volumes of oil shale that will be relatively uniform in quality.

## 2.3 Oil Shale Processing

### 2.3.1 Crushing and Screening

Oil shale for the 20 MW and 50 MW plants will be processed in identical crushing plants. The process plant for the 20 MW plant is scheduled for 300 shifts per year; whereas, the 50 MW plant is scheduled for 900 shifts per year. Secondary crushing and sizing of the oil shale to a minus 8 mm product will be accomplished by a reversible impactor (373 kW motor) in closed circuit with a screen. The design capacity of this plant is 250 tonne per hour which will provide sufficient oil shale when the power plant is operating at 100 percent capacity.

The process plant for the 20 MW plant can attain this capacity while operating at an 87 percent efficiency. It is expected that this plant will operate with a minimum down time for maintenance which will be accomplished on the second and third shift, if necessary. The process plant for the 50 MW plant will operate at a 72 percent efficiency to achieve the design capacity. Maintenance downtime will occur during an operating shift.

The secondary crushing and screening plant for the 400 MW plant will consist of three parallel streams. Each stream will have a reversible impactor (1492 kW motor) in closed circuit with two screens. Two streams will be operating while the third will be on stand-by or out of service for



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maintenance. The design capacity of each stream is 1000 tonne per hour which is adequate for two streams operating at an overall efficiency of 72 percent to maintain the fuel requirements of the 400 MW plant while it operates at 100 percent capacity factor.

The friability of the Sultani oil shale has not been determined and it should be determined by test work before crushing equipment is selected. The impactors selected for the study are believed to be adequate for the capacity requirements.

### 2.3.2 Sampling, Storing and Blending

After the oil shale is crushed and sized, it enters a three stage sampler where reresentative samples are taken for analytical determinations. From the sampler the oil shale is conveyed to storage. The storage capacity is designed to hold a three day supply. For the 20 MW and 50 MW plants the storage capacity consists of three steel bins and for the 400 MW plant there are five concrete silos. The steel bins are each equipped with a variable speed feeder and each of the concrete silos have seven variable speed feeders. The final correction for the quality of the feed to the power plant is made at the time the oil shale is drawn from storage by blending the products from two or more bins or silos.

## 2.4 Capital Cost

The capital costs as determined are order of magnitude estimates based on budget prices from equipment vendors, Bechtel's experience and historical records for projects in that part of the world, and mining costs from a local Jordanian contractor. The summary of costs listed below

exclude interest during construction, spare parts and working capital. These costs are included in the cash flow analyses. The cost basis of this report is second quarter of 1988.

Table 2-5

SUMMARY OF CAPITAL COST

| | 20 MW US $1000 | 50 MW US $1000 | 400 MW US $1000 |
|---|---|---|---|
| Mine Development | 4900 | /833 | 30915 |
| Mine Equipment | 11090 | 12202 | 66012 |
| Process Plant Facilities | 6945 | 8388 | 60989 |
| TOTAL | 22935 | 28423 | 157916 |

## 2.5 Operating Cost

### 2.5.1 Summary of Operating Cost

Operating costs are comprised of costs associated with maintaining and operating the mine equipment, process plant facilities, the mine services facilities and the cost of the work force. Other operating costs such as explosives and insurance are included with the cash flow analysis.

Table 2-6

SUMMARY OF ANNUAL OPERATING COST

| | 20 MW Plant US $1000 | 50 MW Plant US $1000 | 400 MW Plant US $1000 |
|---|---|---|---|
| Mine Equipment | 828 | 2651 | 11935 |
| Process Plant | 127 | 290 | 2394 |
| Services Building | 25 | 50 | 150 |
| Labor | 735 | 1218 | 2411 |
| TOTAL | 1715 | 4209 | 16890 |



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### 2.5.2 Summary of Work Force

The mine and shale processing work force consisting of permanent expatriate employees, the non-manual employees such as supervisors, engineers and administrative workers, and the operators and maintenance workers is listed below for the 20,50 and 400 MW plants.

Table 2-7

SUMMARY OF WORK FORCE

| | 20 MW Plant | 50 MW Plant | 400 MW Plant |
|---|---|---|---|
| Expatriate | 2 | 2 | 2 |
| Non-Manual | 27 | 58 | 70 |
| Operators | 27 | 66 | 201 |
| Maintenance | 19 | 37 | 105 |
| TOTAL | 75 | 163 | 378 |

## 2.6 Cash Flow Analysis

The cash flow analysis for each of the three power plants reflects all costs known in the mining and preparation of the oil shale as a boiler fuel. The determined fuel costs are preliminary based on order of magnitude capital cost estimates, operating costs which are reasonable but variable, interest rates that could fluctuate, and all remaining costs that are subject to change. Although the fuel costs as determined are preliminary, it is expected that they will fall within the order of magnitude range of minus 15 percent and plus 25 percent.

Table 2-8

SUMMARY OF PROCESSED OIL SHALE COSTS

50/50 DEBT/EQUITY RATIO

| | 20 MW Plant US $1000 | 50 MW Plant US $1000 | 400 MW Plant US $1000 |
|---|---|---|---|
| Capital Expenditures | 27869 | 35115 | 187239 |
| Annual Cost | 6827 | 13118 | 56606 |
| Cost per Tonne, $/t | 17.50 | 13.48 | 7.74 |
| Cost per $10^6$Btu, $/$10^6$BTU | 3.53 | 2.72 | 1.56 |

Table 2-9

SUMMARY OF PROCESSED OIL SHALE COSTS
80/20 DEBT/EQUITY RATIO

| | 20 MW Plant US $1000 | 50 MW Plant US $1000 | 400 MW Plant US $1000 |
|---|---|---|---|
| Capital Expenditures | 29389 | 37031 | 201891 |
| Annual Cost | 5582 | 11556 | 48945 |
| Cost per Tonne, $/t | 14.31 | 11.88 | 6.69 |
| Cost per $10^6$Btu, $/$10^6$BTU | 2.89 | 2.39 | 1.35 |

The annual cost, cost per tonne and cost per million Btu are weighted average costs over a 25 year period. These costs reflect second quarter of 1988 costs and they are not escalated.

## 2.7 Spent Shale Disposal

2.7.1 Spent shale pugged with 20 percent water by weight will be conveyed from the pug mills to a dump area within the power plant site. The spent shale is loaded by frontend loader into haul trucks and hauled to the out-of-pit waste pile in the early years of plant operation and then to the backfilling operation in the pit. Equipment used for this purpose is the same as used in the mining operation and it is interchangeable. For this study it is assumed that the spent shale is non-toxic and that the amount of water used in pugging is adequate for dust control in the disposal plan and that no special measures are required to protect the ground water or to suppress fugitive dust when dumping the spent shale ash together with overburden.



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### 2.7.2 Spent Shale Disposal Costs

These costs were determined by the same method used for mining and preparing the oil shale as fuel for the power plant.

Table 2-10

SUMMARY OF SPENT SHALE DISPOSAL COSTS
50/50 DEBT/EQUITY RATIO

| | 20 MW Plant US $1000 | 50 MW Plant US $1000 | 400 MW Plant US $1000 |
|---|---|---|---|
| Capital Expenditures | 1618 | 2315 | 8572 |
| Annual Cost | 394 | 823 | 6378 |
| Cost per Tonne, $/t | 1.20 | 1.01 | 1.04 |

Table 2-11

SUMMARY OF SPENT SHALE DISPOSAL COSTS
80/20 DEBT/EQUITY RATIO

| | 20 MW Plant US $1000 | 50 MW Plant US $1000 | 400 MW Plant US $1000 |
|---|---|---|---|
| Capital Expenditures | 1664 | 2381 | 8714 |
| Annual Cost | 316 | 710 | 5987 |
| Cost per Tonne, $/t | 0.97 | 0.87 | 0.98 |

## 2.8 Comparison of Mining Costs with Contractors Price

The scope of work in the contractor's quoted prices is not defined, but the quotation appears to be for loading and hauling overburden and oil shale a certain distance for a price. If this assumption is correct, the additional work



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required would be done under a force account. From the Bechtel Prefeasibility Study report, selected costs were extracted for the total cost of mining oil shale excluding development cost and oil shale processing costs, and costs to reflect only drilling, blasting, loading and hauling associated with the mining of oil shale. The contractors quoted prices were determined on a cost per tonne basis for comparison. These costs comparisons are listed below:

Table 2-12

COMPARISON OF MINING COSTS WITH CONTRACTOR'S PRICE

| | 20 MW Plant $/Tonne | 50 MW Plant $/Tonne | 400 MW Plant $/Tonne |
|---|---|---|---|
| Bechtel Total Mining Cost | 8.12 | 7.42 | 3.86 |
| Bechtel Load and Haul Cost | 4.66 | 4.67 | 2.94 |
| Contractor's Price | 4.58 | 4.58 | 4.10-4.41 |



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## 3.0 RESERVE EVALUATION

### 3.1 Geology

The Sultani oil shale deposit is located 115 km south of Amman and it can be reached on the Amman-Aqaba Highway. The area is essentially flat, but the east side of the deposit is bordered by a ridge of moderately high mountains which is the limit of the oil shale deposit. Faults cross the area and the Sultani graben, in which the oil bearing Muwaqqar Chalk Marl Formation is preserved, is formed by two faults. The eastern boundary fault has a NNW-SSE trend and the western boundary fault has the same trend in the northern area but gradually changes course and meets the eastern fault in the SE corner of the deposit. The graben is approximately 3 km wide and 8 km long and dips generally towards the NE.

Underlying the Muwaqqar Chalk Marl Formation is the Al Hasa Phosphorite Formation. The phosphorite unit exists on the east and west of the Sultani graben and it was also encountered in the drilling within the graben. Overlying the Muwaqqar are fluviatile and lacustrine gravel of Pleistocene Age and alluvium and wadi sediments of Holocene to recent.

### 3.2 Previous Exploration

A total of 53 boreholes were drilled in two phases. The first phase occurred between 1982 and 1983 when 26 holes were drilled by the Natural Resources Authority (NRA) and BGR of the Federal Republic of Germany. Percussion drilling accounted for 2050 metres of this drilling and 255 metres were cored. The second phase was completed by NRA in 1986. A total of 2087 metres were drilled of which 387 metres were cored.

Based on this drilling, geologic maps were made of the deposit and consist of the following:

Structural contour map of the upper oil shale surface
Structural contour map of the lower oil shale surface
Isopach map of the overburden
Isopach map of the oil shale
Iso-line map of the oil content percent

The Fischer analysis was used to determine the oil content of 42 boreholes. Other analysis such as calcium carbonate, surfur, inorganic carbon and organic carbon were determined for 15 boreholes.

## 3.3 Findings of Oil Shale Exploration

From the conducted exploration programs, the following findings are summarized:

- The overburden thickness ranges between 34 metres and 86 metres. The minimum thickness is found in the NW part of the deposit and the maximum is in the SE.

- Oil shale thickness varies between 1.5 metres and 65 metres. The greatest thickness is in the SE part of the graben. The lower part of the Muwaqqar Chalk Marl Formation consists mainly of bituminous calcareous marl.

- The thicker oil shale beds contain a greater percentage of oil as compared to the thinner beds.

- Organic carbon was found in amounts averaging to between 8 and 11 percent.

- The sulfur content of the oil shale varies between 1.6 and 4.3 percent with most values between 2 and 3 percent.

## 3.4 Oil Shale Reserves

The reserves computations are based on the oil shale isopach map prepared by NRA. The geologic information for this map was obtained from drill holes spaced on approximately 1 km centers. Drilling information is sparse in the south end of the deposit as well as in the northeast area. More reserves exist north of the study area, but are excluded because of unavailable information. The available information is adequate for this prefeasibility study as the reserves fall into proven and probable categories. For the final mine planning more drilling and testing will be required.

Mineable reserves were determined on the basis of the following criteria:

- oil content of greater than 5 percent

- strip ratio of less than 3:1 (overburden, $m^3$: oilshale, $m^3$)

An overburden thickness cut-off was not considered because depths encountered in the southern part of the deposit can be mined successfully. Some of the deeper mineable reserves were eliminated by the established criteria.

Based on this criteria, the deposit has two distinct areas: one in the north and one in the south connected by a narrow throat of approximately one half kilometre wide of low grade oil shale in the central part of the deposit. Because of the two distinct areas, the reserves were calculated separately. Refer to Figure 1.1 for the mining limits of the reserves.

The findings of this investigation are summarized as follows:



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Table 3-1

SULTANI OIL SHALE RESERVES

| Area | Oil Shale Tonnex$10^6$ | Oil Content Percent | Overburden $M^3x10^6$ | Strip Ratios $M^3/M^3$ | Strip Ratios $M^3$/Tonne |
|---|---|---|---|---|---|
| North | 320 | 7.44 | 384 | 2.16:1 | 1.20:1 |
| South | 658 | 7.61 | 627 | 1.71:1 | 0.95:1 |
| Total | 978 | 7.55 | 1011 | 1.86:1 | 1.03:1 |

A density of 1.8 tonne per cubic metre was used in determning the quantity of oil shale. The strip ratios in a mining operation will be slightly higher than those tabulated above because of additional overburden from the pit end and side slopes and oil shale losses that occur in a mining operation.

## 3.5 Reserves by Percent Oil Content

Based on the 5 percent oil content cut-off, the oil shale reserves were determined by their oil content percentage as follows:

Table 3.2

OIL SHALE RESERVES BY PERCENT OIL CONTENT

| Area | 5% Oil t.x$10^6$ | 6% Oil t.x$10^6$ | 7% Oil t.x$10^6$ | 8% Oil t.x$10^6$ | 9% Oil t.x$10^6$ | 10% Oil t.x$10^6$ | Total t.x$10^6$ |
|---|---|---|---|---|---|---|---|
| North | Nil | 24.440 | 158.075 | 114.407 | 23.407 | - | 320.329 |
| South | 2.075 | 82.416 | 238.067 | 186.870 | 144.42 | 4.750 | 658.598 |
| Total | 2.075 | 106.856 | 396.142 | 301.277 | 167.827 | 4.750 | 978.927 |

The oil content percentages used in the above table are based on average values for a borehole. Oil content percentages as presented in the data were determined in sample increments of one metre. These determinations indicate oil contents that are substantially greater than the average values as well as oil shale samples that were nearly barren of oil.

## 3.6 Current Exploration

The NRA is currently exploring the area in the vicinity of the trial pit. The proposed drilling program has hole spacings on 150 metre centers and consists of 29 drill holes. The results of the four drill holes drilled in the trial pit, indicate that the oil content of the oil shale is about 7.5 percent which compares to the 7.55 percent determined for the entire deposit. Subsequent to the four hole drilling program, nine drill holes were drilled in Area 1 which is located south of the trial pit base and 15 drill holes were drilled in Area 2 located east of Area 1 on the south side of the trial pit. Two of the drill holes in Area 1 had negative results and were excluded from the Area 1 results which had a weighted average of 7.48 percent oil. Area 2 had an average of 7.75 percent oil.

It is recommended that additional core hole drilling continue in the areas south and north of this recent drilling on hole spacings of 150 metres. In the area east of this location, fill-in holes should be drilled to establish a grid that is on spacings of 500 metres. Only the North Pit area should be explored.



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## 4.0 20 MW DEMONSTRATION PLANT MINE PLAN

### 4.1 Environmental Considerations

Prior to the commencement of on-site operations, site specific environmental baseline studies should be conducted to develop data in all relevant areas. The key areas to be addressed are the development of protective measures for both surface and ground water supplies, the determination of measures to mitigate surface and groundwater contamination due to mining, further soil testing of the overburden for chemical properties and their suitability for revegetation, site specific air quality monitoring and modeling to ensure that models which are developed are predictive of the mining operation to aid in developing necessary mitigation practices, and the development of protective measures for noise levels and the determination of measures to mitigate noise levels due to mining for protecting the health and welfare of the general public. The program should also develop specific plans and measures related to special conditions, socioeconomic impacts, archeology, paleontology, historical, recreation and human health effects.

### 4.2 Mine Development Plan

A minimum capital expenditure for the development of this small mine is in the best interest of the project to keep the fuel costs as low as possible. It is, therefore, recommended that the existing trial pit be expanded during the construction phase of the demonstration power plant so that the mine can meet the fuel requirement when the power plant is placed in commercial operation. Assuming that the demonstration plant is successful, and that a full scale plant will be constructed, the small mine will be in temporary use until a larger scale mine is developed to support the 400 MW project. The mine plan is developed for a loader and truck operation. Refer to Figure 1.1 for location of mine.

The mine development plan consists of widening the existing ramp, opening the pit with a box-cut, removing and storing top-soil, building haulroads and sedimentation ponds, excavating water ditches, and preparing an area for the disposal of overburden and spent shale. It is assumed that all of this work will be awarded to a local contractor.

Although the GOJ may not have environmental regulations in force, it is intended that the environment will be protected to the satisfaction of the donor agencies. If it is determined that the alluvium and wadi sediments are worth saving to restore the disturbed areas at the end of the project, the sediments will be removed from those areas. These areas include the box-cut, the haulroads, sedimentation ponds, the waste disposal area, as well as the mine service facilities, the area for stockpiling oil shale and the oil shale processing plant. The sediments will be stored and protected to prevent their erosion.

The haulroads will be constructed with local materials and will be wide enough to accommodate two-way traffic for the 77 tonne trucks. This width will be 25 metres including shoulders. Proper drainage will be included on both sides of the highway and culverts will be installed at proper intervals. Rain water run-off from the roads will be collected in sedimentation ponds which will have zero discharge. Three major haulroads, totaling approximately 10 km, will be constructed between the pit and waste disposal, between the pit and process plant, and between the power plant and waste disposal.

The disposal area for the overburden and spent shale will be located outside of the oil shale deposit on the east side. A water ditch will be dug around the area to collect rain run-off water from the waste piles. The ditch will direct the water to a sedimentation ponds. Other sedimentation

ponds will be constructed to collect rain run-off water from disturbed areas at the process plant, oil shale stockpiles and the mine service facilities. A water ditch will be dug around the box-cut to prevent pristine water from entering the pit. The collected water from the ditch will discharge into a natural drainage. Water run-off within the pit will be collected in a sump and will be used for wetting the haul roads.

When the environmental work impacting the mine is completed, the pit excavation can begin. The ramp width will be wide enough to accommodate two-way traffic for the 77 tonne trucks and will be at least three times the width of the truck which is approximately 5.5 metres. The box-cut will be excavated normal to the ramp and will consist of four benches in overburden. The bench height will not exceed 10 metres. In order to gain access to the box-cut for development of the benches, incline roads from the main ramp will be cut into the overburden. These roads will be wide enough to accommodate two-way traffic and will extend around the west side of the box-cut to the east side of the box-cut which will be the advancing face. The advancing face benches will be 40 metres wide. The box-cut configuration will be approximately 220 metres wide by 150 metres long at the surface, 60 metres wide by 85 metres at the top of the oil shale and 35 metres deep. Approximately 500,000 bank cubic metres will be excavated and hauled from the box-cut to the waste disposal. The box-cut will uncover about 125,000 tonnes of oil shale or about one third of the annual requirements.

## 4.3 Mine Operation

### 4.3.1 Contractor's Cost

It is understood that the Natural Resources Authority (NRA) have received several proposals for mining the oil shale for the demonstration plant. The latest proposal was received



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on 12 April 1988 from the Jordan Economic Development and Trading Company (COMEDAT). The cost quoted for the removal of overburden was 680 fils per cubic metre transported up to 1.5 km, and the cost for mining the oil shale was 870 fils per cubic metre transported a distance of 1.0 km. Added cost for transporting oil shale beyond 1.0 km was 29 fils/ tonne/km. The assumption is that the quote is given in bank cubic metres for the purpose of comparing costs to the Owner's mining costs developed in this study. This comparison is addressed in a later section of this report.

These are not complete costs and are therefore not useable as total mining costs. They were used in some of the mine development costs such as removing overburden from the box-cut where a contractor is expected to perform all development and construction work. In this report the operation of the mine is based on all mining investment and operations to be by Owner with Owner equipment.

### 4.3.2 Overburden

Top-soil from the pit area will be removed by a Caterpillar 631E scraper with auger or its equivalent. (All equipment mentioned in this report by a vendor desingation is considered to have an equivalent. Since it is known that an equivalent piece of equipment can be used, it will not be mentioned in the remaining text.) The top-soil will be placed in storage, from where it will be reused as required for land reclamation. After the top-soil is removed an Ingersoll-Rand DM25 blast hole drill will drill 170 mm diameter holes on a 5 m by 5 m. pattern for each of the four benches. ANFO will be the major blasting agent used. The blasting pattern is subject to change as blasting experience is gained. Overburden will be loaded from four benches (overburden thickness varies between 35 and



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40 metres) by a Caterpillar 992C front end loader with a 10.3 $m^3$ bucket into Caterpillar 777 off-highway trucks which have a 77 tonne capacity. It is estimated that three trucks will be required to haul the overburden 3 km to the out-of-pit verburden waste pile. This operation is planned for 50 weeks per year, six days per week and eight hours per day. Approximately 500,000 bank cubic metres per year will be hauled to the out-of-pit stockpile. The stockpile will be maintained level and orderly by a Caterpillar D9N bulldozer.

### 4.3.3 Oil Shale Mining

In order to approach or meet the performance fuel specification, selective mining was chosen as the method of mining oil shale from the pit. A Caterpillar D10N bulldozer with ripper will rip the oil shale and two Caterpillar 631E scrapers equipped with augers will load and deliver the oil shale to either a high or low grade stockpile in the pit. From these stockpiles a Caterpillar 992C front end loader will feed a portable crusher where the oil shale will be reduced in size to approximately 100 mm. The crusher product will be loaded directly from the crusher into Caterpillar 777 trucks which will transport the oil shale to the processing plant stockpiles. In loading the portable crusher, the operator will make a mixture of the two grades of oil shale to approximate the specification of the power plant performance fuel. Annual production of oil shale for the 20 MW project is estimated at 390,000 tonnes. This part of the operation will be scheduled for 300 shifts per year.

### 4.3.4 Mine Design Basis

The mine design is based on mining oil shale meeting the performance fuel calorific value specification of 2250 Btu per pound. The energy input to the boiler is 294.8 x $10^6$ Btu per hour which is equivalent to 59.42 tonnes per hour of the performance fuel. The annual fuel requirement based on a 100 percent power plant capacity factor is 520,519 tonnes and 390,389 tonnes for a 75 percent capacity factor. The mine will be designed to meet the fuel requirement of the power plant when it operates at a 100 percent capacity factor. The mine will be scheduled to operate 300 shifts per year, 2400 hours per year. The mining, crushing and delivery system will be designed for 250 tonnes per hour. The actual required output for a 100 percent power plant capacity factor is 216 tonnes per hour or approximately 86.5 percent of the design capacity. The annual rate of removing overburden will be approximately 500,000 bank cubic metres and the rate of mining oil shale will be 390,000 tonnes per year.

### 4.3.5 Loading and Hauling Equipment Selection Mining Criteria

1. Annual tonnes of oil shale required: 390,000 tonnes
2. Annual overburden removal (1.3:1 strip ratio) 507,000 $bm^3$
3. One way haul: Oil shale = 3 km, Overburden = 3 km
4. Swell: 30 percent
5. Total rolling resistance: 4 percent
6. Truck load: 77 tonnes = 51 $m^3$
7. Front end loader: 10.3 $m^3$
8. Portable crusher: 300 tonnes/hr.



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9. Operating schedule: 300 shifts/year, 8 hrs/shift
10. Design basis: Oil shale = 520,000 tpy,
    Overburden = 676,00 $bm^3/y$

Required Front End Loaders for Overburden

1. Number of passes to load truck = 5
2. Cycle time = 0.7 minutes
3. Spot time = 0.3 minutes
4. Load time = 3.5 minutes

Total load time per truck = 3.8 minutes

Theoretical number of trucks loaded in one hour
50 min/hr divided by 3.8 min/truck = 15.79 trucks/hr.
@ 90 percent mechanical availability and 60 percent utilization, overall FEL efficiency is 54 percent.

Number of trucks loaded in one hour/FEL
15.79 trucks/hr x 0.54 = 8.62 trucks/hr.

Bank cubic metres/300 shifts/yr/FEL
8.62 trucks/hr x 2400 hrs/yr x 51 $m^3$/truck x 0.769 load factor = 811363 $bm^3$

Number of FEL required for overburden loading
@ 100% capacity factor
676,000 $bm^3$/yr divided by 811,363 $bm^3$/yr/FEL = 0.83 FEL

@ 75% capacity factor
507,000 $bm^3$/yr divided by 811,363 $bm^3$/yr/FEL = 0.62 FEL



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Required Front End Loaders for Oil Shale

Design basis of delivery to the process plant will be 250 tph to meet the fuel requirements of the power plant when operating at 100 percent capacity factor. Truck loading is limited by the portable crusher capacity of 300 tph, and not the FEL which has a large capacity.

Trucks to be loaded and delivered to meet design capacity:

250 tph divided by $77^t$/truck = 3.25 truck/hr.

Trucks capable of being loaded from crusher @ 100% capacity:

300 tph divided by $77^t$/truck = 3.90 truck/hr

Efficiency of loading system:

3.25 truck/hr divided by 3.90 truck/hr = 0.83

Number of FEL required for oil shale loading

@ 100% capacity factor

1 FEL x 0.83 efficiency = 0.83 FEL

@ 75% capacity factor

1 FEL x 0.75 x 0.83 = 0.63 FEL

Total FEL Required for Overburden and Oil Shale

@ 100% capacity factor

| | |
|---|---|
| Overburden | 0.83 FEL |
| Oil Shale | 0.83 FEL |
| Total | 1.66 FEL |

@ 75% capacity factor

| | |
|---|---|
| Overburden | 0.62 FEL |
| Oil Shale | 0.63 FEL |
| Total | 1.25 FEL |



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Two(2) FEL will be assigned for the 20 MW plant. Because of the excess capacity at design capacity and operating one shift per day, a spare FEL will not be required.

Required Trucks for Overburden

Cycle Time

| | |
|---|---|
| Spot | 0.30 min |
| Load | 3.50 min |
| Travel loaded | 5.70 min |
| Dump | 0.50 min |
| Travel empty | 3.75 min |
| Total | 13.75 min |

$bm^3$/truck/hr = 60 min divided by 13.75 min/cycle x $51m^3$ x 0.769 load factor = 171 $bm^3$/hr/truck (theoretical)

| | |
|---|---|
| Mechanical availability | 80 percent |
| Utilization | 83 percent |
| Efficiency | 66.4 percent |

Number of trucks required

@ 100% capacity

676,000 $bm^3$/yr divided by (171 $bm^3$/hr/truck x 0.664 eff) = 5954 truck hrs/yr.

scheduled hours = 2400 hrs/yr.

5954 truck hrs/yr. divided by 2400 hrs/yr. = 2.48 trucks

@ 75% capacity

507,000 $bm^3$/yr. divided by (171 $bm^3$/Hr/truck x 0.664 eff) = 4465 truck hrs/yr.

scheduled hours = 2400 hrs/yr.

4465 truck hrs/yr. divided by 2400 hrs/yr. = 1.86 trucks

Required Trucks for Oil Shale

Design capacity @ 100 percent power plant capacity factor is 250 tph.

Cycle time

| | |
|---|---|
| Spot | 0.30 min |
| Load | 11.55 min |
| Travel loaded | 5.70 min |
| Dump | 0.50 min |
| Travel empty | 3.75 min |
| Total | 21.8 min |

Theoretical cycles/truck/hr

60 min/hr divided by 21.8 min/cycle = 2.75 cycles/hr.

| | |
|---|---|
| Mechanical availability | 80 percent |
| Utilization | 83 percent |
| Efficiency | 66.4 percent |

Number of trucks required

@ 100% capacity factor

250 tph divided by (2.75 cyc/hr/truck x 0.664 efficiency x 77t/cycle) = 1.78 trucks

@ 75% capacity factor

188 tph divided by (2.75 cyc/hr/truck x 0.664 efficiency x 77t/cycle) = 1.34 trucks

Total Truck Requirement

@ 100% capacity factor

| | |
|---|---|
| Overburden | 2.48 trucks |
| Oil Shale | 1.78 trucks |
| Total | 4.26 trucks |



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## 5.0 20 MW DEMONSTRATION PLANT PROCESSING PLANT

### 5.1 Stockpiling and Reclaiming

Oil shale delivered by truck from the mine to the processing plant (see Figure 5.1 for flowsheet) will be stored in two separate stockpiles. While one stockpile is being built, the second will be reclaimed by a Caterpillar 988 front end loader which delivers the oil shale to a 50 tonne dump hopper. The oil shale feeds out of the hopper onto a 600 mm wide belt conveyor that conveys the product to the hammermill feed bin.

Sampling and analyzing of the oil shale will take place as the stockpiles are built. These analyses will be used to control the quality of the oil shale deliver from the pit as well as the quality of the oil shale as it is reclaimed. Upon reclaiming the oil shale, the front end loader has the flexibility of loading shale from many points of the tested stockpile and the potential of making a mix that approximates the performance fuel specification. Oil shale processing is scheduled for 300 shifts per year.

### 5.2 Crushing and Sizing

Crushing and sizing of the oil shale to a minus 8 mm product will be accomplished by a reversible impactor in closed circuit with a vibrating screen. The 600 mm belt conveyor conveys minus 100 mm oil shale at a rate of 400 tonne per hour to the impactor feed bin which has a capacity of 500 tonnes. The bin is approximately 5 metres in diameter and 13 metres high. A vibrating feeder with variable speed, distributes the minus 100 mm oil shale at a rate of up to 250 tonnes per hour uniformily across the hammers of a Pennsylvania Reversible Impactor Type CAL 15-14. This impactor is powered by a 373 kw motor and is capable of reducing a friable material of this feed size to a 6 mesh



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(3.36 mm) product at a rate of 360 tonnes per hour. The crushing and screening plant will be designed for 250 tonnes per hour for a minus 8 mm product. Friability tests of the oil shale are required to verify the design capacity.

The design will provide sufficient capacity for the power plant while operating at 100 percent capacity, and the processing plant overall operating efficiency is 87 percent.

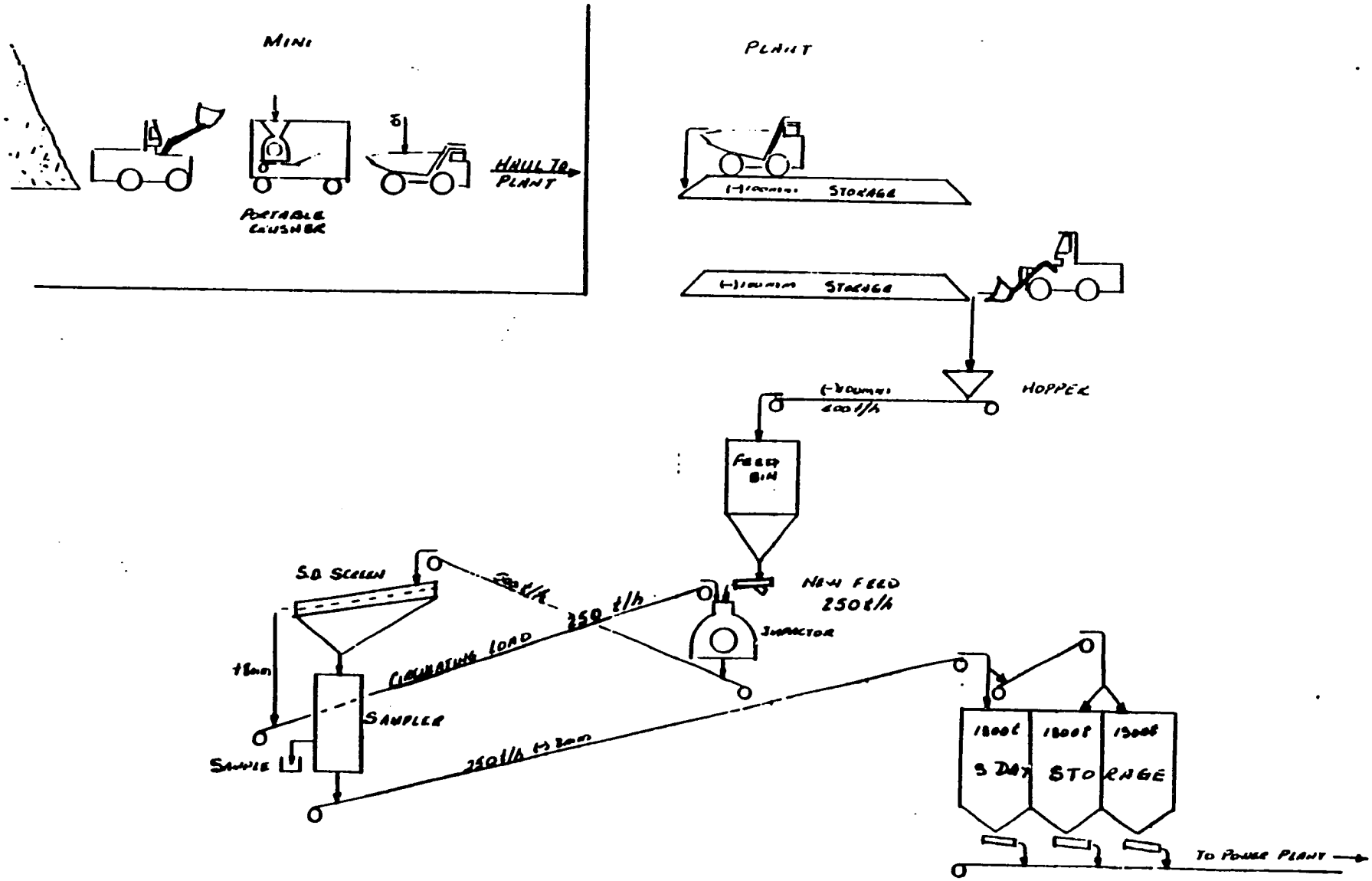
The impactor product is discharged onto a 900 mm wide belt conveyor which conveys the material to a Pennsylvania BHG 24/60 (2.4 m by 6.0 m screen deck) vibrating screen. The oversize product from the screen is returned to the impactor by a 900 mm wide belt conveyor and the undersize product enters a three stage automatic sampler. The return conveyor is designed for a 100 percent circulating load.

Any major maintenance will be scheduled during the power plant scheduled outage. With proper maintenance, the downtime of this plant will be minimal during normal operating periods.

## 5.3 Sampling, Storing and Blending

The minus 8 mm vibrating screen product will be discharged into a sampling tower where samples will be taken in accordance with ASTM standards. These samples will be analyzed at an on-site laboratory for control of the quality fed to the power plant. From the sampler the product will be stored in three steel bins each with a live capacity of 1300 tonnes and having dimensions of approximately 10 metres in diameter and 20 metres high. Each bin will contain the fuel requirement of an average day for the power plant. The bins will be equipped with variable speed feeders for use in making the final mixing of the oil shales at the time of delivery to the power plant.

The variable speed feeders are the interface between the process plant and the power plant. The belt conveyor delivering oil shale to the boiler bunker is for the power plant account.




FLOW SHEET - OIL SHALE PROCESSING PLANT
20 MW DEMONSTRATION PLANT

FIGURE 5.1

## 6.0 20 MW DEMONSTRATION PLANT MINE AND PROCESS PLANT ECONOMICS

### 6.1 Capital Expenditures

#### 6.1.1 Summary of Capital Expenditure

The capital expenditures for the mining and processing plant were determined for the mine development, the mining equipment and the construction of the oil shale process plant. The following table summarizes these expenditures.

Table 6-1

CAPITAL COST SUMMARY FOR 20 MW DEMONSTRATION PLANT
(in U.S. $1000)

| | Base $ | Delivery $ | Erection $ | Total $ | Foreign $ | Local $ |
|---|---|---|---|---|---|---|
| Mine Development | 4444 | 40 | 416 | 4900 | 589 | 4311 |
| Mine Equipment | 9241 | 1386 | 463 | 11090 | 9989 | 1101 |
| Process Plant Facilities | 2301 | 267 | 4377 | 6945 | 2081 | 4864 |
| TOTAL | 15986 | 1693 | 5256 | 22935 | 12659 | 10276 |

These cost are representative of expected costs in Jordan at this time and include engineering, procurement, construction management, direct and indirect construction costs, ocean and inland freight, and a 10 percent contingency. Construction costs are based on Bechtel's experience in the area of Jordan and with the benefit of conceptual engineering. The mining and processing equipment cost estimate is based on vendor budget prices. The delivery cost estimates are average costs taken from Bechtel's records. Special handling features are excluded from the delivery estimate because of their

wide range of costs. A large percentage of the mine development work is based on Comedat's quote of April 12, 1988 for drilling, blasting, loading and hauling overburden. It is to be noted that this is an order of magnitude cost estimate with a range spread of minus 15 percent to plus 25 percent of the capital cost presented in the cost summary.

### 6.1.2 Estimate Basis

Capital equipment quotations were solicited by telephone from a number of vendors. Only budget prices were requested. Installation manhours were assigned to each item of capital equipment based on recent historical data. Values for process piping, electrical, and instrumentation were based on standard factors of the value of the process mechanical equipment as determined from experience.

Bulk construction material and building cost estimates are based on using local suppliers and contractors.

Installation manhours and costs are based on Bechtel's experience in the area of Jordan. Included in these costs are base wages, overtime allowance, fringe benefits, small tools and consumables and contractors overhead and profit.

The major construction indirect costs items are the supply and maintenance of temporary construction facilities and services and the rental and operation of construction equipment.

A factor of 15 percent of the value of the mechanical equipment was used for the delivery cost

estimate. The estimate includes freight to foreign port, ocean freight, and inland freight to site. Import duty is excluded.

Taxes of all kind are excluded from this estimate.

Cost estimate is based on 2Q 1988 costs amd they have not been escalated from that date.

The cost estimate does not include any financing charges, spare parts and working capital. These cost are included in the cash flow analysis for the cost of fuel.

### 6.1.3 Capital Cost Estimate

Table 6-2 Mine Development, Mine Equipment, Process Plant Facilities Capital Cost provides the information used in preparing the capital cost estimate.

## 6.2 Operating Costs

### 6.2.1 Summary of Operating Costs

The operating costs include those costs for the mine equipment, process plant, mine services building and labor for the mine and process plant. Mine equipment operating costs are composed of costs for repair parts, consumables, lubrication, and fuel or electric power. The process plant and the mine services building operating costs are based on a percentage of the base capital cost of each piece of equipment or building. Labor costs include expatriate labor, supervisors, technical and administrative workers, operating and maintenance personnel. Excluded from these operating cost are the cost for explosives and insurance which are

included as operating costs in the cash flow analysis. The following summarizes the operating costs:

Table 6-3

OPERATING COST SUMMARY FOR 20 MW DEMONSTRATION PLANT
(in U.S. $1000)

| | Annual Operating Cost $ | Foreign $ | Local $ |
|---|---|---|---|
| Mine Equipment | 828 | 495 | 333 |
| Process Plant | 127 | 77 | 50 |
| Services Building | 25 | -- | 25 |
| Labor | 735 | 297 | 438 |
| TOTAL | 1715 | 869 | 846 |

### 6.2.1 Basis of Operating Costs

Table 6-4 Mine and Processing Plant Operating Costs presents the method by which the costs were determined for the mining equipment and the process plant facilities as well as the mine services building. There are many variables that influence operating costs and operating costs can be significantly different between companies. The cost and factors used in this estimate were developed by Bechtel from a number of sources and they should be representative of costs expected to occur in Jordan.

Expatriate labor will be used for training and start-up purposes. Only two key expatriate workers will be retained in the permanent work force and the remaining will be replaced as soon as personnel are trained. In addition to the two expatriates, there



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will be a total of 27 people involved with supervision, technical and administrative work, a total of 27 people to operate the mine and process plant and 19 people to maintain these operations.

The total work force will include 75 people. Labor rates and benefits used in this estimate are from the Jordan Electric Authority and from other mining studies performed in the Jordan area. The labor cost for the work force are presented in the following:

| | |
|---|---|
| Table 6-5 | Work Force Summary |
| Table 6-6 | Expatriate Work Force |
| Table 6-7 | Professional/Technical/Administrative |
| Table 6-8 | Mine and Process Plant Operator Work Force |
| Table 6-9 | Mine and Process Plant Maintenance Work Force |

## 6.3 Cash Flow Analysis

The cash flow analysis for the 20 MW Demonstration Plant is shown on Table 6-10 20 MW Demonstration Plant Mining and Processing Plant Cash Flow Analysis. The analysis consists of a two year pre-production period and a 25 year operating period. Debt-equity ratios of 50:50 and 80:20 are used in the analysis.

### 6.3.1 Summary of Cash Flow Analysis

Table 6-11

SUMMARY OF CASH FLOW ANALYSIS

| | Capital Cost $1000 | Product Cost $/Tonne | Product Cost $/10$^6$ Btu |
|---|---|---|---|
| 50:50 Debt/Equity | 27869 | 17.04 | 3.43 |
| 80:20 Debt/Equity | 29389 | 13.85 | 2.79 |



51

The capital cost presented above includes the interest during construction, spare parts and working capital in addition to the capital expenditures summarized in 6.1.1. The product cost is a weighted cost for the 25 year operating period for 390,000 tonne to be mined annually. The cost expressed in $\$/10^6$Btu is based on the performance fuel specification of 2250 Btu/pound.

### 6.3.2 Cash Flow Analysis Basis

The capital expenditure for the mine development, mine equipment and processing plant was presented in Section 6.1. Added to these costs were spare parts for the mine and process plant, and a working capital fund. The spare parts amount to approximately 10 percent of the base value of the equipment and machinery cost and the working capital will be sufficient to cover three months of operating costs and other unforseen costs. Interest during construction for the two debt-equity cases are capitalized.

- The operating costs basis for parts, supplies, fuel and power, and wages and fringes were presented in Section 6.2. In addition to these costs are explosives and insurance. Explosives are based on a powder factor of 0.2 kg per $bm^3$ at a U.S.A. average blasting agents cost of $125/short ton. Explosives are used for overburden blasting only. Insurance cost is based on one half of one percent of the mining equipment and the constructed process plant and services building.

- Interest expenses were computed at a rate of 10 percent and the loan term was 15 years.

- Depreciation is based on the economic life of the mining and processing equipment in hours and its estimated hours of use per year. Details of these determinations are found in Table 6-12 Mine Equipment and Process Plant Depreciation.

- The mine development, pre-production labor, capitalized interest were amortized over a 15 year period and the mine services building was amortized over a 25 year period. The amortization schedule is shown on Table 6-13 20 MW Demonstration Plant Amortization Schedule.

- A mangement fee of $0.50 per ton is used for the responsiblity of operating the mine and process plant. It includes home office expenses attributed to the operation.

- A twenty percent return on equity is used for both debt-equity cases. This is the general acceptable return used for U.S. mining ventures.

Since this study excludes land costs, import duties, sales and use taxes, property and facilities taxes, income taxes for project operations, and income taxes for expatriate employees, the cost of the oil shale product, $17.50 per ton and $14.31 per ton for debt-equity ratios of 50:50 and 80:20, respectively, are accurate to within the limits of the estimate, which ranges between minus 15 percent and plus 25 percent.

TABLE 6-2

CAPITAL COSTS

20 MW DEMONSTRATION PLANT

MINE AND PROCESS PLANT

Table 6-2

MINE DEVELOPMENT, MINE EQUIPMENT,
PROCESS PLANT FACILITIES CAPITAL COSTS
20MW DEMONSTRATION PLANT
(Costs in U.S. $1,000)

| | | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|---|
| **MINE DEVELOPMENT** | | | | | | | | | |
| 1. | Roads | 10K | 150 | 1,500 | -- | 150 | 1,650 | 150 | 1,500 |
| 2. | Top Soil Removal & Storage | $100x10^3bm^3$ | 2.00 | 200 | -- | 20 | 220 | 20 | 200 |
| 3. | Over Burden Removal | $500x10^3bm^3$ | 2.20 | 1,100 | -- | 110 | 1,210 | 110 | 1,100 |
| 4. | Trenches | 10,000m | 10 | 100 | -- | 10 | 110 | 10 | 100 |
| 5. | Sedimentation Ponds | 5 | 50 | 250 | -- | 25 | 275 | 25 | 250 |
| 6. | Mine Service Facilities | 1 | 500 | 500 | 25 | 50 | 575 | 50 | 525 |
| 7. | Mine Electrics | 1 Lot | 100 | 100 | 10 | 10 | 120 | 40 | 80 |
| 8. | Engineering | 1 Lot | 250 | 250 | -- | -- | 250 | 125 | 125 |
| | Sub-Total | | | 4,000 | 35 | 375 | 4,410 | 530 | 3,880 |
| 9. | Contingency - 10% | | | 400 | 4 | 37 | 441 | 53 | 388 |
| | Sub-Total | | | 4,400 | 39 | 412 | 4,851 | 583 | 4,268 |
| 10. | Fee - 1% | | | 44 | 1 | 4 | 49 | 6 | 43 |
| | TOTAL | | | 4,444 | 40 | 416 | 4,900 | 589 | 4,311 |
| **MINE EQUIPMENT** | | | | | | | | | |
| 1. | Scraper 631E W/Auger | 2 | 493 | 986 | 148 | 49 | 1,183 | 1,065 | 118 |
| 2. | Bulldozer D10N w/Ripper | 1 | 411 | 411 | 62 | 21 | 494 | 444 | 50 |
| 3. | Bulldozer D 9N w/Ripper | 1 | 329 | 329 | 49 | 16 | 394 | 355 | 39 |
| 4. | Blast Hole Drill DM25 | 1 | 398 | 398 | 60 | 20 | 478 | 448 | 30 |

Table 6-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

20MW DEMONSTRATION PLANT

(Costs in U.S. $1,000)

| | | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|---|
| 5. | Front End Loader 992C | 2 | 665 | 1,330 | 200 | 67 | 1,597 | 1,437 | 160 |
| 6. | Haul Truck 777 | 6 | 486 | 2,916 | 437 | 146 | 3,499 | 3,149 | 350 |
| 7. | Portable Crusher 300t/h | 1 | 325 | 325 | 49 | 16 | 390 | 351 | 39 |
| 8. | Water Pump | 2 | 16 | 32 | 5 | 2 | 39 | 35 | 4 |
| 9. | Compactor 825C | 1 | 289 | 289 | 43 | 14 | 346 | 312 | 34 |
| 10. | Grader 16G | 1 | 249 | 249 | 37 | 12 | 298 | 280 | 18 |
| 11. | Water Truck 75000 L | 1 | 486 | 486 | 73 | 24 | 583 | 525 | 58 |
| 12. | ANFO Storage | 1 | 30 | 30 | 2 | 2 | 34 | 1 | 33 |
| 13. | Truck - Powder | 1 | 32 | 32 | 5 | 2 | 39 | 35 | 4 |
| 14. | Truck - Fuel | 1 | 81 | 81 | 12 | 4 | 97 | 87 | 10 |
| 15. | Truck - Service/Lube | 1 | 77 | 77 | 12 | 4 | 93 | 83 | 10 |
| 16. | Truck - Supply | 1 | 18 | 18 | 3 | 1 | 22 | 20 | 2 |
| 17. | Truck - Pickup | 4 | 10 | 40 | 6 | 2 | 48 | 43 | 5 |
| 18. | Survey Vehicle | 1 | 20 | 20 | 3 | 1 | 24 | 22 | 2 |
| 19. | Personnel Bus | 1 | 25 | 25 | 4 | 1 | 30 | 27 | 3 |
| 20. | Lowbed & Tractor | 0 | 132 | -- | -- | -- | -- | -- | -- |
| 21. | Fork Lift IT28 | 1 | 73 | 73 | 11 | 4 | 88 | 79 | 9 |
| 22. | Compressor | 1 | 21 | 21 | 3 | 1 | 25 | 23 | 2 |
| 23. | Shop Tools | 1 Lot | 150 | 150 | 23 | 8 | 181 | 170 | 11 |

Table 6-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

20MW DEMONSTRATION PLANT

(Costs in U.S. $1,000)

| | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|
| 24. Light Plants | 0 | -- | -- | -- | -- | -- | -- | -- |
| Sub-Total | | | 8,318 | 1,247 | 417 | 9,982 | 8,991 | 991 |
| 25. Contingency - 10% | | | 832 | 125 | 41 | 998 | 899 | 99 |
| Sub-Total | | | 9,150 | 1,372 | 558 | 10,980 | 9,890 | 1,090 |
| 26. Fee - 1% | | | 91 | 14 | 5 | 110 | 99 | 11 |
| Total | | | 9,241 | 1,386 | 463 | 11,090 | 9,989 | 1,101 |
| **PROCESSING PLANT FACILITIES** | | | | | | | | |
| 1. Front End Loader 988 | 1 | 354 | 354 | 53 | 18 | 425 | 382 | 43 |
| 2. Feed Hopper 50 t | 1 | 18 | 18 | 3 | 43 | 64 | 4 | 60 |
| 3. Belt Conveyor to Feed Bin 600mm x 50m | 1 | 40 | 40 | 6 | 105 | 151 | 54 | 97 |
| 4. Feed Bin 500t 6m Ø x 13m | 1 | 60 | 60 | 3 | 156 | 219 | 16 | 203 |
| 5. Feeder 100t/h - 300t/h | 1 | 23 | 23 | 3 | 61 | 87 | 31 | 56 |
| 6. Impactor 275 t/h | 1 | 60 | 60 | 9 | 138 | 207 | 78 | 129 |
| 7. Belt Conveyor to Screen 900mm x 50m | 1 | 50 | 50 | 8 | 129 | 187 | 67 | 120 |
| 8. Screen | 1 | 75 | 75 | 11 | 190 | 276 | 100 | 176 |

Table 6-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

20MW DEMONSTRATION PLANT

(Costs in U.S. $1,000)

| | | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|---|
| 9. | Belt Conveyor to Impactor 900mm x 50m | 1 | 50 | 50 | 8 | 129 | 187 | 67 | 120 |
| 10. | Sampler | 1 | 175 | 175 | 26 | 449 | 650 | 233 | 417 |
| 11. | Belt Conveyor to storage 600mm x 75m | 1 | 54 | 54 | 8 | 138 | 200 | 72 | 128 |
| 12. | Belt Conveyor top of Storage 600mm x 20m | 1 | 32 | 32 | 4 | 52 | 88 | 39 | 49 |
| 13. | Diverter Valves | 2 | 10 | 20 | 3 | 52 | 75 | 27 | 48 |
| 14. | Storage Bins 10m ø x 20m | 3 | 190 | 570 | 29 | 1,476 | 2,075 | 148 | 1,927 |
| 18. | Dust Collectors | 4 | 35 | 140 | 21 | 150 | 311 | 166 | 145 |
| 15. | Feeders | 3 | 15 | 45 | 7 | 112 | 164 | 60 | 104 |
| 16. | Electrics | 1 Lot | 155 | 155 | 15 | 402 | 572 | 148 | 424 |
| 17. | Instrumentation & Controls | 1 Lot | 50 | 50 | 8 | 135 | 193 | 68 | 125 |
| 19. | Laboratory Equipment | 1 Lot | 100 | 100 | 15 | 5 | 120 | 113 | 7 |
| | Sub-Total | | | 2,071 | 240 | 3,940 | 6,251 | 1,873 | 4,378 |
| 20. | Contingency - 10% | | | 207 | 24 | 394 | 625 | 187 | 438 |
| | Sub-Total | | | 2,278 | 264 | 4,334 | 6,876 | 2,060 | 4,816 |
| 21. | Fee - 1% | | | 23 | 3 | 43 | 69 | 21 | 48 |
| | TOTAL | | | 2,301 | 267 | 4,377 | 6,945 | 2,081 | 4,864 |

Table 6-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

20MW DEMONSTRATION PLANT

(Costs in U.S. $1,000)

CAPITAL COST SUMMARY FOR 20 $MW_e$ DEMONSTRATION PLANT IN U.S. $1,000

| | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|
| Mine Development | 4,444 | 40 | 416 | 4,900 | 589 | 4,311 |
| Mine Equipment | 9,241 | 1,386 | 463 | 11,090 | 9,989 | 1,101 |
| Process Plant Facilities | 2,301 | 267 | 4,377 | 6,945 | 2,081 | 4,864 |
| GRAND TOTAL | 15,986 | 1,693 | 5,256 | 22,935 | 12,659 | 10,276 |

TABLE 6-4

OPERATING COSTS

20 MW DEMONSTRATION PLANT

MINE AND PROCESS PLANT

Table 6-4

MINE AND PROCESSING PLANT OPERATING COSTS

20 MW DEMONSTRATION PLANT

(Costs in US $1000)

| | | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| MINE EQUIPMENT | | | | | | | | | | | | |
| 1. | Scraper | 9.60 | 9.22 | 2.40 | 14.45 | 35.67 | 2976 | | | 106 | 56 | 50 |
| 2. | Bulldozer D10N | 25.00 | 3.05 | 3.45 | 15.48 | 46.98 | 1392 | | | 65 | 39 | 26 |
| 3. | Bulldozer D9N | 21.00 | 2.56 | 2.90 | 13.02 | 39.48 | 1392 | | | 55 | 33 | 22 |
| 4. | Blast Hole Drill | 20.94 | 4.19 | 1.18 | 6.75 | 33.06 | 1536 | | | 51 | 39 | 12 |
| 5. | Front End Loader | 8.85 | 16.52 | 1.42 | 19.93 | 46.72 | 2304 | | | 108 | 59 | 49 |
| 6. | Haul Truck | 10.50 | 9.50 | 1.37 | 10.50 | 31.87 | 7680 | | | 245 | 154 | 91 |
| 7. | Portable Crusher | -- | -- | -- | -- | -- | 960 | 325 | 10 | 33 | 22 | 11 |
| 8. | Water Pump | 2.00 | 1.09 | 0.20 | 1.72 | 5.01 | 876 | | | 4 | 2 | 2 |
| 9. | Compactor | 6.00 | 1.60 | 0.80 | 5.16 | 13.56 | 456 | | | 6 | 3 | 3 |
| 10. | Grader | 8.00 | 6.93 | 2.00 | 6.88 | 23.81 | 1536 | | | 37 | 23 | 14 |
| 11. | Water Truck | 12.81 | 8.56 | 2.32 | 13.76 | 37.45 | 1536 | | | 57 | 32 | 25 |
| 12. | ANFO Bulk Storage | -- | -- | -- | -- | -- | 240 | 30 | 3 | 1 | -- | 1 |
| 13. | Truck-Powder | 1.50 | 1.26 | 0.50 | 1.72 | 4.98 | 960 | | | 5 | 3 | 2 |
| 14. | Truck-Fuel | 2.66 | 2.44 | 0.90 | 2.04 | 8.04 | 960 | | | 8 | 5 | 3 |
| 15. | Truck-Service/Lube | 2.25 | 2.10 | 0.86 | 3.01 | 8.22 | 960 | | | 8 | 4 | 4 |
| 16. | Truck-Supply | 0.93 | 0.81 | 0.25 | 1.08 | 3.07 | 960 | | | 3 | 2 | 1 |
| 17. | Truck-Pickup | 0.44 | 0.39 | 0.20 | 1.29 | 2.32 | 3840 | | | 9 | 3 | 6 |

Table 6-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

20 MW DEMONSTRATION PLANT

(Costs in US $1000)

| | | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| 18. | Survey Vehicle | 0.90 | 0.78 | 0.20 | 1.51 | 3.39 | 960 | | | 3 | 1 | 2 |
| 19. | Personnel Bus | 1.00 | 0.80 | 0.75 | 2.58 | 5.13 | 480 | | | 2 | 1 | 1 |
| 20. | Low Bed & Tractor | 6.00 | 4.75 | 1.00 | 6.02 | 17.77 | 120 | | | 2 | 1 | 1 |
| 21. | Forklift | 5.00 | 2.38 | 0.42 | 2.58 | 10.38 | 960 | | | 10 | 7 | 3 |
| 22. | Compressor | 1.71 | 0.22 | 0.26 | 1.47 | 3.66 | 240 | | | 1 | -- | 1 |
| 23. | Shop Tools | -- | -- | -- | -- | -- | 960 | 150 | 6 | 9 | 6 | 3 |
| 24. | Light Plant | | | | | | | | | | | |
| 25. | Surface Miner | | | | | | | | | | | |
| 26. | Electric Shovel | | | | | | | | | | | |
| 27. | Dump Hopper | | | | | | | | | | | |
| 28. | Feeders | | | | | | | | | | | |
| 29. | Belt Conveyor From Pit | | | | | | | | | | | |
| 30. | Belt Conveyor To Sampler | | | | | | | | | | | |
| 31. | Belt Scale | | | | | | | | | | | |
| 32. | Sampler | | | | | | | | | | | |
| 33. | Electics | | | | | | | | | | | |

Table 5-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

20 MW DEMONSTRATION PLANT

(Costs in US $1000)

| | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| 34. Truck-Mech/Weld | | | | | | | | | | | |
| 35. Truck-Electrician | | | | | | | | | | | |
| 36. Crane | | | | | | | | | | | |
| 37. Core Drill | | | | | | | | | | | |
| 38. Ambulance | | | | | | | | | | | |
| 39. Fire Truck | | | | | | | | | | | |
| 40. Farm Tractor & Accessories | | | | | | | | | | | |
| 41. Back Hoe | | | | | | | | | | | |
| 42. Communication Equip. | | | | | | | | | | | |
| 43. Cable Skidder | | | | | | | | | | | |
| Sub Total | | | | | | | | | 828 | 495 | 333 |
| **PROCESS PLANT** | | | | | | | | | | | |
| 1. Front End Loader | 6.12 | 11.42 | 0.98 | 13.78 | 32.30 | 1488 | | | 48 | 26 | 22 |
| 2. Belt Conveyor to Feed Bin | | | | | | | 40 | 8 | 3 | 2 | 1 |
| 3. Feed Bin | | | | | | | 60 | 6 | 4 | 1 | 3 |
| 4. Feeder | | | | | | | 23 | 6 | 1 | 1 | -- |

Table 6-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

20 MW DEMONSTRATION PLANT

(Costs in US $1000)

| | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| 5. Impactor | | | | | | | 60 | 10 | 6 | 4 | 2 |
| 6. Belt Conveyor to Screen | | | | | | | 50 | 8 | 4 | 3 | 1 |
| 7. Screen | | | | | | | 75 | 6 | 5 | 3 | 2 |
| 8. Belt Conveyor to Impactor | | | | | | | 50 | 8 | 4 | 3 | 1 |
| 9. Sampler | | | | | | | 175 | 6 | 11 | 6 | 5 |
| 10. Belt Conveyor to Storage | | | | | | | 54 | 8 | 4 | 3 | 1 |
| 11. Belt Conveyor Top | | | | | | | 32 | 8 | 3 | 2 | 1 |
| of Storage | | | | | | | 20 | 6 | 1 | -- | 1 |
| 12. Diverter Valve | | | | | | | 45 | 6 | 3 | 2 | 1 |
| 13. Feeder | | | | | | | 155 | 8 | 12 | 9 | 3 |
| 14. Electrics | | | | | | | | | | | |
| 15. Instrumentation & Controls | | | | | | | 50 | 8 | 4 | 3 | 1 |
| 16. Dust Collectors | | | | | | | 140 | 6 | 8 | 5 | 3 |
| 17. Laboratory Equip. | | | | | | | 100 | 6 | 6 | 4 | 2 |
| 18. Plow Feeder | | | | | | | | | | | |

Table 6-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

20 MW DEMONSTRATION PLANT

(Costs in US $1000)

| | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| 19. Plow Feeder Belt Conveyor | | | | | | | | | | | |
| 20. Belt Conveyor to Transfer Twr. | | | | | | | | | | | |
| 21. Belt Conveyor to Sampler | | | | | | | | | | | |
| Sub Total | | | | | | | | | 127 | 77 | 50 |
| **OTHERS** | | | | | | | | | | | |
| 1. Mine Services Building | | | | | | | 500 | 5 | 25 | -- | 25 |
| Sub Total | | | | | | | | | 25 | -- | 25 |
| GRAND TOTAL | | | | | | | | | 980 | 572 | 408 |

TABLES 6-5,6,7,8,9

LABOR FORCE AND COST

20 MW DEMONSTRATION PLANT

MINE AND PROCESS PLANT

TABLE 6-5

WORK FORCE SUMMARY
20 MW DEMONSTRATION PLANT

| | -3 | -2 | -1 | 1 | 2-25 |
|---|---|---|---|---|---|
| | | 1991 | 1992 | 1993 | 1994-2017 |
| SUMMARY - LABOR COST US $ | | | | | |
| EXPATRIATE | | 468,000 | 528,000 | 996,000 | 324,000 |
| SUPERVISOR /TECH/ADMIN | | 73,800 | 102,600 | 205,200 | 205,200 |
| OPERATOR WORK FORCE | | | | 167,580 | 167,580 |
| MAINTENANCE WORK FORCE | | | | 104,760 | 104,760 |
| TOTAL | | 541,800 | 630,600 | 1,473,540 | 801,540 |
| SUMMARY - NUMBER OF EMPLOYEES | | | | | |
| EXPATRIATE | | 3 | 3.5 | 7.5 | 2 |
| SUPERVISOR/TECH/ADM. | | 12 | 17.0 | 27 | 27 |
| OPERATOR WORK FORCE | | | | 27 | 27 |
| MAINTENANCE WORK FORCE | | | | 19 | 19 |
| TOTAL | | 15 | 20.5 | 80.5 | 75 |

TABLE 6-6

EXPATRIATE WORK FORCE
20 MW DEMONSTRATION PLANT

| CLASSIFICATION | NO. | SALARY $/YR | ANNUAL COST - US $ -2 1991 | -1 1992 | 1 1993 | 2-25 1994-2017 |
|---|---|---|---|---|---|---|
| Mine Mgr | | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 |
| Deputy Mine Mgr | | 60,000 | | | | |
| Chief Mining Eng | | 60,000 | 60,000 | 30,000 | | |
| Chief Elec. Eng | | 60,000 | | 30,000 | 30,000 | |
| Chief Safety Eng | | 50,000 | | | 25,000 | |
| Chief Training Eng | | 50,000 | | 25,000 | 25,000 | |
| Chief Acctg Mgr | | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 |
| Shift Foreman | | 50,000 | | | 50,000 | |
| Stripping Foreman | | 50,000 | | | 50,000 | |
| Load & Haul Frm | | 50,000 | | | 50,000 | |
| Maintenance Mgr | | 60,000 | | | | |
| Maintenance Frm | | 5,000 | | | 5,000 | |
| SUBTOTAL | | | 195,000 | 220,000 | 415,000 | 135,000 |
| Indirects...100% of Directs | | | 195,000 | 220,000 | 415,000 | 135,000 |
| SUBTOTAL | | | 390,000 | 440,000 | 830,000 | 270,000 |
| Contingency...20% | | | 78,000 | 88,000 | 166,000 | 54,000 |
| TOTAL | | | 468,000 | 528,000 | 996,000 | 324,000 |

TABLE 6-7

PROFESSIONAL/TECHNICAL/ADMINISTRATIVE
20 MW DEMONSTRATION PLANT

| CLASSIFICATION | NO. | Salary $/YR | ANNUAL COST - US $ -2 1991 | -1 1992 | 1-25 1993-2017 |
|---|---|---|---|---|---|
| Deputy Mine Mgr | | 9,000 | | | |
| Chief Mining Eng | | 8,000 | | | |
| Mining Eng | | 6,000 | 6,000 | 6,000 | 6,000 |
| Geologist | | 6,000 | 6,000 | 6,000 | 6,000 |
| Chief Elec. Eng | | 8,000 | | | |
| Elec. Engineer | | 6,000 | 6,000 | 6,000 | 6,000 |
| Chief Safety Eng | | 5,000 | | | |
| Safety Engineer | | 4,000 | | 4,000 | 4,000 |
| Chief Training Ofc | | 5,000 | | | |
| Training Instructor | | 4,000 | | 8,000 | 4,000 |
| Shift Foreman | | 5,000 | | | 5,000 |
| Stripping Foreman | | 5,000 | | | 5,000 |
| Oil Shale Mining Frm | | 5,000 | | | 5,000 |
| Maintenance Mgr | | 8,000 | | | |
| Shop Foreman | | 6,000 | | | 6,000 |
| Field Maintenance Frm | | 5,000 | | | |
| Surveyor | | 3,000 | | | 9,000 |
| Draftsman | | 3,000 | | | 3,000 |
| Personnel Mgr | | 5,000 | | | 5,000 |
| Personnel Staff | | 4,000 | | | |
| Procurement Mgr | | 5,000 | | | 5,000 |
| Procurement Staff | | 4,000 | | | |
| Warehouse Staff | | 3,000 | | | 3,000 |
| Secretary | | 2,000 | 2,000 | 4,000 | 4,000 |
| Accountant | | 2,000 | 4,000 | 6,000 | 4,000 |
| Cook | | 3,000 | 3,000 | 3,000 | 6,000 |
| Janitor | | 2,000 | 2,000 | 2,000 | 2,000 |
| Chemist | | 6,000 | | | 6,000 |
| Assistant Chemist | | 5,000 | | | |
| Sampler | | 3,000 | | | 3,000 |
| Security Guard | | 3,000 | 12,000 | 12,000 | 12,000 |
| SUBTOTAL | | | 41,000 | 57,000 | 114,000 |
| Indirects..50% of Directs | | | 20,500 | 28,500 | 57,000 |
| SUBTOTAL | | | 61,500 | 85,500 | 171,000 |
| Contingency..20% | | | 12,300 | 17,100 | 34,200 |
| TOTAL | | | 73,800 | 102,600 | 205,200 |

TABLE 6-8

MINE AND PROCESS PLANT OPERATOR WORK FORCE
20 MW DEMONSTRATION PLANT

| CLASSIFICATION | NO. | Salary $/YR | ANNUAL COST - US $ -2 1991 | -1 1992 | 1-25 1993-2017 |
|---|---|---|---|---|---|
| Blast Hole Driller | | 3,600 | | | 3,600 |
| Blast Hole Helper | | 2,700 | | | 2,700 |
| Shot Loader | | 3,000 | | | 1,500 |
| Shot Loader Helper | | 2,700 | | | 5,400 |
| Shot Firer | | 3,000 | | | 1,500 |
| Bulldozer Operator | | 3,000 | | | 6,000 |
| Front End Loader Opr. | | 3,000 | | | 6,000 |
| Electric Shovel Opr. | | --- | | | |
| Truck Driver | | 3,000 | | | 15,000 |
| Scraper Operator | | 3,000 | | | 6,000 |
| Portable Crusher Opr. | | 3,000 | | | 3,000 |
| Surface Miner Opr. | | --- | | | |
| Belt Tender | | --- | | | |
| Water Truck Driver | | 3,000 | | | 3,000 |
| Grader Operator | | 3,000 | | | 3,000 |
| Powder Truck | | 2,700 | | | 2,700 |
| Fuel Truck Driver | | 2,700 | | | 2,700 |
| Service/Lube Truck Dr. | | 2,700 | | | 2,700 |
| Supply Truck Driver | | 2,700 | | | 2,700 |
| Crane Operator | | | | | --- |
| Back Hoe Opr. | | --- | | | |
| Core Drill Operator | | --- | | | |
| Core Drill Helper | | --- | | | |
| Utility Operator | | 3,000 | | | 3,000 |
| PROCESS PLANT | | | | | |
| Front End Loader Opr. | | 3,000 | | | 3,000 |
| Operator | | 3,000 | | | 3,000 |
| Operator Helper | | 2,700 | | | 2,700 |
| Belt Tender | | 7,500 | | | 2,500 |
| Laborer | | 2,400 | | | 2,400 |
| SUBTOTAL | | | | | 93,100 |
| Indirects..50% of Directs | | | | | 46,550 |
| SUBTOTAL | | | | | 139,650 |
| Contingency..20% | | | | | 27,930 |
| TOTAL | | | | | 167,580 |

TABLE 6-9

MINE AND PROCESS PLANT MAINTENANCE WORK FORCE
20 MW DEMONSTRATION PLANT

| CLASSIFICATION | NO | Salary $/YR | ANNUAL COST - US $ -2 1991 | -1 1992 | 1-25 1993-2017 |
|---|---|---|---|---|---|
| Lead Mechanic - Mine | | --- | | | |
| Lead Mechanic - Truck | | --- | | | |
| Lead Mechanic - Plant | | --- | | | |
| Mechanic - Mine & Plt. | | 3,600 | | | 7,200 |
| Mechanic Helper | | 2,700 | | | 10,800 |
| Truck Mechanic | | 3,600 | | | 7,200 |
| Truck Mechanic Hlp. | | 2,700 | | | 10,800 |
| Welder | | 3,600 | | | 3,600 |
| Shop Journeyman | | 3,600 | | | 3,600 |
| Machine Shop Helper | | 2,700 | | | 2,700 |
| Lead Electrician | | --- | | | |
| Electrician | | 3,600 | | | 3,600 |
| Electrician Helper | | 2,700 | | | 2,700 |
| Instrument Maint. | | 3,600 | | | 3,600 |
| Carpenter/Painter | | --- | | | |
| Laborer | | 2,400 | | | 2,400 |
| SUBTOTAL | | | | | 58,200 |
| Indirects..50% of Directs | | | | | 29,100 |
| SUBTOTAL | | | | | 87,300 |
| Contingency..20% | | | | | 17,460 |
| TOTAL | | | | | 104,760 |

TABLE 6-10

CASH FLOW ANALYSIS

20 MW DEMONSTRATION PLANT

MINE AND PROCESS PLANT

Table 6-10
MINING AND PROCESSING PLANT CASH FLOW ANALYSIS
20MW DEMONSTRATION PLANT
(Cost in US $1000)

| | -2 1991 | -1 1992 | 1 1993 | 2 1994 | 3 1995 | 4 1996 | 5 1997 | 6 1998 | 7 1999 | 8 2000 | 9 2001 | 10 2002 | 11 2003 | 12 2004 | 13 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, M W | | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| II. OIL SHALE, TONNES/YR x 1000 | | | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | | | |
| 50/50 Debt/Equity Ratio | | | | | | | | | | | | | | | |
| Mine Development | 2000 | 2900 | | | | | | | | | | | | | |
| Mine Equipment | | 11090 | | | | | | | | | | | | | |
| Process Plt Facility | 2000 | 4945 | | | | | | | | | | | | | |
| Spare Parts | | 1200 | | | | | | | | | | | | | |
| Working Capital | | 1200 | | | | | | | | | | | | | |
| SUBTOTAL | 4000 | 21335 | | | | | | | | | | | | | |
| Capitalized Interest | 1267 | 1267 | | | | | | | | | | | | | |
| TOTAL | 5267 | 22602 | | | | | | | | | | | | | |
| 80/20 Debt/Equity Ratio | | | | | | | | | | | | | | | |
| Capitalized Interest | 2027 | 2067 | | | | | | | | | | | | | |
| TOTAL | 6027 | 23362 | | | | | | | | | | | | | |
| IV. OPERATING COST | | | | | | | | | | | | | | | |
| Parts, Sup,Fuel/Power | --- | ----- | 980 | 980 | 980 | 980 | 980 | 980 | 908 | 980 | 980 | 980 | 980 | 980 | 980 |
| Wages and Fringes | 542 | 631 | 1474 | 802 | 802 | 802 | 802 | 802 | 802 | 802 | 802 | 802 | 802 | 802 | 802 |
| Explosives | --- | ----- | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
| Insurance | --- | ----- | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 |
| TOTAL | 542 | 631 | 2558 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 |

Table 6-10 (Cont)

| | -2 1991 | -1 1992 | 1 1993 | 2 1994 | 3 1995 | 4 1996 | 5 1997 | 6 1998 | 7 1999 | 8 2000 | 9 2001 | 10 2002 | 11 2003 | 12 2004 | 13 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **V. INTEREST EXPENSE** | | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 1393 | 1301 | 1208 | 1115 | 1022 | 929 | 836 | 743 | 650 | 557 | 465 | 372 | 279 | | |
| 80/20 D/E Ratio | 2351 | 2194 | 2038 | 1881 | 1724 | 1567 | 1411 | 1254 | 1097 | 940 | 784 | 627 | 470 | | |
| **VI DEPRECIATION & AMORTIZATION** | | | | | | | | | | | | | | | |
| Depreciation | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | |
| Amortization 50/50 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | |
| Amortization 80/20 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | |
| TOTAL 50/50 | 1589 | 1589 | 1589 | 1589 | 1589 | 1589 | 1589 | 1589 | 1589 | 1589 | 1589 | 1589 | 1589 | 1589 | |
| TOTAL 80/20 | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 | 1690 | |
| **VII. MANAGEMENT FEE** | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | |
| **VIII. RETURN ON EQUITY** | | | | | | | | | | | | | | | |
| 50/50 Debt/Equity | 2782 | 2787 | 2787 | 2787 | 2782 | 2782 | 2787 | 2787 | 2787 | 2787 | 2787 | 2787 | 2782 | 2786 | |
| 80/20 Debt/Equity | 1176 | 1176 | 1176 | 1176 | 1176 | 1176 | 11761 | 1176 | 1176 | 1176 | 1176 | 1176 | 1176 | 1176 | |
| **IX. ROYALTY** | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | |
| **X. COST-PROCESSED OIL SHALE** | | | | | | | | | | | | | | | |
| 50/50 Debt/Equity | 8631 | 7867 | 7774 | 7682 | 7588 | 7495 | 7407 | 7309 | 7216 | 7123 | 7031 | 6938 | 6845 | | |
| 80/20 Debt/Equity | 8079 | 7250 | 7094 | 6937 | 6780 | 6623 | 6467 | 6310 | 6153 | 5996 | 5840 | 5683 | 5526 | | |
| **XI. COST - $/TONNE** | | | | | | | | | | | | | | | |
| 50/50 Debt/Equity | 22.13 | 20.17 | 19.93 | 19.69 | 19.46 | 19.22 | 18.99 | 18.74 | 18.50 | 18.26 | 18.03 | 17.79 | 17.55 | | |
| 80/20 Debt/Equity | 20.72 | 18.59 | 18.19 | 17.79 | 17.38 | 16.98 | 16.58 | 16.18 | 15.78 | 15.37 | 14.97 | 14.57 | 14.17 | | |
| **XII. COST - $/$10^6$BTU** | | | | | | | | | | | | | | | |
| 50/50 Debt/Equity | 4.46 | 4.07 | 4.02 | 3.97 | 3.87 | 3.83 | 3.78 | 3.73 | 3.73 | 3.68 | 3.63 | 3.59 | 3.54 | | |
| 80/20 Debt/Equity | 4.18 | 3.75 | 3.67 | 3.59 | 3.50 | 3.42 | 3.34 | 3.26 | 3.18 | 3.10 | 3.02 | 2.94 | 2.86 | | |

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Table 6-10 (Cont)
MINING AND PROCESSING PLANT CASH FLOW ANALYSIS
20MW DEMONSTRATION PLANT
(Cost in US $1000)

| | 14<br>2006 | 15<br>2007 | 16<br>2008 | 17<br>2009 | 18<br>2010 | 19<br>2011 | 20<br>2012 | 21<br>2013 | 22<br>2014 | 23<br>2015 | 24<br>2016 | 25<br>2017 | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, M W | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | | |
| II. OIL SHALE, TONNES/YR x 1000 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | | 9750 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | | |
| 50/50 Debt/Equity Ratio | | | | | | | | | | | | | | |
| Mine Development | | | | | | | | | | | | | | |
| Mine Equipment | | | | | | | | | | | | | | |
| Process Plt Facility | | | | | | | | | | | | | | |
| Spare Parts | | | | | | | | | | | | | | |
| Working Capital | | | | | | | | | | | | | | |
| SUBTOTAL | | | | | | | | | | | | | | |
| Capitalized Interest | | | | | | | | | | | | | | |
| TOTAL | | | | | | | | | | | | | | 27869 |
| 80/20 Debt/Equity Ratio | | | | | | | | | | | | | | |
| Capitalized Interest | | | | | | | | | | | | | | |
| TOTAL | | | | | | | | | | | | | | 29389 |
| IV. OPERATING COST | | | | | | | | | | | | | | |
| Parts, Sup,Fuel/Power | 980 | 980 | 980 | 980 | 980 | 980 | 908 | 980 | 980 | 980 | 980 | 980 | 980 | |
| Wages and Fringes | 802 | 802 | | 802 | 802 | 802 | 802 | 802 | 802 | 802 | 802 | 802 | 802 | |
| Explosives | --- | ----- | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | |
| Insurance | --- | ----- | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | |
| TOTAL | 542 | 631 | 2558 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 | 1886 | |

Table 6-10 (Cont)

| | 14<br>2006 | 15<br>2007 | 16<br>2008 | 17<br>2009 | 18<br>2010 | 19<br>2011 | 20<br>2012 | 21<br>2013 | 22<br>2014 | 23<br>2015 | 24<br>2016 | 25<br>2017 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V. INTEREST EXPENSE | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 186 | 93 | | | | | | | | | | | |
| 80/20 D/E Ratio | 314 | 157 | | | | | | | | | | | |
| VI DEPRECIATION & AMORTIZATION | | | | | | | | | | | | | |
| Depreciation | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | 1032 | |
| Amortization 50/50 | 557 | 557 | 26 | .26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | |
| Amortization 80/20 | 658 | 658 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | |
| TOTAL 50/50 | 1589 | 1589 | 1058 | 1058 | 1058 | 1058 | 1058 | 1058 | 1058 | 1058 | 1058 | 1058 | |
| TOTAL 80/20 | 1690 | 1690 | 1058 | 1058 | 1058 | 1058 | 1058 | 1058 | 1058 | 1058 | 1058 | 1058 | |
| VII. MANAGEMENT FEE | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 195 | |
| VIII. RETURN ON EQUITY | | | | | | | | | | | | | |
| 50/50 Debt/Equity | 2787 | 2787 | 2787 | 2787 | 2787 | 2787 | 2787 | 2787 | 2787 | 2787 | 2787 | 2787 | |
| 80/20 Debt/Equity | 1176 | 1176 | 1176 | 1176 | 1176 | 1176 | 1176 | 1176 | 1176 | 1176 | 1176 | 1176 | |
| IX. ROYALTY | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | |
| X. COST-PROCESSED OIL SHALE | | | | | | | | | | | | | |
| 50/50 Debt/Equity | 6752 | 6659 | 6035 | 6035 | 6035 | 6035 | 6035 | 6035 | 6035 | 6035 | 6035 | 6035 | 170666 |
| 80/20 Debt/Equity | 5370 | 5213 | 4424 | 4424 | 4424 | 4424 | 4424 | 4424 | 4424 | 4424 | 4424 | 4424 | 139561 |
| XI. COST - $/TONNE | | | | | | | | | | | | | |
| 50/50 Debt/Equity | 17.31 | 17.07 | 15.47 | 15.47 | 15.47 | 15.47 | 15.47 | 15.47 | 15.47 | 15.47 | 15.47 | 15.47 | 17.50 |
| 80/20 Debt/Equity | 13.77 | 13.37 | 11.34 | 11.34 | 11.34 | 11.34 | 11.34 | 11.34 | 11.34 | 11.34 | 11.34 | 11.34 | 14.31 |
| XII. COST - $/$10^6$BTU | | | | | | | | | | | | | |
| 50/50 Debt/Equity | 3.49 | 3.44 | 3.12 | 3.12 | 3.12 | 3.12 | 3.12 | 3.12 | 3.12 | 3.12 | 3.12 | 3.12 | 3.53 |
| 80/20 Debt/Equity | 2.76 | 2.69 | 2.29 | 2.29 | 2.29 | 2.29 | 2.29 | 2.29 | 2.29 | 2.29 | 2.29 | 2.29 | 2.89 |

TABLE 6-12,13

DEPRECIATION AND AMORTIZATION

20 MW DEMONSTRATION PLANT

MINE AND PROCESS PLANT

Table 6-12

MINE EQUIPMENT AND PROCESS PLANT DEPRECIATION

20 MW DEMONSTRATION PLANT

(Costs in US $1000)

| | Total Cost | Salvage Value | Deprec Value | Economic Life,Hrs | Avail % | Utilizat'n % | Effic % | Annual SchedHrs | Annual OprHrs | Deprec $/Hr | Deprec $/Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MINE EQUIPMENT | | | | | | | | | | | |
| 1. Scraper | 1314 | 99 | 1215 | 17000 | 78 | 80 | 62 | 2400 | 1488 | 71 | 106 |
| 2. Bull Dozer D10N | 549 | 41 | 508 | 15000 | 73 | 80 | 58 | 2400 | 1392 | 34 | 47 |
| 3. Bull Dozer D9N | 438 | 33 | 405 | 15000 | 73 | 80 | 58 | 2400 | 1392 | 27 | 38 |
| 4. Blast Hole Drill | 531 | 40 | 491 | 40000 | 80 | 80 | 64 | 2400 | 1536 | 12 | 19 |
| 5. Front End Loader | 1774 | 133 | 1641 | 18000 | 80 | 60 | 48 | 2400 | 1152 | 91 | 105 |
| 6. Haul Truck | 3887 | 292 | 3595 | 25000 | 80 | 80 | 64 | 2400 | 1536 | 144 | 221 |
| 7. Portable Crusher | 433 | 33 | 400 | 20000 | 80 | 50 | 40 | 2400 | 960 | 20 | 19 |
| 8. Water Pump | 43 | 3 | 40 | 20000 | 95 | 5 | 5 | 2400 | 438 | 2 | 1 |
| 9. Compactor | 384 | 29 | 355 | 20000 | 95 | 20 | 19 | 2400 | 456 | 12 | 5 |
| 10. Grader | 331 | 25 | 306 | 20000 | 80 | 80 | 64 | 2400 | 1536 | 15 | 24 |
| 11. Water Truck | 648 | 49 | 599 | 35000 | 80 | 80 | 64 | 2400 | 1536 | 17 | 26 |
| 12. ANFO Bulk Storage | 41 | 3 | 39 | 20000 | 100 | 10 | 10 | 2400 | 240 | 2 | 1 |
| 13. Truck-Powder | 43 | 3 | 40 | 15000 | 80 | 50 | 40 | 2400 | 960 | 3 | 3 |
| 14. Truck-Fuel | 108 | 8 | 100 | 15000 | 80 | 50 | 40 | 2400 | 960 | 7 | 6 |
| 15. Truck-Service/Lube | 103 | 8 | 95 | 15000 | 80 | 50 | 40 | 2400 | 960 | 6 | 6 |
| 16. Truck-Supply | 24 | 2 | 22 | 15000 | 80 | 50 | 40 | 2400 | 960 | 1 | 1 |

Table 6-12 (Cont)

MINE EQUIPMENT AND PROCESS PLANT DEPRECIATION

20 MW DEMONSTRATION PLANT

(Costs in US $1000)

| | Total Cost | Salvage Value | Deprec Value | Economic Life,Hrs | Avail % | Utilizat'n % | Effic % | Annual SchedHrs | Annual OprHrs | Deprec $/Hr | Deprec $/Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **MINE EQUIPMENT (Cont'd.)** | | | | | | | | | | | |
| 17. Truck-Pick-up | 53 | 4 | 49 | 9000 | 80 | 50 | 40 | 2400 | 960 | 5 | 5 |
| 18. Survey Vehicle | 27 | 2 | 25 | 9000 | 80 | 50 | 40 | 2400 | 960 | 3 | 3 |
| 19. Personnel Bus | 33 | 3 | 30 | 15000 | 80 | 25 | 20 | 2400 | 480 | 2 | 1 |
| 20. Low Bed & Tractor | 177 | 13 | 164 | 25000 | 95 | 5 | 5 | 2400 | 120 | 7 | 1 |
| 21. Fork Lift | 98 | 7 | 91 | 10000 | 80 | 50 | 40 | 2400 | 960 | 9 | 9 |
| 22. Compressor | 28 | 2 | 26 | 20000 | 80 | 10 | 10 | 2400 | 240 | 1 | 1 |
| 23. Shop Tools | 201 | 15 | 186 | 40000 | 100 | 40 | 40 | 2400 | 960 | 5 | 4 |
| 24. Light Plants | - | - | - | - | - | - | - | - | - | - | - |
| SubTotal: | | | | | | | | | | | 652 |
| **PROCESS PLANT FACILITIES** | | | | | | | | | | | |
| 1. Front End Loader | 472 | 35 | 437 | 18000 | 80 | 50 | 40 | 2400 | 960 | 24 | 23 |
| 2. Feed Hopper | 71 | 2 | 69 | 40000 | 90 | 50 | 45 | 2400 | 1080 | 2 | 2 |
| 3. Belt Conveyor to Feed Bin | 168 | 4 | 164 | 40000 | 90 | 83 | 75 | 2400 | 1800 | 4 | 7 |
| 4. Feed Bin | 243 | 6 | 237 | 40000 | 90 | 83 | 75 | 2400 | 1800 | 6 | 11 |
| 5. Feeder | 97 | 2 | 95 | 20000 | 90 | 83 | 75 | 2400 | 1800 | 5 | 9 |

Table 6-12 (Cont)

MINE EQUIPMENT AND PROCESS PLANT DEPRECIATION

20 MW DEMONSTRATION PLANT

(Costs in US $1000)

| | Total Cost | Salvage Value | Deprec Value | Economic Life,Hrs | Avail % | Utilizat'n % | Effic % | Annual SchedHrs | Annual OprHrs | Deprec $/Hr | Deprec $/Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PROCESS PLANT FACILITIES (Cont) | | | | | | | | | | | |
| 6. Impactor | 230 | 6 | 224 | 40000 | 90 | 83 | 75 | 2400 | 1800 | 6 | 10 |
| 7. Belt Conveyor to Screen | 208 | 5 | 203 | 40000 | 90 | 83 | 75 | 2400 | 1800 | 5 | 9 |
| 8. Screen | 307 | 8 | 299 | 40000 | 90 | 83 | 75 | 2400 | 1800 | 7 | 13 |
| 9. Belt Conveyor to Impactor | 208 | 5 | 203 | 40000 | 90 | 83 | 75 | 2400 | 1800 | 5 | 9 |
| 10. Sampler | 722 | 18 | 704 | 40000 | 90 | 83 | 75 | 2400 | 1800 | 18 | 32 |
| 11. Belt Conveyor to Storage | 222 | 5 | 217 | 40000 | 90 | 50 | 75 | 2400 | 1800 | 5 | 10 |
| 12. Belt Conveyor Top of Storage | 98 | 3 | 95 | 40000 | 90 | 83 | 75 | 2400 | 1800 | 2 | 4 |
| 13. Diverter Valve | 83 | 2 | 81 | 40000 | 90 | 83 | 45 | 2400 | 1080 | 4 | 4 |
| 14. Storage Bin | 2305 | 57 | 2248 | 40000 | 90 | 83 | 75 | 2400 | 1800 | 56 | 101 |
| 15. Feeder | 182 | 5 | 177 | 20000 | 90 | 83 | 75 | 2400 | 6570 | 9 | 58 |
| 16. Electrics | 635 | 16 | 619 | 40000 | 100 | 83 | 83 | 2400 | 1992 | 15 | 31 |
| 17. Instrumentation & Controls | 214 | 5 | 209 | 40000 | 100 | 83 | 83 | 2400 | 1992 | 5 | 10 |
| 18. Dust Collectors | 345 | 14 | 331 | 20000 | 100 | 83 | 83 | 2400 | 1992 | 17 | 33 |
| 19. Laboratory Equipment | 133 | 10 | 123 | 40000 | 100 | 50 | 50 | 2400 | 1200 | 3 | 40 |
| Sub-Total | | | | | | | | | | | 380 |
| TOTAL | | | | | | | | | | | 1032 |

Table 6-13

AMORTIZATION SCHEDULE
20MW DEMONSTRATION PLANT
(Cost in US $1000)

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| 20MW PLANT 50/50 | | | | | | | | | | | | | | | | | |
| 1. | Mine Development | 284 | 284 | 284 | 284 | 284 | 284 | 284 | 294 | 284 | 284 | 284 | 284 | 284 | 284 | 284 | - |
| 2. | Mine Service Facilities | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| 3. | Pre-Op Labor | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | - |
| 4. | Sub-Total | 388 | 388 | 388 | 388 | 388 | 388 | 388 | 388 | 388 | 388 | 388 | 388 | 388 | 388 | 388 | 26 |
| 5. | Capitalized Interest | 169 | 169 | 169 | 169 | 169 | 169 | 169 | 169 | 169 | 169 | 169 | 169 | 169 | 169 | 169 | - |
| 6. | TOTAL: | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 557 | 26 |
| 20MW PLANT 80/20 | | | | | | | | | | | | | | | | | |
| 7. | Capitalized Interest | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | 270 | - |
| 8. | TOTAL: | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 658 | 26 |

Table 6-13 (Cont)

AMORTIZATION SCHEDULE
20MW DEMONSTRATION PLANT
(Cost in US $1000)

| | 17<br>2009 | 18<br>2010 | 19<br>2011 | 20<br>2012 | 21<br>2013 | 22<br>2014 | 23<br>2015 | 24<br>2016 | 25<br>2017 |
|---|---|---|---|---|---|---|---|---|---|
| **20MW PLANT 50/50** | | | | | | | | | |
| 1. Mine Development | - | - | - | - | - | - | - | - | - |
| 2. Mine Service Facilities | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| 3. Pre-Op Labor | - | - | - | - | - | - | - | - | - |
| 4. Sub-Total | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| 5. Capitalized Interest | - | - | - | - | - | - | - | - | - |
| 6. TOTAL: | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| **20MW PLANT 80/20** | | | | | | | | | |
| 7. Capitalized Interest | - | - | - | - | - | - | - | - | - |
| 8. TOTAL: | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |

# 7.0 50 MW PROTOTYPE PLANT

## 7.1 Environmental Considerations

Prior to the commencement of on-site operations, site specific environmental baseline studies should be conducted to develop data in all relevant areas. The key areas to be addressed are the development of protective measures for both surface and ground water supplies, the determination of measures to mitigate surface and groundwater contamination due to mining, further soil testing of the overburden for chemical properties and their suitability for revegetation, site specific air quality monitoring and modeling to ensure that models which are developed are predictive of the mining operation to aid in developing necessary mitigation practices, and the development of protective measures for noise levels and the determination of measures to mitigate noise levels due to mining for protecting the health and welfare of the general public. The program should also develop specific plans and measures related to special conditions, socioeconomic impacts, archeolology, paleontology, historical, recreation and human health effects.

## 7.2 Mine Development Plan

A minimum capital expenditure for the development of this small mine is in the best interest of the project to keep the fuel costs as low as possible. It is, therefore, recommended that the existing trial pit be developed during the construction phase of the power plant so that the mine can meet the fuel requirement when the power plant is placed in commercial operation. Assuming that the 50 MW prototype plant is successful and that a full scale plant will be constructed, the small mine will be in temporary use until a larger mine is developed. The mine will be developed for a loader and truck operation. Refer to Figure 1.1 for location of mine.



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The mine development plan consists of widening the existing ramp, opening the pit with a box-cut, removing and storing top-soil, building haulroads and sedimentation ponds, excavating water ditches, and preparing an area for the disposal of overburden and spent shale. It is assumed that all of this work will be awarded to a local contractor.

Although the GOJ may not have environmental regulations in force, it is intended that the environment will be protected to the satisfaction of the donor agencies. If it is determined that the alluvium and wadi sediments are worth saving to restore the disturbed areas at the end of the project, the sediments will be removed from those areas. These areas include the box-cut, the haulroads sedimentation ponds, the waste disposal area, as well as the mine service facilities, the area for stockpiling oil shale and the oil shale processing plant. The sediments will be stored and protected to prevent their errosion.

The haulroads will be constructed with local materials and will be wide enough to accommodate two-way traffic for the 77 tonne trucks. This width will be 20 metres including shoulders. Proper drainage will be included on both sides of the highway and culverts will be installed at proper intervals. Rain water run-off from the roads will be collected in sedimentation ponds which will have zero discharge. Three major haulroads, totaling approximately 10 km, will be constructed between the pit and waste disposal, between the pit and process plant, and between the powerplant and waste disposal.

The disposal area for the overburden and spent shale will be located outside of the oil shale deposit on the east side. A water ditch will be dug around the area to collect rain run-off water from the waste piles. The ditch will direct



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the water to a sedimentation ponds. Other sedimentation ponds will be constructed to collect rain run-off water from disturbed areas at the process plant, oil shale stockpiles and the mine service facilities. A water ditch will be dug around the box-cut to prevent pristine water from entering the pit. The collected water from the ditch will discharge into a natural drainage. Water run-off within the pit will be collected in a sump and will be used for wetting the haul roads.

When the environmental work impacting the mine is completed, the pit excavation can begin. The ramp width will be wide enough to accommodate two-way traffic for the 77 tonne trucks and will be at least three times the width of the truck which is approximately 5.5 metres. The box-cut will be excavated normal to the ramp and will consist of four benches in overburden. The bench height will not exceed 10 metres. In order to gain access to the box-cut for development of the benches, incline roads from the main ramp will be cut into he overburden. These roads will be wide enough to accommodate two-way traffic and will extend around the west side of the box-cut to the east side of the box-cut which will be the advancing face. The advancing face benches will be 40 metres wide. The box-cut configuratio. will be approximately 220 metres wide by 235 metres long at the surface, 60 metres by 175 metres at the top of the oil shale and 35 metres deep. Approximately 1 million bank cubic metres will be excavated and hauled from the box-cut to the waste disposal. The box-cut will uncover about 250,000 tonnes of oil shale or about 25 percent of the annual requirements.

## 7.3 Mine Operation

### 7.3.1 Contractor's Cost

It is understood that the Natural Resources Authority (NRA) have received several proposals for mining the oil shale for

the demonstration plant. The latest proposal was received on 12 April 1988 from the Jordan Economic Development and Trading Company (COMEDAT). The cost quoted for the removal of overburden was 680 fils per cubic metre transported up to 1.5 km, and the cost for mining the oil shale was 870 fils per cubic metre transported a distance of 1.0 km. Added cost for transporting oil shale beyond 1.0 km was 29 fils/tonne/km. The assumption is that the quote is given in bank cubic metres for the purpose of comparing costs to the Owners mining costs. This comparison is addressed in a later section of this report.

These are not complete costs and are therefore not acceptable as total mining costs. They were used in some of the mine development costs such as removing overburden from the box-cut where a contractor is expected to perform all development and construction work. In this report the operation of the mine is based on all mining to be by Owner with Owner equipment.

### 7.3.2 Overburden Removal

Top soil from the pit area will be removed by a Caterpillar 631 E scraper with auger or its equivalent. (All equipment mentioned in this report by vendor designation is considered to have an equivalent. Since it is known that an equivalent piece of euipment can be used, it will not be mentioned in the remaining text.) This top soil will be placed in storage, from where it will be reclaimed as required for land reclamation. After the top-soil is removed an Ingersoll-Rand DM25 blast hole drill will drill 170 mm diameter holes on a 5 m by 5 m pattern for each of the four benches. ANFO will be the major blasting agent used. The blasting pattern is subject to change as blasting experience is gained. Overburden will be loaded from four



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benches (overburden thickness varies between 35 and 40 metres) by a Caterpillar 992 C front end loader with a 10.3 $m^3$ bucket into Caterpillar 777 off-highway trucks which have a 77 tonne capacity. It is estimated that three trucks will be required to haul the overburden 3 km to the out-of-pit overburden stockpile. This operation is planned for 50 weeks year, six days per week and 24 hours per day. Approximately 1.25 million bank cubic metres per year will be hauled to the out-of-pit stockpile. The stockpile will be maintained level and orderly by a Caterpillar D9N bulldozer. Lighting plants will be used to light the mining area during the dark hours.

### 7.3.3 Oil Shale Mining

In order to approach or meet the performance fuel specification, selective mining was chosen as the method of mining oil shale from the pit. A Caterpillar D10N bulldozer with ripper will rip the oil shale and two Caterpiller 631E scrapers equipped with augers will load and deliver the oil shale to either a high or low grade stockpile in the pit. From these stockpiles a Caterpillar 992C front end loader will feed a portable crusher where the oil shale will be reduced in size to approximately 100 mm. The crusher products will be loaded directly from the crusher into Caterpillar 777 trucks which will transport the oil shale to the processing plant stockpiles. In loading the portable crusher, the operator will make a mixture of the two grades of oil shale to approximate the specification of the performance fuel. Annual production of oils shale is estimated at 973,000 tonnes. This part of the operation will be scheduled for 500 shifts per year.



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### 7.3.4 Mine Design Basis

The mine design is based on mining oil shale meeting the performance fuel calorific value specification of 2250 Btu per pound. The energy input to the boiler is 734.6 x $10^6$ Btu per hour which is equivalent to 148.07 tonnes per hour of the performance fuel.

The annual fuel requirement based on a 100 percent capacity factor is 1,297,093 tonnes and 972,820 tonnes for a 75 percent capacity factor. The mine will be designed to meet the fuel requirement of the power plant when it operates at a 100 percent capacity factor. The mine will be scheduled to operate 900 shifts per year, 7200 hours per year. The mining, crushing and delivery system will be designed for 250 tonnes per hour. The actual required output for a 100 percent power plant capacity factor is 180 tonnes per hour or approximately 72 percent of the design capacity. The annual rate of removing overburden will be approximately 1,265,000 bank cubic metres and the rate of mining oil shale will be 973,000 tonnes per year.

### 7.3.5 Loading and Hauling Equipment Selection Mining Criteria

1. Annual tonnes of oil shale required 973,000 tonnes
2. Annual overburden removal (1.3:1 strip ratio) 1,265,000 $bm^3$
3. One way haul: Oil shale = 3 km, Overburden = 3 km
4. Swell: 30 percent
5. Total rolling resistance: 4 percent

6. Truck load: 77 tonnes = 51 $m^3$
7. Front end load: 10.3 $m^3$
8. Portable crusher: 300 tonnes/hr
9. Operating schedule: 900 shifts/year, 8 hrs/shift
10. Design basis: Oil shale = 1,297,000 tpy, Overburden = 1,686,000 $bm^3/y$

Required Front End Loaders for Overburden

1. Number of passes to load truck = 5
2. Cycle time = 0.7 minutes
3. Spot time = 0.3 minutes
4. Load time = 3.5 minutes

Total load time per truck = 3.8 minutes

Theoretical number of trucks loaded in one hour

60 min/hr divided by 3.8 min/truck = 15.79 trucks/hr.

@ 90 percent mechanical availability and 60 percent utilization, overall FEL efficiency is 54 percent

Number of trucks loaded in one hour/FEL

15.79 trucks/hr x 0.54 = 8.62 trucks/hr.

Bank cubic metres/900 shifts/yr/FEL

8.62 trucks/hr x 7200 hrs/yr x 51 $m^3$/truck x 0.769 load factor = 2,434,000 $bm^3$

Number of FEL required for overburden loading

@ 100% capacity factor

1,686,000 $bm^3$/yr. divided by 2,434,000 $bm^3$/yr/FEL = 0.69 FEL

@ 75% capacity factor

1,265,000 $bm^3$/yr divided by 2,434,000 $bm^3$/yr/FEL = 0.52 FEL

Required Front End Loader for Oil Shale

Design basis of delivery to the process plant will be 250 tph to meet the fuel requirements of the power plant when operating at 100 percent capacity



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factor. Truck loading is limited by the portable crusher capacity of 300 tph and not the FEL which has a larger capacity.

Trucks to be loaded and delivered to meet design capacity:

250 tph divided by 77t/truck = 3.25 truck/hr.

Trucks capable of being loaded from crusher @ 100% capacity:

300 tph divided by 77t/truck = 3.90 truck/hr

Efficiency of loading system:

3.24 truck/hr divided by 3.90 truck/hr = 0.83

Number of FEL required for oil shale loading

@ 100% capacity factor

1 FEL x 0.83 efficiency = 0.83 FEL

@ 75% capcity

1 FEL x 0.75 x 0.83 = 0.63 FEL

<u>Total FEL Required for Overburden and Oil Shale</u>

@ 100% capacity factor

| | |
|---|---|
| Overburden | 0.69 FEL |
| Oil Shale | 0.83 FEL |
| Total: | 1.52 FEL |

@ 75% capacity factor

| | |
|---|---|
| Overburden | 0.52 FEL |
| Oil Shale | 0.63 FEL |
| Total: | 1.15 FEL |

Two(2) FEL will be assigned for the 50 MW plant. One spare FEL will be required to back up the mining and the spent shale disposal operations.



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Required Trucks for Overburden

Cycle Time

| | |
|---|---|
| Spot | 0.30 min |
| Load | 3.50 min |
| Travel Loaded | 5.70 min |
| Dump | 0.50 min |
| Travel empty | 3.75 min |
| Total | 13.75 min |

$bm^3$/truck/hr = 60 min divided by 13.75 min/cycle x 51 $m^3$ x 0.769 load factor = 171 $bm^3$/hr/truck (theoretical)

| | |
|---|---|
| Mechanical avaialbility | 80 percent |
| Utilization | 83 percent |
| Efficiency | 66.4 percent |

Number of trucks required

@ 100% capacity

1,686,000 $bm^3$/yr divided by (171 $bm^3$/hr/truck x 0.664 eff) = 14849 truck hrs/yr

scheduled hours = 7200 hrs/yr.

14849 truck-hrs/yr divided by 7200 hrs/yr = 2.06 trucks

@ 75 capacity

1,265,000 $bm^3$/yr divided by (171 $bm^3$/hr/truck x 0.664 eff) = 11141 truck hrs/yr

scheduled hours = 7200 hrs/yr

11141 truck hrs/yr divided by 7200 hrs/yr = 1.55 trucks

Required Trucks for Oils Shale

Design capacity @ 100 percent capacity factor is 250 tph.

Cycle Time

| | |
|---|---|
| Spot | 0.30 min |
| Load | 11.55 min |



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| | |
|---|---|
| Travel Loaded | 5.70 min |
| Dump | 0.50 min |
| Travel empty | 3.75 min |
| Total | 21.8 min |

Theoretical cycles/truck/hr

60 min/hr divided by 21.8 min/cycle = 2.75 cycles/hr

| | |
|---|---|
| Mechanical avaialbility | 80 percent |
| Utilization | 83 percent |
| Efficiency | 66.4 percent |

Number of trucks required

@ 100% capacity

250 tph divided by (2.75 cyc/hr/truck x 0.665 efficiency x 77t/cycle) = 1.78 trucks

@ 75% capacity

188 tph divided by (2.75 cyc/hr/truck x 0.665 efficiency x 77t/cycle) = 1.34 trucks

Total Truck Requirement

@ 100% capacity factor

| | |
|---|---|
| Overburden | 2.06 trucks |
| Oil Shale | 1.78 trucks |
| Total: | 3.84 trucks |

@ 75% capacity factor

| | |
|---|---|
| Overburden | 1.55 trucks |
| Oil Shale | 1.34 trucks |
| Total: | 2.89 trucks |

Assign 4 trucks and 1 spare for a total of 5 trucks.

### 7.3.6 Mine Services and Services Facilities

One water tanker with a 77000 litre capacity is included in the fleet of equipment for wetting down



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the haulroads. The fleet also includes a fuel truck and a lube and service truck which will service those pieces of equipment at the mine. An ANFO storage tank, and explosive mixing truck and other explosive storages are provided to meet the blasting requirements.

The mine services facilities include the maintenance and warehousing facilities to maintain the mining and processing equipment. In addition these facilities have a change house, a training room and offices. These facilities are separate from the power plant services facilities because of the different types of equipment employed at these operations.

Only minor support facilities will be provided at the maintenance building since it is intended that overhaul and repair of equipment components will be let to local contractors. The space allocated for repair work is therefore based on component replacement. The repair of heavy equipment will consist of six vehicle repair bays sized to accommodate the 77 tonne trucks. Four bays will be used for major repair work, one bay for preventive maintenance and one bay for welding work. All bays will be serviced by a 23-tonne overhead crane. One repair bay will be equipped with conveyor belting for floor protection when servicing tracked vehicles.



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## 8.0 50 MW PROTOTYPE PLANT PROCESSING PLANT

### 8.1 Stockpiling and Reclaiming

Oil shale delivered by truck from the mine to the processing plant (see Figure 8.1 for flowsheet) will be stored in two separate stockpiles. While one stockpile is being built, the second will be reclaimed by a Caterpillar 988 front end loader which delivers the oil shale to a 50 tonne dump hopper. The oil shale feeds out of the hopper onto a 600 mm wide belt conveyor that conveys the product to the hammermill feed bin. Refer to Figure 8.1.

Sampling and analyzing of the oil shale will take place as the stockpiles are built. These analyses will be used to control the quality of the oil shale delivered from the pit as well as the quality of the oil shale as it is reclaimed. Upon reclaiming the oil shale, the front end loader has the flexibility of loading shale from many points of the tested stockpile and the potential of making a mix that approximates the performance fuel specification. Oil shale processing is scheduled for 900 shifts per year.

### 8.2 Crushing and Sizing

Crushing and sizing of the oil shale to a minus 8 mm product will be accomplished by a reversible impactor in closed circuit with a vibrating screen. The 600 mm belt conveyor conveys minus 100 mm oil shale at a rate of 400 tonnes per hour to the impactor feed bin which has a capacity of 500 tonnes. The bin is approximately 5 metres in diameter and 13 metres high. A vibrating feeder with variable speed distributes the minus 100 mm oil shale at a rate of up to 250 tonnes per hour uniformily across the hammers of a Pennsylvania Reversible Impactor Type CAL 15-14. This impactor is powered by a 373 kw motor and is capable of reducing a friable material of this feed size to a 6 mesh



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(3.36 mm) product at a rate of 360 tonnes per hour. The crushing and screening plant will be designed for 250 tonnes per hour for a minus 8 mm product. Friability tests of the oil shale are required to verify the design capacity.

The average hourly rate of this system is 180 tonnes. The 250 tonnes per hour design capacity will provide sufficient capacity for the power plant while operating at 100 percent capacity, and the processing plant overall operating efficiency is 72 percent.

The impactor product is discharged onto a 900 mm wide belt belt convyor which conveys the material to a Pennsylvania BHG 24/60 (2.4 m by 6.0 m screen deck) vibrating screen. The oversize product from the screen is returned to the impactor by a 900 mm wide belt conveyor and the undersize product enters a three stage automatic sampler. The return conveyor is designed for a 100 percent circulating load.

Any major maintenance will be scheduled during the power plant scheduled outage. The plant will be scheduled to operate 20 hours per day and shut down for maintenance on the remaining 4 hours.

## 8.3 Sampling, Storing and Blending

The minus 8 mm vibrating screen product will discharge into a sampling tower where samples will be taken in accordance with ASTM standards. These samples will be analyzed at ar on-site laboratory for control of the quality fed to the power plant. From the sampler the product will be stored in three steel bins each with a live capacity of 3000 tonne having dimensions of approximately 12 meters in diameter and 30 metres high. Each bin will contain the fuel requirement of an average day for the power plant. The bins will be equipped with variable speed feeders for use in making the



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final mixing of the oil shales at the time of delivery to the power plant.

The variable speed feeders are the interface between the process plant and the power plant. The belt conveyor delivering oil shale to the boiler bunker is for the power plant account.



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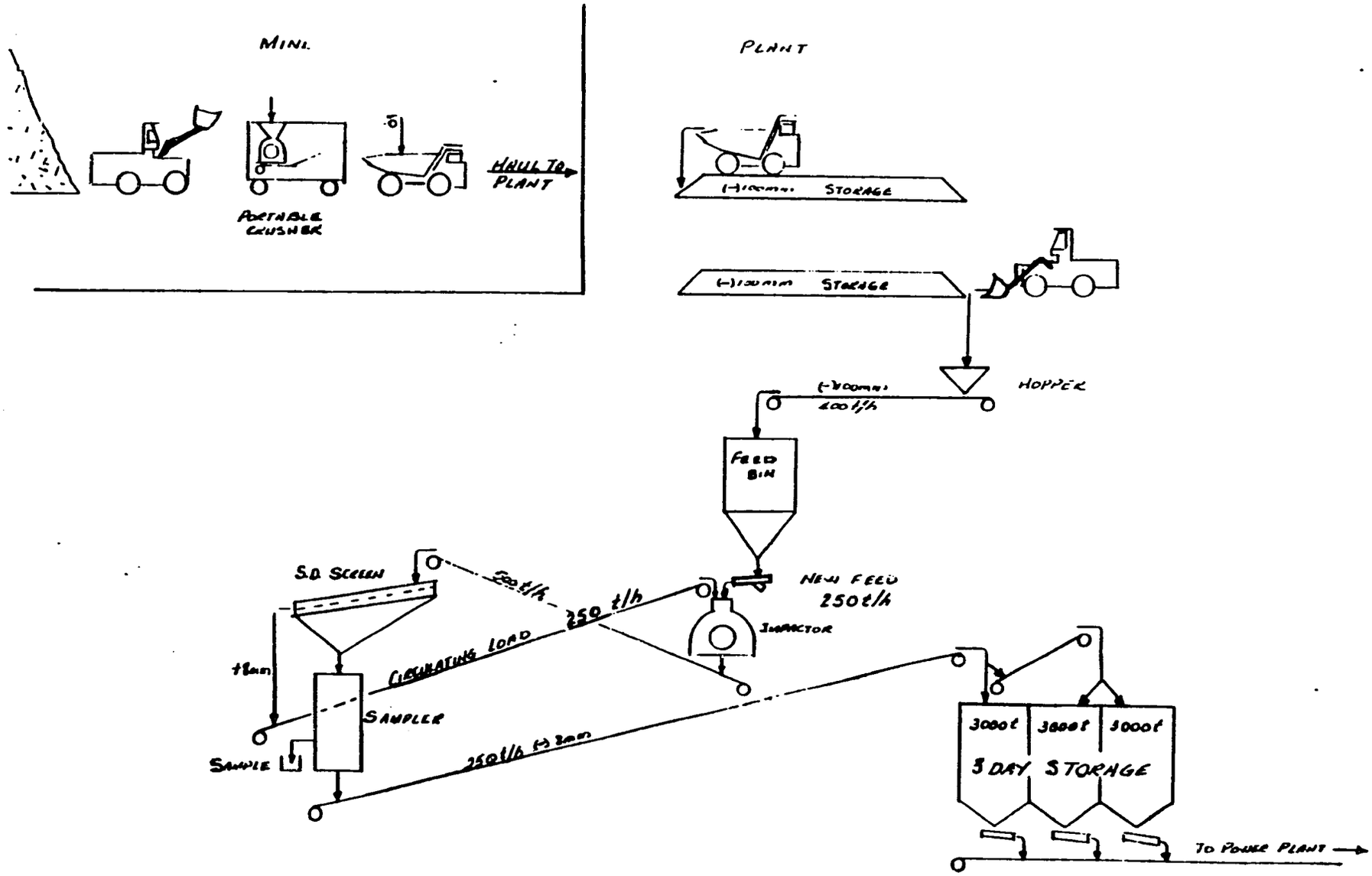


FLOW SHEET - OIL SHALE PROCESSING PLANT
50 MW PROTOTYPE PLANT

FIGURE 8·1

## 9.0 50 MW PROTOTYPE PLANT MINE AND PROCESS PLANT ECONOMICS

### 9.1 Capital Expenditure

#### 9.1.1 Summary of Capital Expenditure

The capital expenditures for the mining and processing plant were determined for the mine development, the mining equipment and the construction of the oil shale process plant. The following table summarizes these expenditures.

Table 9-1

CAPITAL COST SUMMARY FOR 50 MW PROTOTYPE PLANT
(in U.S. $1000)

| | Base $ | Delivery $ | Erection $ | Total $ | Foreign $ | Local $ |
|---|---|---|---|---|---|---|
| Mine Development | 7110 | 39 | 684 | 7833 | 856 | 6977 |
| Mine Equipment | 10165 | 1527 | 510 | 12202 | 11222 | 980 |
| Process Plant Facilities | 2901 | 290 | 5197 | 8388 | 2162 | 6226 |
| TOTAL | 20176 | 1856 | 6391 | 28423 | 14240 | 14183 |

These costs are representative of expected costs in Jordan at this time and include engineering, procurement, construction management, direct and indirect construction costs, ocean and inland freight, and a 10 percent contingency. Construction costs are based on Bechtels experience in the area of Jordan and with the benefit of conceptual engineering. The mining and processing equipment cost estimate is based on vendor budget prices. The delivery cost estimates are average costs taken from Bechtel's records. Special handling features are excluded from the delivery estimate because of their



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wide range of costs. A large percentage of the mine development work is based on Comedat's quote of April 12, 1988 for drilling, blasting, loading and hauling overburden. It is to be noted that this is an order of magnitude cost estimate with a range spread of minus 15 percent to plus 25 percent of the capital cost presented in the cost summary.

### 9.1.2 Estimate Basis

Capital equipment quotations were solicited by telephone from a number of vendors. Only budget prices were requested. Installation manhours were assigned to each item of capital equipment based on recent historical data. Values for process piping, electrical, and instrumentation were based on standard factors of the value of the process mechanical equipment as determined from experience.

Bulk construction material and building cost estimates are based on using local suppliers and contractors.

Installation manhours and costs are based on Bechtel's experience in the area of Jordan. Included in these costs are base wages, overtime allowance, fringe benefits, small tools and consumables, and contractor's overhead and profit.

The major construction indirect costs items are the supply and maintenance of temporary construction facilities and services and the rental and operation of construction equipment.

A factor of 15 percent of the value of the mechanical equipment was used for the delivery cost estimates. The estimate includes freight to foreign



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port, ocean freight, and inland freight to site. Import duty is excluded.

Taxes of all kind are excluded from this estimate.

Cost estimate is based on 2Q 1988 costs and they have not been escalated from that date.

The cost estimate does not include any financing charges, spare parts and working capital. These cost are included in the cash flow analysis for the cost of fuel.

### 9.1.3 Capital Cost Estimate

Table 9-2 Mine Development, Mine Equipment, Process Plant Facilities Capital Cost provides the information used in preparing the capital cost estimate.

## 9.2 Operating Costs

### 9.2.1 Summary of Operating Costs

The operating costs include those costs for the mine equipment, process plant, mine services building and labor for the mine and process plant. Mine equipment operating costs are composed of costs for repair parts, consumables, lubrication, and fuel or electric power. The process plant and the mine services building operating costs are based on a percentage of the base capital cost of each piece of equipment or building. Labor costs include expatriate labor, supervisors, technical and administrative workers, operating and maintenance personnel. Excluded from these operating cost are the cost for explosives and insurance which are included as operating costs in the cash flow analysis. The following summarizes the operating costs:



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Table 9-3

OPERATING COST SUMMARY FOR 50 MW PROTOTYPE PLANT
(in U.S. $1000)

| | Annual Operating Cost $ | Foreign $ | Local $ |
|---|---|---|---|
| Mine Equipment | 2651 | 1571 | 1080 |
| Process Plant | 290 | 177 | 113 |
| Services Building | 50 | -- | 50 |
| Labor | 1218 | 297 | 921 |
| TOTAL | 4209 | 2045 | 2164 |

### 9.2.2 Basis of Operating Costs

Table 9-4 Mine and Processing Plant Operating Costs presents the method by which the costs were determined for the mining equipment and the process plant facilities as well as the mine services building. There are many variables that influence operating costs and operating costs can be significantly different between companies. The cost and factors used in this estimate were developed by Bechtel from a number of sources and they should be representative of costs expected to occur in Jordan.

Expatriate labor will be used for training and start-up purposes. Only two key expatriate workers will be retained in the permanent work force and the remaining will be replaced as soon as personnel are trained. In addition to the two expatriates, there will be a total of 58 people involved with supervision, technical and adminstrative work, a total of 66 people to operate the mine and process plant and 37 people to maintain these operations.



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The total work force will include 163 people. Labor rates used in this estimate are from the Jordan Electric Authority and other mining studies performed in the Jordan area. The labor cost for the work force are presented in the folllowing:

Table 9-5 Work Force Summary
Table 9-6 Expatriate Work Force
Table 9-7 Professional/Technical/Administrative
Table 9-8 Mine and Process Plant Operator Work Force
Table 9-9 Mine and Process Plant Maintenance Work Force

## 9.3 Cash Flow Analysis

The cash flow analysis for the 50 MW Prototype Plant is shown on Table 9-10 50 MW Prototype Plant Mining and Processing Plant Cash Flow Analysis. The analysis consists of a two year pre-production period and a 25 year operating period. Debt-equity ratios of 50:50 and 80:20 are used in the analysis.

### 9.3.1 Summary of Cash Flow Analysis

Table 9-11

SUMMARY OF CASH FLOW ANALYSIS

| | Capital Cost $1000 | Product Cost $/Tonne | Product Cost $/10$^6$ Btu |
|---|---|---|---|
| 50:50 Debt/Equity | 35115 | 13.48 | 2.72 |
| 80:20 Debt/Equity | 37031 | 11.88 | 2.39 |

The capital cost presented above includes the interst during construction, spare parts and work capital in addition to the capital expenditures summarized in 9.1.1. The product cost is a weighted cost for the 25 year operating period for 973,000



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tonne to be mined annually. The cost expressed in $\$/10^6$Btu is based on the performance fuel specification of 2250 Btu/pound.

### 9.3.2 Cash Flow Analysis Basis

The capital expenditure for the mine development, mine equipment and processing plant was presented in Section 9.1. Added to these costs were spare parts for the mine and process plant and a working capital fund. The spare parts amount to approximately 10 percent of the base value of the equipment and machinery cost and the working capital will be sufficient to cover three months of operating costs and other unforseen costs. Interest during construction for the two debt-equity cases are capitalized.

- The operating costs basis for parts, supplies, fuel and power, and wages and fringes were presented in Section 9.2. In addition to these costs are explosives and insurance. Explosives are based on a powder factor of 0.2 kg per $bm^3$ at a U.S. cost of average blasting agents cost of $125/short ton. Explosives are used for overburden blasting only. Insurance cost is based on one half of one percent of the mining equipment and the constructed process plant and services building.

- Interest expenses were computed at a rate of 10 percent and the loan term was 15 years.

- Depreciation is based on the economic life of the mining and processing equipment in hours and its estimated hours of use per year. Details of these determinations are found in Table 9-12 Mine Equipment and Process Plant Depreciation.



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- The mine development, pre-production labor, capitalized interest were amortized over a 15 year period and the mine services building was amortized over a 25 year period. The amortization schedule is shown on Table 9-13 50 MW Prototype Plant Amortization Schedule.

- A mangement fee of $0.50 per ton is used for the responsiblity of operating the mine and process plant. It includes home office expenses attributed to the operation.

- A twenty percent return on equity is used for both debt-equity cases. This is the general acceptable return in U.S. mining ventures.

Since this study excludes land costs, import duties, sales and use taxes, property and facilities taxes, income taxes for project operations, and income taxes for expatriate employees, the cost of the oil shale product, $13.48 per tonne and $11.88 per tonne for debt-equity ratios of 50:50 and 80:20, respectively, are accurate to within the limits of the estimate, which ranges between minus 15 percent and plus 25 percent.

TABLE 9-2

CAPITAL COSTS

50 MW PROTOTYPE PLANT

MINE AND PROCESS PLANT



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Table 9-2

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

50MW PROTOTYPE PLANT

(Costs in U.S. $1,000)

| | | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|---|
| **MINE DEVELOPMENT** | | | | | | | | | |
| 1. | Roads | 10km | 150 | 1,500 | -- | 150 | 1,650 | 150 | 1,500 |
| 2. | Top Soil Removal & Storage | $200x10^3bm^3$ | 2.00 | 400 | -- | 40 | 440 | 40 | 400 |
| 3. | Over Burden Removal | $1.5x10^6bm^3$ | 2.20 | 3,300 | -- | 330 | 3,630 | 330 | 3,300 |
| 4. | Trenches | 10,000m | 10 | 100 | -- | 10 | 110 | 10 | 100 |
| 5. | Sedimentation Ponds | 5 | 50 | 250 | -- | 25 | 275 | 25 | 250 |
| 6. | Mine Service Facilities | 1 | 500 | 500 | 25 | 50 | 575 | 50 | 525 |
| 7. | Mine Electrics | 1 Lot | 100 | 100 | 10 | 10 | 120 | 40 | 80 |
| 8. | Engineering | 1 Lot | 250 | 250 | -- | -- | 250 | 125 | 125 |
| | Sub-Total | | | 6,400 | 35 | 615 | 7,050 | 770 | 6,280 |
| 9. | Contingency - 10% | | | 640 | 3 | 62 | 705 | 77 | 628 |
| | Sub-Total | | | 7,040 | 38 | 677 | 7,755 | 847 | 6,908 |
| 10. | Fee - 1% | | | 70 | 1 | 7 | 78 | 9 | 69 |
| | TOTAL | | | 7,110 | 39 | 684 | 7,833 | 856 | 6,977 |
| **MINE EQUIPMENT** | | | | | | | | | |
| 1. | Scraper 631E W/Auger | 2 | 493 | 986 | 148 | 49 | 1,183 | 1,065 | 118 |
| 2. | Bulldozer D10N w/Ripper | 2 | 411 | 822 | 123 | 41 | 986 | 925 | 61 |
| 3. | Bulldozer D 9N w/Ripper | 1 | 309 | 309 | 46 | 15 | 370 | 334 | 36 |

Table 9-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

50MW PROTOTYPE PLANT

(Costs in U.S. $1,000)

| | | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|---|
| 4. | Blast Hole Drill DM25 | 1 | 398 | 398 | 60 | 20 | 478 | 448 | 30 |
| 5. | Front End Loader 992C | 3 | 665 | 1,995 | 299 | 100 | 2,394 | 1,245 | 149 |
| 6. | Haul Truck 777 | 5 | 486 | 2,430 | 365 | 122 | 2,917 | 2,625 | 292 |
| 7. | Portable Crusher | 1 | 325 | 325 | 49 | 16 | 390 | 366 | 24 |
| 8. | Water Pump | 2 | 16 | 32 | 5 | 2 | 39 | 35 | 4 |
| 9. | Compactor 825C | 1 | 289 | 289 | 43 | 14 | 346 | 323 | 23 |
| 10. | Grader 16G | 1 | 249 | 249 | 37 | 12 | 298 | 270 | 28 |
| 11. | Water Truck 75000 L | 1 | 486 | 486 | 73 | 24 | 583 | 547 | 36 |
| 12. | ANFO Storage | 1 | 30 | 30 | 5 | 2 | 37 | 33 | 4 |
| 13. | Truck - Powder | 1 | 32 | 32 | 5 | 2 | 39 | 35 | 4 |
| 14. | Truck - Fuel | 1 | 81 | 81 | 12 | 4 | 97 | 87 | 10 |
| 15. | Truck - Service/Lube | 1 | 77 | 77 | 12 | 4 | 93 | 83 | 10 |
| 16. | Truck - Supply | 1 | 18 | 18 | 3 | 1 | 22 | 20 | 2 |
| 17. | Truck - Pickup | 6 | 10 | 60 | 9 | 3 | 72 | 65 | 7 |
| 18. | Survey Vehicle | 1 | 20 | 20 | 3 | 1 | 24 | 22 | 2 |
| 19. | Personnel Bus | 2 | 25 | 50 | 8 | 3 | 61 | 57 | 4 |
| 20. | Lowbed & Tractor | 1 | 132 | 132 | 20 | 7 | 159 | 149 | 10 |

Table 9-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

50MW PROTOTYPE PLANT

(Costs in U.S. $1,000)

| | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|
| 21. Fork Lift IT28 | 1 | 73 | 73 | 11 | 4 | 88 | 79 | 9 |
| 22. Compressor | 1 | 21 | 21 | 3 | 1 | 25 | 23 | 2 |
| 23. Shop Tools | 1 Lot | 150 | 150 | 23 | 8 | 181 | 170 | 11 |
| 24. Light Plants | 6 | 14 | 84 | 13 | 4 | 101 | 95 | 6 |
| Sub-Total | | | 9,149 | 1,375 | 459 | 10,983 | 10,101 | 882 |
| 25. Contingency - 10% | | | 915 | 137 | 46 | 1,098 | 1,010 | 88 |
| Sub-Total | | | 10,064 | 1,512 | 505 | 12,081 | 11,111 | 970 |
| 26. Fee - 1% | | | 101 | 15 | 5 | 121 | 111 | 10 |
| Total | | | 10,165 | 1,527 | 510 | 12,202 | 11,222 | 980 |
| **PROCESSING PLANT FACILITIES** | | | | | | | | |
| 1. Front End Loader 988 | 1 | 354 | 354 | 53 | 18 | 425 | 382 | 43 |
| 2. Feed Hopper 50t | 1 | 18 | 18 | 3 | 43 | 64 | 4 | 60 |
| 3. Belt Conveyor to Feed Bin 600mm x 50m | 1 | 40 | 40 | 6 | 105 | 151 | 54 | 97 |

Table 9-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

50MW PROTOTYPE PLANT

(Costs in U.S. $1,000)

| | | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|---|
| 4. | Feed Bin 500t 6m Ø x 13m | 1 | 60 | 60 | 3 | 156 | 219 | 16 | 203 |
| 5. | Feeder 100t/h - 300t/h | 1 | 23 | 23 | 3 | 61 | 87 | 31 | 56 |
| 6. | Impactor 275 t/h | 1 | 60 | 60 | 9 | 138 | 207 | 78 | 129 |
| 7. | Belt Conveyor to Screen 900mm x 50m | 1 | 50 | 50 | 8 | 129 | 187 | 67 | 120 |
| 8. | Screen | 1 | 75 | 75 | 11 | 190 | 276 | 100 | 176 |
| 9. | Belt Conveyor to Impactor 900mm x 50m | 1 | 50 | 50 | 8 | 129 | 187 | 67 | 120 |
| 10. | Sampler | 1 | 175 | 175 | 26 | 449 | 650 | 233 | 417 |
| 11. | Belt Conveyor to storage 600mm x 75m | 1 | 54 | 54 | 8 | 138 | 200 | 72 | 128 |
| 12. | Belt Conveyor top of Storage 600mm x 16m | 1 | 32 | 32 | 4 | 52 | 88 | 39 | 49 |
| 13. | Diverter Valves | 2 | 10 | 20 | 3 | 52 | 75 | 27 | 48 |
| 14. | Storage Bins 13m Ø x 30m | 3 | 370 | 1,110 | 50 | 2,214 | 3,374 | 221 | 3,153 |
| 15. | Feeders | 3 | 15 | 45 | 7 | 112 | 164 | 60 | 104 |
| 16. | Electrics | 1 Lot | 155 | 155 | 15 | 402 | 572 | 148 | 424 |

Table 9-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

50MW PROTOTYPE PLANT

(Costs in U.S. $1,000)

| | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|
| 17. Instrumentation & Controls | 1 Lot | 50 | 50 | 8 | 135 | 193 | 68 | 125 |
| 18. Dust Collectors | 4 | 35 | 140 | 21 | 150 | 311 | 166 | 145 |
| 19. Laboratory Equipment | 1 Lot | 100 | 100 | 15 | 5 | 120 | 113 | 7 |
| Sub-Total | | | 2,611 | 261 | 4,678 | 7,550 | 1,946 | 5,604 |
| 20. Contingency - 10% | | | 261 | 26 | 468 | 755 | 195 | 560 |
| Sub-Total | | | 2,827 | 287 | 5,146 | 8,305 | 2,141 | 6,164 |
| 21. Fee - 1% | | | 29 | 3 | 51 | 83 | 21 | 67 |
| TOTAL | | | 2,901 | 290 | 5,197 | 8,388 | 2,162 | 6,226 |

CAPITAL COST SUMMARY FOR 50 $MW_e$ DEMONSTRATION PLANT IN U.S. $1,000

| | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|
| Mine Development | 7,110 | 39 | 684 | 7,833 | 856 | 6,977 |
| Mine Equipment | 10,165 | 1,527 | 510 | 12,202 | 11,222 | 980 |
| Process Plant Facilities | 2,901 | 290 | 5,197 | 8,388 | 2,162 | 6,226 |
| GRAND TOTAL | 20,176 | 1,856 | 6,391 | 28,423 | 14,240 | 14,183 |

TABLE 9-4

OPERATING COSTS

50 MW PROTOTYPE PLANT

MINE AND PROCESS PLANT

Table 9-4

MINE AND PROCESSING PLANT OPERATING COSTS

50MW PROTOTYPE PLANT

(Costs in US $1000)

| | | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| MINE EQUIPMENT | | | | | | | | | | | | |
| 1. | Scraper | 9.60 | 9.22 | 2.40 | 14.45 | 35.67 | 8928 | | | 318 | 168 | 150 |
| 2. | Bulldozer D10N | 25.00 | 3.05 | 3.45 | 15.48 | 46.98 | 8352 | | | 392 | 234 | 158 |
| 3. | Bulldozer D9N | 21.00 | 2.56 | 2.90 | 13.02 | 39.48 | 4176 | | | 165 | 99 | 66 |
| 4. | Blast Hole Drill | 20.94 | 4.19 | 1.18 | 6.75 | 33.06 | 4608 | | | 152 | 115 | 37 |
| 5. | Front End Loader | 8.85 | 16.52 | 1.42 | 19.93 | 46.72 | 10368 | | | 4811 | 263 | 221 |
| 6. | Haul Truck | 10.50 | 9.50 | 1.37 | 10.50 | 31.87 | 18432 | | | 587 | 369 | 218 |
| 7. | Portable Crusher | -- | -- | -- | -- | -- | 2880 | 325 | 25 | 81 | 54 | 27 |
| 8. | Water Pump | 2.00 | 1.09 | 0.20 | 1.72 | 5.01 | 876 | | | 4 | 2 | 2 |
| 9. | Compactor | 6.00 | 1.60 | 0.80 | 5.16 | 13.56 | 456 | | | 6 | 3 | 3 |
| 10. | Grader | 8.00 | 6.93 | 2.00 | 6.88 | 23.81 | 4608 | | | 110 | 69 | 41 |
| 11. | Water Truck | 12.81 | 8.56 | 2.32 | 13.76 | 37.45 | 4608 | | | 173 | 99 | 74 |
| 12. | ANFO Bulk Storage | -- | -- | -- | -- | -- | 240 | 30 | 10 | 3 | -- | 3 |
| 13. | Truck-Powder | 1.50 | 1.26 | 0.50 | 1.72 | 4.98 | 960 | | | 5 | 3 | 2 |
| 14. | Truck-Fuel | 2.66 | 2.44 | 0.90 | 2.04 | 8.04 | 1920 | | | 15 | 9 | 6 |
| 15. | Truck-Service/Lube | 2.25 | 2.10 | 0.86 | 3.01 | 8.22 | 1920 | | | 16 | 9 | 7 |
| 16. | Truck-Supply | 0.93 | 0.81 | 0.25 | 1.08 | 3.07 | 1920 | | | 6 | 3 | 3 |
| 17. | Truck-Pickup | 0.44 | 0.39 | 0.20 | 1.29 | 2.32 | 17280 | | | 40 | 14 | 26 |

Table 9-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

50MW PROTOTYPE PLANT

(Costs in US $1000)

| | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| 18. Survey Vehicle | 0.90 | 0.78 | 0.20 | 1.51 | 3.39 | 960 | | | 3 | 1 | 2 |
| 19. Personnel Bus | 1.00 | 0.80 | 0.75 | 2.58 | 5.13 | 2880 | | | 15 | 5 | 10 |
| 20. Low Bed & Tractor | 6.00 | 4.75 | 1.00 | 6.02 | 17.77 | 120 | | | 2 | 1 | 1 |
| 21. Forklift | 5.00 | 2.38 | 0.42 | 2.58 | 10.38 | 2880 | | | 30 | 21 | 9 |
| 22. Compressor | 1.71 | 0.22 | 0.26 | 1.47 | 3.66 | 720 | | | 3 | 2 | 1 |
| 23. Shop Tools | -- | -- | -- | -- | -- | 2880 | 150 | 15 | 23 | 15 | 8 |
| 24. Light Plant | 0.85 | 0.21 | 0.10 | 0.26 | 1.42 | 12960 | | | 18 | 13 | 5 |
| 25. Surface Miner | | | | | | | | | | | |
| 26. Electric Shovel | | | | | | | | | | | |
| 27. Dump Hopper | | | | | | | | | | | |
| 28. Feeders | | | | | | | | | | | |
| 29. Belt Conveyor From Pit | | | | | | | | | | | |
| 30. Belt Conveyor To Sampler | | | | | | | | | | | |
| 31. Belt Scale | | | | | | | | | | | |
| 32. Sampler | | | | | | | | | | | |
| 33. Electrics | | | | | | | | | | | |

Table 9-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

50MW PROTOTYPE PLANT

(Costs in US $1000)

| | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| 34. Truck-Mech/Weld | | | | | | | | | | | |
| 35. Truck-Electrician | | | | | | | | | | | |
| 36. Crane | | | | | | | | | | | |
| 37. Core Drill | | | | | | | | | | | |
| 38. Ambulance | | | | | | | | | | | |
| 39. Fire Truck | | | | | | | | | | | |
| 40. Farm Tractor & Accessories | | | | | | | | | | | |
| 41. Back Hoe | | | | | | | | | | | |
| 42. Communication Equip. | | | | | | | | | | | |
| 43. Cable Skidder | | | | | | | | | | | |
| Sub Total | | | | | | | | | 2651 | 1571 | 1080 |
| **PROCESS PLANT** | | | | | | | | | | | |
| 1. Front End Loader | 6.12 | 11.42 | 0.98 | 13.78 | 32.30 | 2880 | | | 93 | 50 | 43 |
| 2. Belt Conveyor to Feed Bin | | | | | | 5400 | 40 | 20 | 8 | 5 | 3 |

Table 9-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

50MW PROTOTYPE PLANT

(Costs in US $1000)

| | | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| 3. | Feed Bin | | | | | | 5400 | 60 | 15 | 9 | 6 | 3 |
| 4. | Feeder | | | | | | 5400 | 23 | 15 | 4 | 3 | 1 |
| 5. | Impactor | | | | | | 5400 | 60 | 25 | 15 | 10 | 5 |
| 6. | Belt Conveyor to Screen | | | | | | 5400 | 50 | 20 | 10 | 7 | 3 |
| 7. | Screen | | | | | | 5400 | 75 | 15 | 11 | 7 | 4 |
| 8. | Belt Conveyor to Impactor | | | | | | 5400 | 50 | 20 | 10 | 7 | 3 |
| 9. | Sampler | | | | | | 5400 | 175 | 15 | 26 | 13 | 13 |
| 10. | Belt Conveyor to Storage | | | | | | 5400 | 54 | 20 | 11 | 7 | 4 |
| 11. | Belt Conveyor Top | | | | | | 5400 | 32 | 20 | 6 | 4 | 2 |
| | of Storage | | | | | | 5400 | 20 | 15 | 3 | 1 | 2 |
| 12. | Diverter Valve | | | | | | 5400 | 20 | 15 | 3 | 1 | 2 |
| 13. | Feeder | | | | | | 5400 | 45 | 15 | 7 | 5 | 2 |
| 14. | Electrics | | | | | | 5976 | 155 | 20 | 31 | 21 | 10 |
| 15. | Instrumentation & Controls | | | | | | 5976 | 50 | 20 | 10 | 7 | 3 |

Table 9-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

50MW PROTOTYPE PLANT

(Costs in US $1000)

| | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| 16. Dust Collectors | | | | | | 5976 | 140 | 15 | 21 | 14 | 7 |
| 17. Laboratory Equip. | | | | | | 3600 | 100 | 15 | 15 | 10 | 5 |
| 18. Plow Feeder | | | | | | | | | | | |
| 19. Plow Feeder Belt Conveyor | | | | | | | | | | | |
| 20. Belt Conveyor to Transfer Twr. | | | | | | | | | | | |
| 21. Belt Conveyor to Sampler | | | | | | | | | | | |
| Sub Total | | | | | | | | | 290 | 177 | 113 |
| **OTHERS** | | | | | | | | | | | |
| 1. Mine Services Building | | | | | | | 500 | 10 | 50 | -- | 50 |
| Sub Total | | | | | | | | | 50 | -- | 50 |
| GRAND TOTAL | | | | | | | | | 2991 | 1748 | 1243 |

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TABLE 9-5,6,7,8,9

LABOR FORCE AND COSTS

50 MW PROTOTYPE PLANT

MINE AND PROCESS PLANT

Table 9-5
WORK FORCE SUMMARY
50 MW PROTOTYPE PLANT

| | -3 | -2 | -1 | 1 | 2-25 |
|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999-2022 |
| SUMMARY - LABOR COST, US $ | | | | | |
| EXPATRIATE | | 468,000 | 528,000 | 996,000 | 324,000 |
| SUPERVISOR /TECH/ADMIN | | 73,800 | 102,600 | 390,600 | 390,600 |
| OPERATOR WORK FORCE | | | | 203,580 | 203,580 |
| MAINTENANCE WORK FORCE | | | | 104,760 | 104,760 |
| TOTAL | | 541,800 | 630,600 | 3,164,580 | 1,328,580 |
| SUMMARY - NUMBER OF EMPLOYEES | | | | | |
| EXPATRIATE | | 3 | 3.5 | 20 | 2 |
| SUPERVISOR/TECH/ADM. | | 12 | 17 | 58 | 58 |
| OPERATOR WORK FORCE | | | | 66 | 66 |
| MAINTENANCE WORK FORCE | | | | 37 | 37 |
| TOTAL | | 15 | 20.5 | 181 | 163 |

Table 9-6

EXPATRIATE WORK FORCE
50 MW PROTOTYPE PLANT

| | | | ANNUAL COST - US $ | | | |
|---|---|---|---|---|---|---|
| | | SALARY | -2 | -1 | 1 | 2-25 |
| | | $/YR | 1996 | 1997 | 1998 | 1999-2022 |
| CLASSIFICATION | NO. | | | | | |
| Mine Mgr | | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 |
| Deputy Mine Mgr | | 60,000 | | | | |
| Chief Mining Eng | | 60,000 | 60,000 | 30,000 | | |
| Chief Elec. Eng | | 60,000 | | 30,000 | 30,000 | |
| Chief Safety Eng | | 50,000 | | | 25,000 | |
| Chief Training Eng | | 50,000 | | 25,000 | 25,000 | |
| Chief Acctg Mgr | | 60,000 | 60,000 | 60,000 | 60,000 | 60,000 |
| Shift Foreman | | 50,000 | | | 150,000 | |
| Stripping Foreman | | 50,000 | | | 150,000 | |
| Load & Haul Frm | | 50,000 | | | 150,000 | |
| Maintenance Mgr | | 60,000 | | | | |
| Maintenance Frm | | 50,000 | | | 150,000 | |
| SUBTOTAL | | | 195,000 | 220,000 | 900,000 | 135,000 |
| Indirects...100% of Directs | | | 195,000 | 220,000 | 900,000 | 135,000 |
| SUBTOTAL | | | 390,000 | 440,000 | 1,800,000 | 270,000 |
| Contingency...20% | | | 78,000 | 88,000 | 360,000 | 54,000 |
| TOTAL | | | 468,000 | 528,000 | 2,160,000 | 324,000 |

Table 9-7

PROFESSIONAL/TECHNICAL/ADMINISTRATIVE
50 MW PROTOTYPE PLANT

| CLASSIFICATION | NO. | Salary $/YR | ANNUAL COST - US $ -2 1996 | -1 1997 | 1-25 1998-2022 |
|---|---|---|---|---|---|
| Deputy Mine Mgr | | -- | | | |
| Chief Mining Eng | | -- | | | |
| Mining Eng | | 6,000 | 6,000 | 6,000 | 6,000 |
| Geologist | | 6,000 | 6,000 | 6,000 | 6,000 |
| Chief Elec. Eng | | -- | | | |
| Elec. Engineer | | 6,000 | 6,000 | 6,000 | 6,000 |
| Chief Safety Eng | | -- | | | |
| Safety Engineer | | 4,000 | | 4,000 | 4,000 |
| Chief Training Ofc | | 5,000 | | | 5,000 |
| Training Instructor | | 4,000 | | 8,000 | 8,000 |
| Shift Foreman | | 5,000 | | | 15,000 |
| Stripping Foreman | | 5,000 | | | 15,000 |
| Oil Shale Mining Frm | | 5,000 | | | 15,000 |
| Maintenance Mgr | | -- | | | |
| Shop Foreman | | 6,000 | | | 18,000 |
| Field Maintenance Frm | | 5,000 | | | 15,000 |
| Surveyor | | 3,000 | | | 9,000 |
| Draftsman | | 3,000 | | | 3,000 |
| Personnel Mgr | | 5,000 | | | 5,000 |
| Personnel Staff | | 4,000 | | | 4,000 |
| Procurement Mgr | | 5,000 | | | 5,000 |
| Procurement Staff | | 4,000 | | | 4,000 |
| Warehouse Staff | | 3,000 | | | 9,000 |
| Secretary | | 2,000 | 2,000 | 4,000 | 8,000 |
| Accountant | | 2,000 | 4,000 | 6,000 | 8,000 |
| Cook | | 3,000 | 3,000 | 3,000 | 9,000 |
| Janitor | | 2,000 | 2,000 | 2,000 | 8,000 |
| Chemist | | 6,000 | | | 6,000 |
| Assistant Chemist | | 5,000 | | | 5,000 |
| Sampler | | 3,000 | | | 9,000 |
| Security Guard | | 3,000 | 12,000 | 12,000 | 12,000 |
| SUBTOTAL | | | 41,000 | 57,000 | 217,000 |
| Indirects..50% of Directs | | | 20,500 | 28,500 | 108,500 |
| SUBTOTAL | | | 61,500 | 85,500 | 325,500 |
| Contingency..20% | | | 12,300 | 17,100 | 65,100 |
| TOTAL | | | 73,800 | 102,600 | 390,600 |

Table 9-8

MINE AND PROCESS PLANT OPERATOR WORK FORCE
50 MW PROTOTYPE PLANT

| CLASSIFICATION | NO. | Salary $/YR | ANNUAL COST - US $ -2 1991 | -1 1992 | 1-25 1993-2017 |
|---|---|---|---|---|---|
| Blast Hole Driller | | 3,600 | | | 10,800 |
| Blast Hole Helper | | 2,700 | | | 8,100 |
| Shot Loader | | 3,000 | | | 6,000 |
| Shot Loader Helper | | 2,700 | | | 8,100 |
| Shot Firer | | 3,000 | | | 3,000 |
| Bulldozer Operator | | 3,000 | | | 21,000 |
| Front End Loader Opr. | | 3,000 | | | 21,000 |
| Electric Shovel Opr. | | --- | | | |
| Truck Driver | | 3,000 | | | 36,0000 |
| Scraper Operator | | 3,000 | | | 18,000 |
| Portable Crusher Opr. | | 3,000 | | | 9,000 |
| Surface Miner Opr. | | --- | | | |
| Belt Tender | | --- | | | |
| Water Truck Driver | | 3,000 | | | 9,000 |
| Grader Operator | | 3,000 | | | 9,000 |
| Powder Truck | | 2,700 | | | 2,700 |
| Fuel Truck Driver | | 2,700 | | | 5,400 |
| Service/Lube Truck Dr. | | 2,700 | | | 5,400 |
| Supply Truck Driver | | 2,700 | | | 2,700 |
| Crane Operator | | --- | | | |
| Back Hoe Opr. | | --- | | | |
| Core Drill Operator | | --- | | | |
| Core Drill Helper | | --- | | | |
| Utility Operator | | 3,000 | | | 12,000 |
| PROCESS PLANT | | | | | |
| Front End Loader Opr. | | 3,000 | | | 9,000 |
| Operator | | 3,000 | | | 9,000 |
| Operator Helper | | 2,700 | | | 8,100 |
| Belt Tender | | 2,500 | | | 7,500 |
| Laborer | | 2,400 | | | 7,200 |
| SUBTOTAL | | | | | 228,000 |
| Indirects..50% of Directs | | | | | 114,000 |
| SUBTOTAL | | | | | 342,000 |
| Contingency..20% | | | | | 68,400 |
| TOTAL | | | | | 410,400 |

Table 9-9

MINE AND PROCESS PLANT MAINTENANCE WORK FORCE
50 MW PROTOTYPE PLANT

| CLASSIFICATION | NO. | Salary $/YR | ANNUAL COST US $ -2 1996 | -1 1997 | 1-25 1998-2022 |
|---|---|---|---|---|---|
| Lead Mechanic - Mine | | --- | | | |
| Lead Mechanic - Truck | | --- | | | |
| Lead Mechanic - Plant | | --- | | | |
| Mechanic - Mine & Plt. | | 3,600 | | | 14,400 |
| Mechanic Helper | | 2,700 | | | 21,600 |
| Truck Mechanic | | 3,600 | | | 14,400 |
| Truck Mechanic Hlp. | | 2,700 | | | 21,600 |
| Welder | | 3,600 | | | 7,200 |
| Shop Journeyman | | 3,600 | | | 7,200 |
| Machine Ship Helper | | 2,700 | | | 5,400 |
| Lead Electrician | | --- | | | |
| Electrician | | 3,600 | | | 7,200 |
| Electrician Helper | | 2,700 | | | 8,100 |
| Instrument Maint. | | 3,600 | | | 3,600 |
| Carpenter/Painter | | --- | | | |
| Laborer | | 2,400 | | | 2,400 |
| SUBTOTAL | | | | | 113,100 |
| Indirects..50% of Directs | | | | | 56,550 |
| SUBTOTAL | | | | | 169,650 |
| Contingency..20% | | | | | 33,930 |
| TOTAL | | | | | 203,580 |

TABLE 9-10

CASH FLOW ANALYSIS

50 MW PROTOTYPE PLANT

MINE AND PROCESS PLANT

Table 9-10
MINING AND PROCESSING PLANT CASH FLOW ANALYSIS
50 MW PROTOTYPE PLANT
(All costs in $1000 unless otherwise noted)

| | -2 1996 | -1 1997 | 1 1998 | 2 1999 | 3 2000 | 4 2001 | 5 2002 | 6 2003 | 7 2004 | 8 2005 | 9 2006 | 10 2007 | 11 2008 | 12 2009 | 13 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, MW | | | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| II. OIL SHALE, TONNES/YR x 1000 | | | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | | | |
| 50/50 Debt/Equity Ratio | | | | | | | | | | | | | | | |
| Mine Development | 4111 | 3722 | | | | | | | | | | | | | |
| Mine Equipment | | 12202 | | | | | | | | | | | | | |
| Process Plt Facility | 4000 | 4388 | | | | | | | | | | | | | |
| Spare Parts | | 1300 | | | | | | | | | | | | | |
| Working Capital | | 2200 | | | | | | | | | | | | | |
| SUBTOTAL | 8111 | 23812 | | | | | | | | | | | | | |
| Capitalized Interest | 1596 | 1596 | | | | | | | | | | | | | |
| TOTAL | 9707 | 25408 | | | | | | | | | | | | | |
| 80/20 Debt/Equity Ratio | | | | | | | | | | | | | | | |
| Capitalized Interest | 2554 | 2554 | | | | | | | | | | | | | |
| TOTAL | 10665 | 26366 | | | | | | | | | | | | | |
| IV. OPERATING COST | | | | | | | | | | | | | | | |
| Parts, Sup,Fuel/Power | --- | ----- | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 |
| Wages and Fringes | 542 | 631 | 3165 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 |
| Explosives | --- | ----- | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 |
| Insurance | --- | ----- | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 |
| TOTAL | 542 | 631 | 6285 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 |

Table 9-10 (Cont)

| | -2 1996 | -1 1997 | 1 1998 | 2 1999 | 3 2000 | 4 2001 | 5 2002 | 6 2003 | 7 2004 | 8 2005 | 9 2006 | 10 2007 | 11 2008 | 12 2009 | 13 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V. INTEREST EXPENSE | | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | | | 1756 | 1639 | 1522 | 1405 | 1288 | 1171 | 1054 | 936 | 819 | 702 | 585 | 468 | 351 |
| 80/20 D/E Ratio | | | 2962 | 2765 | 2568 | 2370 | 2173 | 1975 | 1778 | 1580 | 1383 | 1185 | 988 | 790 | 593 |
| VI DEPRECIATION & AMORTIZATION | | | | | | | | | | | | | | | |
| Depreciation | | | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 |
| Amortization 50/50 | | | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 |
| Amortization 80/20 | | | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 |
| TOTAL 50/50 | | | 4071 | 4071 | 4071 | 4071 | 4071 | 4071 | 4071 | 4071 | 4071 | 4071 | 4071 | 4071 | 4071 |
| TOTAL 80/20 | | | 4209 | 4209 | 4209 | 4209 | 4209 | 4209 | 4209 | 4209 | 4209 | 4209 | 4209 | 4209 | 4209 |
| VII MANAGEMENT FEE | | | 487 | 487 | 487 | 487 | 487 | 487 | 487 | 487 | 487 | 487 | 487 | 487 | 487 |
| VIII RETURN ON EQUITY | | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | | | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 |
| 80/20 D/E Ratio | | | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 |
| IX ROYALTY | | | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 |
| X COST-PROCESSED OIL SHALE | | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | | | 16386 | 14430 | 14313 | 14196 | 14075 | 13962 | 13845 | 13727 | 1361 | 13494 | 13376 | 13259 | 13142 |
| 80/20 D/E Ratio | | | 15696 | 13663 | 13466 | 13268 | 13071 | 12873 | 12676 | 12478 | 12281 | 12083 | 11886 | 11688 | 11491 |
| XI COST - $/TONNE | | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | | | 16.84 | 14.83 | 14.71 | 14.59 | 14.47 | 14.35 | 14/23 | 14.11 | 13.99 | 13.87 | 13.75 | 13.63 | 13.51 |
| 80/20 D/E Ratio | | | 16.13 | 14.04 | 13.83 | 13.64 | 13.43 | 13.23 | 13.03 | 12.82 | 12.62 | 12.42 | 12.22 | 12.01 | 11.81 |
| XII COST - $/10$^6$ BTU | | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | | | 3.39 | 2.99 | 2.97 | 2.94 | 2.92 | 2.89 | 2.87 | 2.84 | 2.82 | 2.80 | 2.77 | 2.75 | 2.72 |
| 80/20 D/E Ratio | | | 3.25 | 2.83 | 2.79 | 2.75 | 2.71 | 2.67 | 2.63 | 2.58 | 2.54 | 2.50 | 2.46 | 2.42 | 2.38 |

Table 9-10 (Cont)
MINING AND PROCESSING PLANT CASH FLOW ANALYSIS
50 MW PROTOTYPE PLANT
(All costs in $1000 unless otherwise noted)

| | 14<br>2011 | 15<br>2012 | 16<br>2013 | 17<br>2014 | 18<br>2015 | 19<br>2016 | 20<br>2017 | 21<br>2018 | 22<br>2019 | 23<br>2020 | 24<br>2021 | 25<br>2022 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, MW | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | |
| II. OIL SHALE, TONNES/YR x 1000 | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 973 | 24,325 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | |
| 50/50 Debt/Equity Ratio | | | | | | | | | | | | | |
| Mine Development | | | | | | | | | | | | | |
| Mine Equipment | | | | | | | | | | | | | |
| Process Plant Facilities | | | | | | | | | | | | | |
| Spare Parts | | | | | | | | | | | | | |
| Working Capital | | | | | | | | | | | | | |
| SUBTOTAL | | | | | | | | | | | | | |
| Capitalized Interest | | | | | | | | | | | | | |
| TOTAL | | | | | | | | | | | | | |
| 80/20 Debt/Equity Ratio | | | | | | | | | | | | | 35,115 |
| Capitalized Interest | | | | | | | | | | | | | |
| TOTAL | | | | | | | | | | | | | |
| IV. OPERATING COST | | | | | | | | | | | | | 37,031 |
| Parts, Sup,Fuel/Power | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | 2991 | |
| Wages and Fringes | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | 1329 | |
| Explosives | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | 31 | |
| Insurance | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | |
| TOTAL | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | 4449 | |

Table 9-10 (Cont)

| | 14<br>2011 | 15<br>2012 | 16<br>2013 | 17<br>2014 | 18<br>2015 | 19<br>2016 | 20<br>2017 | 21<br>2018 | 22<br>2019 | 23<br>2020 | 24<br>2021 | 25<br>2022 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V. INTEREST EXPENSE | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 234 | 117 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | |
| 80/20 D/E Ratio | 395 | 198 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | |
| VI. DEPRECIATION & AMORTIZATION | | | | | | | | | | | | | |
| Depreciation | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | 3274 | |
| Amortization 50/50 | 797 | 797 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | |
| Amortization 80/20 | 935 | 935 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | |
| TOTAL 50/50 | 4071 | 4071 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | |
| TOTAL 80/20 | 4209 | 4209 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | 3300 | |
| VII MANAGEMENT FEE | 487 | 487 | 487 | 487 | 487 | 487 | 487 | 487 | 487 | 487 | 487 | 487 | |
| VIII RETURN ON EQUITY | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | 3512 | |
| 80/20 D/E Ratio | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | 1481 | |
| IX ROYALTY | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | |
| X COST-PROCESSED OIL SHALE | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 13025 | 12908 | 12020 | 12020 | 12020 | 12020 | 12020 | 12020 | 12020 | 12020 | 12020 | 12020 | 327947 |
| 80/20 D/E Ratio | 11293 | 11096 | 9989 | 9989 | 9989 | 9989 | 9989 | 9989 | 9989 | 9989 | 9989 | 9989 | 288899 |
| XI COST - $/TONNE | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 13.39 | 13.27 | 12.35 | 12.35 | 12.35 | 12.35 | 12.35 | 12.35 | 12.35 | 12.35 | 12.35 | 12.35 | 13.48 |
| 80/20 D/E Ratio | 11.61 | 11.40 | 10.27 | 10.27 | 10.27 | 10.27 | 10.2 | 10.27 | 10.27 | 10.27 | 10.27 | 10.27 | 11.88 |
| XII COST - $/10$^6$ BTU | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 2.70 | 2.67 | 2.49 | 2.49 | 2.49 | 2.49 | 2.49 | 2.49 | 2.49 | 2.49 | 2.49 | 2.49 | 2.72 |
| 80/20 D/E Ratio | 2.34 | 2.30 | 2.07 | 2.07 | 2.07 | 2.07 | 2.07 | 2.07 | 2.07 | 2.07 | 2.07 | 2.07 | 2.39 |

TABLE 9-12,13

DEPRECIATION AND AMORTIZATION

50 MW PROTOTYPE PLANT

MINE AND PROCESS PLANT

Table 9-12

MINE EQUIPMENT AND PROCESS PLANT DEPRECIATION

50 MW PROTOTYPE PLANT

(Costs in US $1000)

| | TOTAL COST | SALVAGE VALUE | DEPRECI VALUE | ECONOMIC LIFE, HRS | AVAIL % | UTIL % | EFF % | ANNUAL SCHED. HRS. | ANNUAL OPER. HRS. | DEPRECI $/HR | DEPRECI $/YR. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MINE DEVELOPMENT | | | | | | | | | | | |
| 1. Mine Service Facilities | ---------- SEE AMORTIZATION SCHEDULE ------ | | | | | | | | | | |
| 2. Balance of Mine Develop | | | | | | | | | | | |
| MINE EQUIPMENT | | | | | | | | | | | |
| 1. Scraper | 1314 | 99 | 1215 | 17000 | 78 | 80 | 62 | 7200 | 4464 | 71 | 319 |
| 2. Bull Dozer D10N | 1095 | 82 | 1013 | 15000 | 73 | 80 | 58 | 7200 | 4176 | 68 | 282 |
| 3. Bull Dozer D9N | 411 | 31 | 380 | 15000 | 73 | 80 | 58 | 7200 | 4176 | 25 | 106 |
| 4. Blast Hole Drill | 531 | 40 | 491 | 40000 | 80 | 80 | 64 | 7200 | 4608 | 12 | 56 |
| 5. Front End Loader | 2660 | 200 | 2460 | 18000 | 80 | 60 | 48 | 7200 | 3456 | 137 | 472 |
| 6. Haul Truck | 3241 | 243 | 2998 | 25000 | 80 | 80 | 64 | 7200 | 4608 | 120 | 553 |
| 7. Portable Crusher | 433 | 33 | 400 | 20000 | 80 | 50 | 40 | 7200 | 2880 | 20 | 58 |
| 8. Water Pump | 43 | 3 | 40 | 20000 | 95 | 5 | 5 | 8760 | 438 | 2 | 1 |
| 9. Compactor | 384 | 29 | 355 | 20000 | 95 | 20 | 19 | 2400 | 456 | 18 | 8 |
| 10. Grader | 331 | 25 | 306 | 20000 | 80 | 80 | 64 | 7200 | 4608 | 15 | 71 |
| 11. Water Truck | 648 | 49 | 599 | 35000 | 80 | 80 | 64 | 7200 | 4608 | 17 | 79 |
| 12. ANFO Bulk Storage | 41 | 3 | 38 | 20000 | 100 | 10 | 10 | 2400 | 240 | 2 | 1 |
| 13. Truck - Power | 43 | 3 | 40 | 15000 | 80 | 50 | 40 | 2400 | 960 | 3 | 3 |

Table 9-12 (Cont)

MINE EQUIPMENT AND PROCESS PLANT DEPRECIATION

50 MW PROTOTYPE PLANT

(Costs in US $1000)

| | TOTAL COST | SALVAGE VALUE | DEPRECI VALUE | ECONOMIC LIFE, HRS | AVAIL % | UTIL % | EFF % | ANNUAL SCHED. HRS. | ANNUAL OPER. HRS. | DEPRECI $/HR | DEPRECI $/YR. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MINE EQUIPMENT (cont) | | | | | | | | | | | |
| 14. Truck - Fuel | 108 | 8 | 100 | 15000 | 80 | 50 | 40 | 4800 | 1920 | 7 | 13 |
| 15. Truck - Service/Lube | 103 | 8 | 95 | 15000 | 80 | 50 | 40 | 4800 | 1920 | 6 | 12 |
| 16. Truck - Supply | 24 | 2 | 22 | 15000 | 80 | 50 | 40 | 4800 | 1920 | 2 | 3 |
| 17. Truck - Pick-Up | 80 | 6 | 74 | 9000 | 80 | 50 | 40 | 7200 | 2880 | 8 | 24 |
| 18. Survey Vehicle | 27 | 2 | 25 | 9000 | 80 | 25 | 20 | 7200 | 960 | 3 | 3 |
| 19. Personal Bus | 68 | 5 | 63 | 1500 | 80 | 25 | 20 | 7200 | 1440 | 4 | 6 |
| 20. Low Bed & Tractor | 177 | 13 | 164 | 2500 | 95 | 5 | 5 | 2400 | 120 | 7 | 1 |
| 21. Fork Lift | 98 | 7 | 91 | 10000 | 80 | 50 | 40 | 7200 | 2880 | 9 | 26 |
| 22. Compressor | 28 | 2 | 26 | 20000 | 95 | 10 | 10 | 7200 | 7200 | 1 | 1 |
| 23. Shop Tools | 201 | 15 | 186 | 40000 | 100 | 40 | 40 | 7200 | 7200 | 1 | 1 |
| 24. Light Plants | 112 | 8 | 104 | 20000 | 90 | 50 | 45 | 4800 | 2160 | 5 | 11 |
| SubTotal: | | | | | | | | | | | 2122 |
| PROCESS PLANT FACILITIES | | | | | | | | | | | |
| 1. Front End Loader | 472 | 35 | 437 | 18000 | 80 | 50 | 40 | 7200 | 2880 | 24 | 70 |
| 2. Feed Hopper | 71 | 2 | 69 | 40000 | 90 | 50 | 45 | 7200 | 3240 | 2 | 6 |

Table 9-12 (Cont)

MINE EQUIPMENT AND PROCESS PLANT DEPRECIATION

50 MW PROTOTYPE PLANT

(Costs in US $1000)

| | TOTAL COST | SALVAGE VALUE | DEPRECI VALUE | ECONOMIC LIFE, HRS | AVAIL % | UTIL % | EFF % | ANNUAL SCHED. HRS. | ANNUAL OPER. HRS. | DEPRECI $/HR | DEPRECI $/YR. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PROCESS PLANT FACILITIES (cont) | | | | | | | | | | | |
| 3. Belt Conveyor to Feed Bin | 168 | 4 | 164 | 40000 | 90 | 83 | 75 | 7200 | 5400 | 4 | 22 |
| 4. Feed Bin | 243 | 6 | 237 | 40000 | 90 | 83 | 75 | 7200 | 5400 | 6 | 32 |
| 5. Feeder | 97 | 2 | 95 | 20000 | 90 | 83 | 75 | 7200 | 5400 | 5 | 26 |
| 6. Impactor | 230 | 6 | 224 | 40000 | 90 | 83 | 75 | 7200 | 5400 | 6 | 30 |
| 7. Belt Conveyor to Screen | 208 | 5 | 203 | 40000 | 90 | 83 | 75 | 7200 | 5400 | 5 | 27 |
| 8. Screen | 307 | 8 | 299 | 40000 | 90 | 83 | 75 | 7200 | 5400 | 7 | 40 |
| 9. Belt Conveyor to Impactor | 208 | 5 | 203 | 40000 | 90 | 83 | 75 | 7200 | 5400 | 5 | 27 |
| 10. Sampler | 722 | 18 | 704 | 40000 | 90 | 83 | 75 | 7200 | 5400 | 18 | 95 |
| 11. Belt Conveyor to Storage | 222 | 5 | 217 | 40000 | 90 | 83 | 75 | 7200 | 5400 | 5 | 29 |
| 12. Belt Conveyor Top of Storage | 98 | 3 | 95 | 40000 | 90 | 83 | 75 | 7200 | 5400 | 2 | 13 |

Table 9-12 (Cont)
MINE EQUIPMENT AND PROCESS PLANT DEPRECIATION
50 MW PROTOTYPE PLANT
(Costs in US $1000)

| PROCESS PLANT FACILITIES (cont) | TOTAL COST | SALVAGE VALUE | DEPRECI VALUE | ECONOMIC LIFE, HRS | AVAIL % | UTIL % | EFF % | ANNUAL SCHED. HRS. | ANNUAL OPER. HRS. | DEPRECI $/HR | DEPRECI $/YR. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13. Diverter Valve | 83 | 2 | 81 | 20000 | 90 | 50 | 45 | 7200 | 3240 | 4 | 13 |
| 14. Storage Bin | 3748 | 111 | 3637 | 40000 | 90 | 83 | 75 | 7200 | 5400 | 91 | 491 |
| 15. Feeder | 182 | 5 | 177 | 20000 | 90 | 83 | 75 | 7200 | 5400 | 9 | 48 |
| 16. Electrics | 635 | 16 | 619 | 40000 | 100 | 83 | 83 | 7200 | 5976 | 15 | 92 |
| 17. Instrumentation & Controls | 214 | 5 | 209 | 40000 | 100 | 83 | 83 | 7200 | 5976 | 5 | 31 |
| 18. Dust Collectors | 345 | 14 | 331 | 20000 | 100 | 83 | 83 | 7200 | 5976 | 8 | 49 |
| 19. Laboratory Equipment | 133 | 10 | 123 | 40000 | 100 | 50 | 50 | 7200 | 3600 | 3 | 11 |
| SubTotal | | | | | | | | | | | 1152 |
| TOTAL: | | | | | | | | | | | 3274 |

Table 9-13
AMORTIZATION SCHEDULE
50MW PROTOTYPE PLANT
(Cost in US $1000)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| **50 MW PLANT 5/50** | | | | | | | | | | | | | | | | |
| 1. Mine Development | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | 480 | - |
| 2. Mine Service Facilities | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| 3. Pre-Op Labor | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | 78 | - |
| 4. Sub-Total | 584 | 584 | 584 | 584 | 584 | 584 | 584 | 584 | 584 | 584 | 584 | 584 | 584 | 584 | 584 | 26 |
| 5. Capitalized Interests | 213 | 213 | 213 | 213 | 213 | 213 | 213 | 213 | 213 | 213 | 213 | 213 | 213 | 213 | 213 | - |
| 6. TOTAL: | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 797 | 26 |
| **50 MW PLANT 8/20** | | | | | | | | | | | | | | | | |
| 7. Capitalized Interest | 341 | 341 | 341 | 341 | 341 | 341 | 341 | 341 | 341 | 341 | 341 | 341 | 341 | 341 | 341 | - |
| 8. TOTAL: | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 935 | 26 |

Table 9-13 (Cont)
AMORTIZATION SCHEDULE
50MW PROTOTYPE PLANT
(Cost in US $1000)

| | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| **50 MW PLANT 50/50** | | | | | | | | | |
| 1. Mine Development | - | - | - | - | - | - | - | - | - |
| 2. Mine Service Facilities | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| 3. Pre-Op Labor | - | - | - | - | - | - | - | - | - |
| 4. Sub-Total | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| 5. Capitalized Interests | - | - | - | - | - | - | - | - | - |
| 6. TOTAL: | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| **50 MW PLANT 80/20** | | | | | | | | | |
| 7. Capitalized Interest | - | - | - | - | - | - | - | - | - |
| 8. TOTAL: | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |

# 10.0 400 MW COMMERCIAL SCALE MINE PLAN

## 10.1 Factored Estimates

The use of factored estimates for the mining portion of the 400 MW commercial scale integrated project is not recommended, because the amount of materials to be handled is significantly greater than those of the smaller mines and processing plants. The design concept for a full scale mine and process plant is more capital intensive, but the cost per tonne of processed oil shale fuel is significantly decreased. The smaller mines and processing plants were developed and designed to keep capital costs at a minimum and they would be abandoned in favor of the larger scale mine and process plant in the event a full scale plant were to be constructed. Since the fuel cost of generating electricity is a major cost component, a cost that reflects the economics of a large scale mining and crushing operation for the processed oil shale product was developed for this case study.

## 10.2 Mine Development Plan

### 10.2.1 General

The northern area of the deposit was selected for the large scale mine primarily because of the ease of mine development in the shallower overburden along the west flank of the deposit. Refer to Figure 1.1.

There are two known obstacles in the northern area; namely, the major highway that cuts across the northwest corner of the deposit and the railroad that divides the area. The highway does not affect sufficient reserves to justify its relocation. However, the railroad relocation would prevent the development of a new mine which is much more costly than relocating a track to circumvent the deposit. This decision can be delayed until after 18 or 19 years of mine operation.



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The general development plan for the mine includes driving a ramp from the surface to the oil shale, opening a box-cut to expose the oil shale and advancing the pit from the box-cut to the east by a series of 80 metre wide cuts. The cuts will be oriented in a northwest-southeast direction and will vary in lengths from two to three kilometres.

### 10.2.2 Environmental Consideration

During the development stage of the mine consideration will be given to preserve the top-soil for the restoration of the land as soon as permitted by the mining operation, and to protect the surface and ground water from contamination. Top-soil will be removed from the mining area, the ramp, the haulroads, waste disposal area, mine service facilities and water sedimentation ponds and then stored in designated areas. The top-soil stockpiles will be protected from erosional forces and rain run-off water from the stockpiles will be collected in sedimentation ponds. Around the perimeter of the pit a trench will be dug to collect water from entering the pit. This pristine water will be discharged into a natural drainage channel. At the waste disposal site, a ditch will be dug around the stockpile area to collect rain run-off water from the disturbed area and stockpile. This water will be stored in a sedimentation pond designed for zero discharge. The haulroads from the pit and power plant to the waste disposal area will be constructed with drainage ditches on both sides of the road and water will be transferred from one ditch to the other by a series of culvert pipes. The water will be stored in sedimentation ponds design for zero discharge. One sedimentation pond will be built at the mine service facilities to collect rain run-off water from its disturbed area. Rain run-off water



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at the pit will be collected in a sump and pumped to the surface into a sedimentation pond. If any of the collected water is environmentally suitable, it will be used for dust suppression of the haulroads.

### 10.2.3 Incline Ramp

The incline ramp will be driven in a northwesterly direction along the west boundary of the deposit on a grade of 8 percent beginning at approximatly N56350 and E246950. The 30 metre wide ramp will be approximately 700 metres long. Based on side slopes of 0.5:1, the estimated amount of overburden will be 1.055 million bank cubic metres and the amount of oil shale recovered will be 165,000 tonnes. The 30 metre wide ramp will accommodate the oil shale belt conveyor and two-way truck traffic which will be necessary in the early years of operation for the disposal of overburden to the out-of-pit waste storage. Any oil shale mined during the development stage will be used to supplement the fuel requirement of whichever plant, 20 MW or 50 MW, was constructed before the full scale plant.

### 10.2.4 Box-cut

The box-cut is an excavation in the overburden which exposes the top of the oil shale for its extraction. Box-cuts are normally completed before production of oil shale is started to avoid delays in mining. Once the box-cut is completed, overburden is routinely removed from the advancing face at a rate that allows oil shale mining to meet the power plant fuel requirements.

The box-cut will be located along the west flank of the oil shale deposit immediately north of the



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incline ramp. The excavation of the ramp and box-cut will be coordinated since the ramp is the access to the box-cut. The overburden at this location is 35 metres thick and the oil shale is 20 metres thick. The box-cut will be comprised of three ten metre benches and one five metre bench in overburden materials and two ten metre benches in the oil shale. The oil shale benches will be mined as far as is necessary to provide space at the base of the ramp for the construction of the oil shale truck dump hoppers and conveyor belt. On the west side and north end of the box-cut, off-sets in the excavation will be left at the lower and intermediate level to allow for two-way truck traffic which will be required for the back-fill operation of the pit. The east side of the box-cut will be the advancing face consisting of four benches in the overburden which are 40 metres wide. The south end of the pit slope will be excavated to include roads for two-way traffic at a lower and intermediate level for the haulage of overburden out-of-the pit during the early years of operation. The length of the box-cut will be approximately 1000 metres and 80 metres wide at the top of the oil shale. Approximately 7.4 million bank cubic metres of overburden is estimated to be excavated and hauled to the out-of-pit waste dump.

The bench height of the box-cut is limited to ten metres because of safety for the type of equipment used in the excavation. This work, as well as all other development work, will be performed by a local contractor. Upon start of operation the Owner will operate the mine with its own equipment. Gradually, the mine bench height will be increased from 10 metres to 15 metres as the electric shovels are brought into service.

### 10.2.5 Overburden Disposal

The out-of-pit disposal area is located outside of the oil shale deposit along the east flank. The disposal area will include all waste materials from the expanded trial pit, the main mine development work and the mine overburden and spent shale of the first two 100 megawatt units for a minimum period of two years. It is estimated that the waste from the mine will be in excess of 25 million bank cubic metres and the spent shale equivalent will be in excess of 6 million bank cubic metres. In the backfill operation a slope of 5:1 will be maintained for slope stability and safety of the workers and equipment at the base of the pit and at the two in-pit backfill levels. During the course of mining, there will always be a need to store waste materials at this out-of-pit storage because of the material swell and the need to maintain a road at the bottom of the pit for delivery of oil shale to the truck dump hoppers. The out-of-pit storage pile is intended to be a permanent feature and it may require some special reclamation conditions, such as height and slopes.

### 10.2.6 In-pit Oil Shale Truck Dump and Belt Conveyor

At the base of the ramp an oil shale truck dump station will be constructed. This installation will consist of two rear dump truck hoppers, each with a capacity of 300 tonnes, equipped with a feeder capable of feeding 2000 tph from each hopper. The product dumped into the hopper will be minus 150 mm or 200 mm as mined by the surface miner. In-pit crushers are not required. As the pit advances these hoppers may be moved to decrease the haul distance.

Oil shale from the truck dump hoppers will be fed unto a 1500 mm wide belt conveyor capable of conveying as much as 3000 tph up the incline. The conveyor will be located on the west side of the ramp and will have a length of 1200 metres. This conveyor will be a permanent installation, and if the truck dump hoppers are relocated, a new conveyor will link the hopper and the incline conveyor.

### 10.2.7 Mine Service Facilities

The mine service facilities for the full scale mine will be an expansion of the service facilities of the smaller mine to accommodate the increase in the number of employees and equipment. These facilities will include additional truck maintenance bays for the 136 tonne trucks, maintenance bays for light vehicles and for other mobil equipment, and expansion of the warehouse, change house, training room, offices and cafeteria.

### 10.2.8 Mine Electrics

It is estimated that 6 kilometres of 132 kV powerline will be required to bring power to the mine for the electric power shovel. Three portable transformers, each with 5000 kVA capacity, will transform the power to 7.2 kV. The three blast hole drills will receive power from these transformers. If electric drives are selected for the surface miners, these transformer will be their source of power. The mine service facilities and mine incline conveyor belt will be supplied with power from the process plant circuit.



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## 10.3 Mine Operation

### 10.3.1 General Description

The basic mining activities include drilling and blasting overburden, loading and hauling overburden to out-of-pit waste stockpile or to backfilling the pit when space permits, and mining, hauling and conveying oil shale to out-of-pit stockpiles. For the 400 megawatt plant, the average hourly rate of mining will be approximately 1440 tonnes of performance fuel specification oil shale based on 900 shifts per year. The design rate of mining is 2000 tonnes per hour and based on a 100 percent capacity factor of the power plant, 72 percent of the design capacity is utilized.

The Sultani mine will be a large operation producing approximately 7.78 million tonnes of oil shale per year and moving 10.0 million bank cubic metres of overburden. To move these volumes of material efficiently, equipment must be sized and matched properly. Major equipment selected for this operation are three blast hole drills capable of drilling 250 mm diameter holes, three electric power shovels with dipper capacity of 20 cubic metres, twenty haul trucks with a carrying payload of 136 tonnes and two surface miners each capable of mining oil shale at the rate of 2000 tonnes per hour.

Because of the vertical and lateral variation in the oil content of the oil shale and the need for a consistent grade of fuel to the power plant, selective mining and elaborate blending of oil shale will be utilized.

### 10.3.2 Drilling and Blasting Overburden

Overburden drilling will be accomplished by three Ingersoll-Rand DM 50E Drillmaster blasthole drills. The 250 mm diameter holes will have burden and spacing centers of 10 metres and will be subject to change as on-site experience is gained. One drill will be stationed on each of the three benches, but will be able to move to other benches when required.

The explosive used in the blasting operation will be primarily ANFO. Primers will consist of commercial cast primers and sensitized slurry boosters may be required to ensure effective detonation. To eliminate the extensive use of blasting caps in the circuit, non-electric initiation systems and detonating cord will be used for trunklines and downhole lines. Blasting delays will be used between rows of holes and occasionally between holes in the same row to improve fragmentation and reduce ground vibration and air blast levels. A powder factor of 0.2 kg per bank cubic metre is used for cost-estimating and will be subject to change as on-site experience is gained.

On-site explosive storage will be provided for bulk blasting agents, bagged ANFO, and high explosives. The construction of these facilities will comply with appropriate standards.

Blasting will be done on a daily basis and access to the blasting area will be controlled prior to the time of blasting.



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### 10.3.3 Loading and Hauling Overburden

Loading of overburden will be by three P&H 2300 electric shovels with 20 cubic metre dipper capacity. These shovels will load Caterpillar 785 trucks which have 136 tonne capacities. The shovel and truck are matched so that five passes from the shovel will fill the truck. Three or four trucks will be assigned to each of the shovels depending on the haul distance.

From the box-cut the bench height will be increased to 15 metres from 10 metres and the four benches will become three. As mining progresses toward the east, the overburden becomes thicker and eventually four- 15 metre high benches will be required. The three shovels will work the four benches. Two Caterpillar 992 C front end loaders equipped with high lifts and 9.1 $m^3$ buckets will serve as back-up to a shovel or will be used to supplement the loading capacity when needed.

Overburden will be hauled to the out-of-pit storage until it is safe to begin backfilling the pit. This will probably occur after the second 100 megawatt unit has operated a full year. At the out-of-pit storage, bulldozers will continuously level the dumping areas to maintain a steady flow of truck traffic.

### 10.3.4 Mining, Hauling and Conveying Oil Shale

Selective mining of the oil shale will be accomplished by two Easi-Miner Model 1224 continuous surface miners. The machine will excavate the oil shale in plies of up to 610 mm thick and 4140 mm wide. The thickness of these plies can be varied from 150 mm to 610 mm with a cutting tolerance of



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25 mm. This feature provides the mining selectivity required for this operation in separating high and low grade oil shales and removing waste materials. These machines are expected to be able to cut the soft in-place oil shales and blasting is not required. The size of the product cut by the surface miner is a function of the speed with which it can cut the oil shale. In soft materials the product size can be as large as 200 mm and in moderately hard materials the machine will cut pieces as large as 150 mm. These sizes are capable of being transported by a conveyor belt and a primary crusher is not required.

The oil shale will be loaded directly from the surface miner into a Caterpillar 785 truck which will transport it to the oil shale truck dump hopper. (Refer to Figure 10.1.) The surface miner has the capability of mining 2000 tonnes per hour. Two dump hoppers are provided to prevent delays when both surface miners are operating. Each hopper is equipped with a feeder capable of feeding as much as 2000 tonnes per hours. Normally, the feed rate will be approximately 1000 tph from each feeder, and on occassion one feeder may feed at its maximum rate when one of the feeders is out of service. The belt conveyor will be able to handle surges of 3000 tph.

The incline conveyor will be 1500 mm wide constructed with a steel cord belt. It will have an overall length of approximately 1200 metres and the incline angle of the conveyor will be the same as that of the ramp which is driven on an 8 percent grade.

### 10.3.5 Backfilling of Pit

The backfilling of the pit will be made safe to protect the workers and equipment working in or around this operation. The recommended backfill slope will be 5:1 to provide slope stability and adequate distance between the backfilling benches. Three backfill benches will be provided. The lower and intermediate level will be backfilled with overburden and the upper bench will be filled with spent shale and overburden. Spent shale will be trucked from the power plant. Because of material swell and the need to maintain a road at the base of the pit for the transport of oil shale, overburden from the upper bench will on occasion be stored at the out-of-pit storage. Backfilling of the lower level will commence shortly after the oil shale is removed in the first cut. A full scale operation will begin after the third cut is removed. Spent shale disposal in the pit will not occur until this time.

### 10.3.6 Reclamation Plan

Reclamation procedures should minimize adverse impacts during mining and to restore all affected lands to their pre-mining land use. The major objectives of the reclamation effort are to control wind and water erosion. To attain these goals the overburden must be classfied as to its textural and chemical suitability and handled accordingly. It will be necessary to locate, segregate, and bury all undesirable materials, to replace overburden materials in an appropriate manner and to revegetate with appropriate plant species. Reclamation is a continuous and integral part of the mining activities and the final mine plans and reclamation plans should be developed together.

The operator should institute an ongoing sampling program for overburden. The sampling procedure should include both visual and chemical methods for classification of overburden suitability. By sampling ahead of mining, the operator can assure that only suitable materials will be placed near the surface. Analyses performed on drill samples should include acid-base potential, texture, pH, SAR, conductivity and trace elements such as B, Mo, Cu and Pb.

After the land is backfilled and grading is complete, the surface will be scarified by deep ripping before surfacing land with top soil. Graders and farm type equipment will be used to prepare the surface so as to promote water retention for erosion control and vegatation establishment.

### 10.3.7 Phosphorite Recovery

Recent core drilling indicates the presence of a potentially interesting layer of phosphate mineral immeditely underlying the oil shale beds.

Development of a modified mining plan will be necessary if it is decided to recover the underlying phosphorite.



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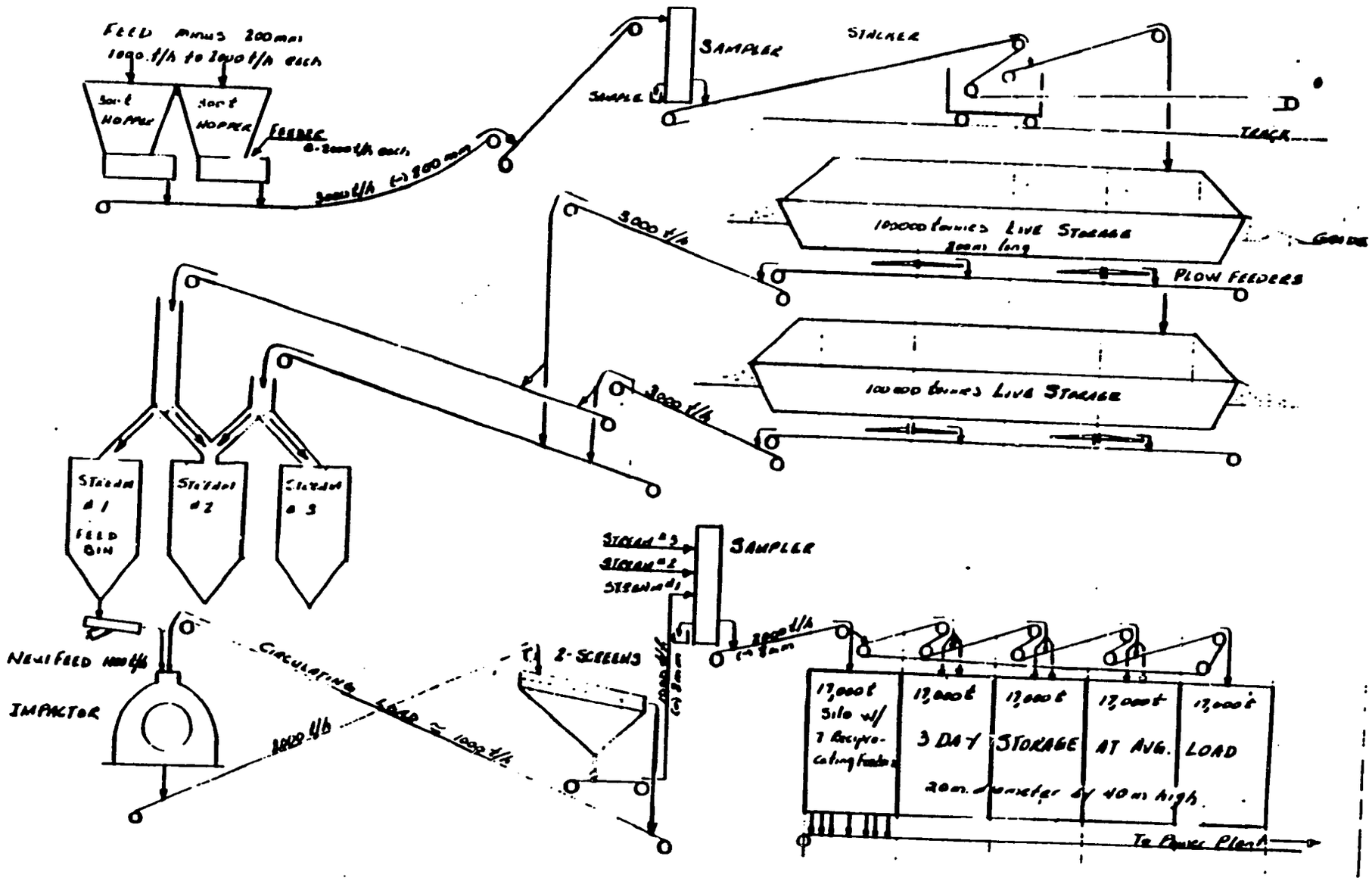


FLOW SHEET - OIL SHALE PROCESSING PLANT
400 MW FULL SCALE PLANT
FIGURE 10.1

## 11.0 400 MW COMMERCIAL SCALE SHALE PROCESSING PLANT

### 11.1 Sampling, Storing and Reclaiming

Oil shale conveyed from the pit bottom to the surface will be transferred to a 1500 mm wide belt conveyor that elevates the oil shale to a three stage sampler. The sampler will be designed in accordance to ASTM standards. A belt scale will weigh the oil shale going to the sampler and samples representing a pre-determined amount of tonnes will be collected. These samples will be analyzed for quality control of the product through the system. Refer to Figure 10.1 Flow Sheet for 400 MW Process Plant. After leaving the sampler, the oil shale is discharged onto a double wing traveling stacker capable of stacking 3000 tonnes per hour. The stacker is located between two open storage piles. Stacking of oil shale will occur in one storage facility, while the second is being reclaimed. Stockpiling of oil shale along side the storages and reclaiming by bulldozer will be the method used to feed the plant in case of prolonged outages of the conveying and stacking system.

The two storage and reclaim facilities will be constructed of concrete with a V-shaped bottom and will be 200 metres long. Each storage facility will be able to store 100,000 tonnes of which most will be live storage except for small amounts at both ends. At each of the storage facilities, reclaiming will be by two rotary plow feeders with variable speed drives. The reclaim system is designed for 3000 tonnes per hour.

Control of the oil shale quality begins with the mining of oil shale. If both surface miners are mining either high grade or low grade oil shale, the mode of storing will be to keep the grades of oil shale separated in the storage. Upon reclaiming, the speed of the rotary plow feeders will be



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controlled to mix the oil shales into a product that approximates the performance fuel specification. If both surface miners are mining diferent grades of oil shale and trying to approximate the performance fuel specification at the pit, the traveling stacker will travel back and forth between the two ends of the storage, building a windrow as well as leveling out any quality peaks and valleys.

Because of the representative sampling and testing that is continuously performed, the calorific value of the oil shale within the storage pile is known. Further mixing will be made by controlling the speed of the rotary plow feeders before the oil shale is delivered to the impactor feed bins.

## 11.2 Crushing and Sizing

At full scale operation, three crushing and sizing circuits will be constructed. Two circuits will be operating, while the third will be on a stand-by basis or out of service for maintenance. Each circuit will have the capacity of producing 1000 tonnes per hour of minus 8 mm product. The built-in reliabilty of an extra circuit is a necessity because of the power plant dependence on a steady supply of fuel. At an annual rate of 7.78 million tonnes, there will be considerable abrasion wear on parts such as hammers, screen cloth, and chute liners which would be difficult to maintain with two crushing and screening circuits.

Oil shale from the two storage facilities will be conveyed to the transfer tower at a rate of 3000 tonnes per hour. At the transfer tower, the oil shale is transferred onto either one of two conveyors that delivers the oil shale to either of three feed bin through a chute arrangement. The feed bins will be 8 metres in diameter and 16 metres high, each having a capacity of 1000 tonnes. The bins will be equipped with a vibrating feeder capable of feeding 1000 tonnes per



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hour across the width of the crushing chamber of a Pennsylvania Crusher Reversible Impactor Type CA 10-72. Each circuit will have the impactor in closed circuit with two screens, Pennsylvania Crusher Type BHG 38/95 (3.8 m by 9.5 m screen deck). The undersize material will be conveyed to the sampler and the oversize will be conveyed to the impactor. Until tests are made of the friability of the oil shale, the circulating load has been estimated at 100 percent for the purpose of this study.

## 11.3 Sampling, Storing and Blending

The undersize product from all screens in conveyed to a common sampler where samples are extracted before the product is stored in concrete silos. The three stage sampler will be built according to ASTM standards.

After the oil shale leaves the sampler, it is conveyed by belt conveyor to the top of the silos and discharges the oil shale onto a conveyor belt system that distributes the oil shale into five silos. The stationary tripper and diverter valve arrangement at each silo will allow for either filling the silo or passing the material to another silo. The silos are 20 metres in diameter and 40 metres high and each will have a capacity of approximately 17,000 tonnes which will provide a three day storage for the power plant operating at full capacity. Each silo is equipped with seven variable speed reciprocating plate feeders for the final mixing of the power plant feed. Feed from four silos can be withdrawn simultaneously, while the fifth is being filled and tested.

The reciprocating plate feeders will be the interface with the power plant for this study. Conveying from the silos to the boiler fuel bunkers will be for the power plant account.



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## 12.0 400 MW FULL SCALE MINE AND PROCESS PLANT ECONOMICS

### 12.1 Capital Expenditure

#### 12.1.1 Summary of Capital Expenditure

The capital expenditures for the mining and processing plant were determined for the mine development, the mining equipment and the construction of the oil shale process plant. The following table summarizes these expenditures.

Table 12-1

CAPITAL COST SUMMARY FOR 400 MW FULL SCALE PLANT
(in U.S. $1000)

| | Base $ | Delivery $ | Erection $ | Total $ | Foreign $ | Local $ |
|---|---|---|---|---|---|---|
| Mine Development | 27953 | 250 | 2712 | 30915 | 4851 | 26064 |
| Mine Equipment | 46595 | 6968 | 12449 | 66012 | 51784 | 14228 |
| Process Plant Facilities | 31193 | 1985 | 27811 | 60989 | 18715 | 42274 |
| TOTAL | 105741 | 9203 | 42972 | 157916 | 75350 | 82566 |

These costs are reprsentative of expected costs in Jordan at this time and include engineering, procurement, construction management, direct and indirect construction costs, ocean and inland freight, and a 10 percent contingency. Construction costs are based on Bechtel's experience in the area of Jordan and with the benefit of conceptual engineering. The mining and processing equipment cost estimate is based on vendor budget prices. The delivery cost estimates are average costs taken from Bechtel's records. Special handling features are excluded from the delivery estimates because of



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their wide range of costs. A large percentage of the mine development work is based on Comedat's quote of April 12, 1988 for drilling, blasting, loading and hauling overburden. It is to be noted that this is an order of magnitude cost estimate with a range spread of minus 15 percent to plus 25 percent of the capital cost presented in the cost summary.

### 12.1.2 Estimate Basis

Capital equipment quotations were solicited by telephone from a number of vendors. Only budget prices were requested. Installation manhours were assigned to each item of capital equipment based on recent historical data. Values for process piping, electrical and instrumentation were based on standard factors of the value of the process mechanical equipment as determined from experience.

Bulk construction material and building cost estimates are based on using local suppliers and contractors.

Installation manhours and costs are based on Bechtel's experience in the area of Jordan. Included in these costs are base wages, overtime allowance, fringe benefits, small tools and consumables, and contractor's overhead and profit.

The major construction indirect costs items are the supply and maintenance of temporary construction facilities and services and the rental and operation of construction equipment.



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A factor of 15 percent of the value of the mechanical equipment was used for the delivery cost estimate. The estimate includes freight to foreign port, ocean freight, and inland freight to site. Import duty is excluded.

Taxes of all kind are excluded from this estimate.

Cost estimate is based on 2 Q 1988 costs and they have not been escalated from that date.

The cost estimate does not include any financing charges, spare parts and working capital. These cost are included in the cash flow analysis for the cost of fuel.

### 12.1.3 Capital Cost Estimate

Table 12-2 Mine Development, Mine Equipment, Process Plant Facilities Capital Cost provides the information used in preparing the capital cost estimate.

## 12.2 Operating Costs

### 12.2.1 Summary of Operating Costs

The operating costs include those costs for the mine equipment, process plant, mine services building, and labor for the mine and process plant. Mine equipment operating costs are composed of costs for repair parts, consumables, lubrication, and fuel or electric power. The process plant and the mine services building operating costs are based on a percentage of the base capital cost of each piece of equipment or building. Labor costs include expatriate labor, supervisors, technical and



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administrative workers, operating and maintenance personnel. Excluded from these operating cost are the cost for explosives and insurance which are included as operating costs in the cash flow analysis. The following summarizes the operating costs:

Table 12-3

OPERATING COST SUMMARY FOR 400 MW FULL SCALE PLANT
(in U.S. $1000)

| | Annual Operating Cost $ | Foreign $ | Local $ |
|---|---|---|---|
| Mine Equipment | 11935 | 7793 | 4142 |
| Process Plant | 2394 | 1634 | 760 |
| Services Building | 150 | -- | 150 |
| Labor | 2411 | 385 | 2026 |
| TOTAL | 16890 | 9812 | 7978 |

### 12.2.2 Basis of Operating Costs

Table 12-4 Mine and Processing Plant Operating Costs presents the method by which the costs were determined for the mining equipment and the process plant facilities as well as the mine services building. There are many variables that influence operating costs and operating costs can be significantly different between companies. The cost and factors used in this estimate were developed by Bechtel from a number of sources and they should be representative of costs expected to occur in Jordan.

Expatriate labor will be used for training and start-up purposes. Only two key expatriate workers will be retained in the permanent work force and the remaining will be replaced as soon as personnel are trained. In addition to the two expatriates, there will be a total of 70 people involved with supervision, technical and administrative work, a total of 201 people to operate the mine and process plant and 105 people to maintain these operations at the 400 MW level. The total workforce will include 378 people. Labor rates used in this estimate are from the Jordan Electric Authority and other mining studies performed in the Jordan area. The labor cost for the work force are presented in the following:

Table 12-5 Work Force Summary
Table 12-6 Expatriate Work Force
Table 12-7 Professional/Technical/Administrative
Table 12-8 Mine and Process Plant Operator Work Force
Table 12-9 Mine and Process Plant Maintenance Work Force

## 12.3 Cash Flow Analysis

The cash flow analysis for the 400 MW Full Scale Plant is shown on Table 12-10 400 MW Full Scale Plant Mining and Processing Plant Cash Flow Analysis. The analysis consists of a three year pre-production period and a 25 year operating period. Debt-equity ratios of 50:50 and 80:20 are used in the analysis.

### 12.3.1 Summary of Cash Flow Analysis

Table 12-11

SUMMARY OF CASH FLOW ANALYSIS FOR 400 MW PLANT

| | Capital Cost $1000 | Product Cost $/Tonne | Product Cost $/10$^6$ Btu |
|---|---|---|---|
| 50:50 Debt/Equity | 187,239 | 7.74 | 1.56 |
| 80:20 Debt/Equity | 201,891 | 6.69 | 1.35 |

The capital cost presented above includes the interst during construction, spare parts and working capital in addition to the capital expenditures summarized in 12.1.1. The product cost is a weighted cost for the 25 year operating period for 7,783,000 tonnes to be mined annually. This cost expressed in $/10$^6$Btu is based on the performance fuel specification of 2250 Btu/pound.

### 12.3.2 Cash Flow Analysis Basis

The capital expenditure for the mine development, mine equipment and processing plant was presented in Section 12.1. Added to these costs were spare parts for the mine and process plant and a working capital fund. The spare parts amount to approximately 10 percent of the base value of the equipment and machinery cost and the working capital will be sufficient to cover three months of operating costs and other unforseen costs. Interest during construction for the two debt-equity cases are capitalized.

- The operating costs basis for parts, supplies, fuel and power, and wages and fringes were



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presented in Section 12.2. In addition to these costs are explosives and insurance. Explosives are based on a powder factor of 0.2 kg per $bm^3$ at a U.S. average blasting agents cost of $125/short ton. Explosives are used for overburden blasting only. Insurance cost is based on one half of one percent for the cost of the mining equipment, the constructed process plant and services building.

- Interest expenses were computed at a rate of 10 percent and the loan term was 15 years. Because of the long construction period, two separate loans are used in the analysis.

- Depreciation is based on the economic life of the mining and processing equipment in hours and its estimated hours of use per year. Details of these determinations are found in Table 12-12 Mine Equipment and Process Plant Depreciation.

- The mine development, pre-production labor, cpaitalized interest were amortized over a 15 year period and the mine services building was amortized over a 25 year period. The amortization schedule is shown on Table 12-13 400 MW Full Scale Plant Amortization Schedule.

- A mangement fee of $0.50 per ton is used for the responsiblity of operating the mine and process plant. It includes home office expenses attributed to the operation.

- A twenty percent return on equity is used for both debt-equity cases.



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Since this study excludes land costs, import duties, sales and use taxes, property and facilities taxes, income taxes for project operations, and income taxes for expatriate employees, the cost of the oil shale product, $7.74 per ton and $6.69 per ton for debt-equity ratios of 50:50 and 80:20, respectively, are accurate to within the limits of the estimate, which ranges between minus 15 percent and plus 25 percent.

TABLE 12-2

CAPITAL COSTS

400 MW FULL SCALE PLANT

MINE AND PROCESS PLANT

Table 12-2

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

400MW FULL SCALE PLANT

(Costs in U.S. $1,000)

| | | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|---|
| **MINE DEVELOPMENT** | | | | | | | | | |
| 1. | Roads | 8km | 150 | 1,200 | -- | 120 | 1,320 | 120 | 1,200 |
| 2. | Top Soil Removal & Storage | $500x10^3m^3$ | 2.00 | 1,000 | -- | 100 | 1,110 | 100 | 1,000 |
| 3. | Incline Ramp | $1150x10^3m^3$ | 2.00 | 1,000 | -- | 253 | 2,783 | 253 | 2,530 |
| 4. | Box Cut | $7400x10^3m^3$ | 2.20 | 16,280 | -- | 1,628 | 17,908 | 1,628 | 16,280 |
| 5. | Trenches | 15000m | 10 | 150 | -- | 15 | 165 | 15 | 150 |
| 6. | Sedimentation Ponds | 5 | 50 | 250 | -- | 25 | 275 | 25 | 250 |
| 7. | Mine Service Facilities | 1 | 1500 | 1,500 | -- | 150 | 1,650 | 150 | 1,500 |
| 8. | Mine Electrics | 1 Lot | 1500 | 1,500 | 225 | 150 | 1,875 | 1,575 | 300 |
| 9. | Engineering | | 750 | 750 | -- | -- | 750 | 500 | 250 |
| | Sub-Total | | | 25,160 | 225 | 2,441 | 27,826 | 4,366 | 23,460 |
| 10. | Contingency - 10% | | | 2,516 | 23 | 244 | 2,783 | 437 | 2,346 |
| | Sub-Total | | | 27,676 | 248 | 2,685 | 30,609 | 4,803 | 25,806 |
| 11. | Fee | | | 277 | 2 | 27 | 306 | 48 | 258 |
| | TOTAL | | | 27,953 | 250 | 2,712 | 30,915 | 4,851 | 26,064 |
| **MINE EQUIPMENT** | | | | | | | | | |
| 1. | Scraper 657 w/Auger | 1 | 826 | 826 | 124 | 41 | 991 | 888 | 103 |
| 2. | Bulldozer D10N w/Ripper | 3 | 411 | 1,233 | 185 | 62 | 1,480 | 1,388 | 92 |

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Table 12-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

400MW FULL SCALE PLANT

(Costs in U.S. $1,000)

| | | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|---|
| 3. | Bulldozer D9N w/Ripper | 6 | 309 | 1,854 | 278 | 93 | 2,225 | 2,002 | 223 |
| 4. | Blast Hole Drill DM50E | 3 | 466 | 1,398 | 210 | 70 | 1,678 | 1,510 | 168 |
| 5. | Electric Shovel P&H 2300 | 3 | 3,300 | 9,900 | 1,485 | 1,485 | 12,870 | 10,746 | 2,124 |
| 6. | Haul Truck 785 | 20 | 707 | 14,140 | 2,121 | 707 | 16,968 | 15,908 | 1,060 |
| 7. | Front End Loader 992C | 2 | 685 | 1,370 | 206 | 69 | 1,645 | 1,480 | 165 |
| 8. | Surface Miner 1224 | 2 | 1,500 | 3,000 | 450 | 150 | 3,600 | 3,240 | 360 |
| 9. | Grader 16G | 2 | 249 | 498 | 75 | 25 | 598 | 538 | 60 |
| 10. | Water Truck | 2 | 486 | 972 | 146 | 49 | 1,167 | 1,050 | 117 |
| 11. | Compactor | 1 | 289 | 289 | 43 | 14 | 346 | 312 | 34 |
| 12. | Crane 40T | 1 | 348 | 348 | 52 | 17 | 417 | 375 | 42 |
| 13. | Forklift IT28 | 2 | 73 | 146 | 22 | 7 | 175 | 158 | 17 |
| 14. | Forklift IT12 | 2 | 48 | 96 | 14 | 5 | 115 | 108 | 7 |
| 15. | Core Drill | 1 | 305 | 305 | 46 | 15 | 366 | 329 | 37 |
| 16. | Cable Skidder | 2 | 65 | 130 | 20 | 7 | 157 | 141 | 16 |
| 17. | Back Hoe | 1 | 310 | 310 | 47 | 16 | 373 | 336 | 37 |
| 18. | Water Pump | 8 | 16 | 128 | 19 | 6 | 153 | 138 | 15 |
| 19. | Truck-Powder | 2 | 50 | 100 | 15 | 5 | 120 | 108 | 12 |
| 20. | Truck-Fuel | 2 | 80 | 162 | 24 | 8 | 194 | 182 | 12 |

Table 12-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

400MW FULL SCALE PLANT

(Costs in U.S. $1,000)

| | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|
| 21. Truck-Service/Lube | 2 | 65 | 130 | 20 | 7 | 157 | 141 | 16 |
| 22. Truck-Mech/Weld | 1 | 77 | 77 | 12 | 4 | 93 | 84 | 9 |
| 23. Truck-Electrician | 1 | 54 | 54 | 8 | 3 | 65 | 59 | 6 |
| 24. Truck-Supply | 2 | 30 | 60 | 9 | 3 | 72 | 65 | 7 |
| 25. Truck-Pickup | 10 | 12 | 120 | 18 | 6 | 144 | 130 | 14 |
| 26. Tractor/Lowbed | 1 | 132 | 132 | 20 | 7 | 159 | 139 | 20 |
| 27. Survey Vehicle | 2 | 20 | 40 | 6 | 2 | 48 | 43 | 5 |
| 28. Ambulance | 1 | 86 | 86 | 13 | 4 | 103 | 93 | 10 |
| 29. Fire Truck | 1 | 88 | 88 | 13 | 4 | 105 | 94 | 11 |
| 30. Personnel Bus | 3 | 25 | 75 | 11 | 4 | 90 | 77 | 13 |
| 32. Light Plant | 12 | 14 | 168 | 25 | 8 | 201 | 189 | 12 |
| 33. Farm Tractor | 1 | 15 | 15 | 2 | 1 | 18 | 16 | 2 |
| 34. Reclamation Tools | 1 Lot | 25 | 25 | 4 | 1 | 30 | 27 | 3 |
| 35. Communicaltion Equip. | 1 Lot | 100 | 100 | 15 | 5 | 120 | 113 | 7 |
| 36. Dump Hopper | 2 | 90 | 180 | 12 | 224 | 416 | 22 | 394 |
| 37. Feeder | 2 | 120 | 240 | 36 | 621 | 897 | 320 | 577 |

Table 12-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

400MW FULL SCALE PLANT

(Costs in U.S. $1,000)

| | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|
| 38. Belt Conveyor From Pit | 1 | 2,360 | 2,360 | 354 | 6,109 | 8,823 | 3,148 | 5,675 |
| 39. Belt Conveyor to Sampler | 1 | 330 | 330 | 50 | 863 | 1,243 | 441 | 802 |
| 40. Belt Scale | 1 | 20 | 20 | 3 | 34 | 57 | 25 | 32 |
| 41. Sampler | 1 | 175 | 175 | 25 | 430 | 630 | 230 | 400 |
| 42. Shop Tools | 1 Lot | 200 | 200 | 30 | 10 | 240 | 216 | 24 |
| 43. ANFO Bulk Storage | 2 | 30 | 60 | 4 | 4 | 68 | 2 | 66 |
| Sub Total | | | 41,940 | 6,272 | 11,205 | 59,417 | 46,611 | 12,806 |
| 44. Contingency | | | 4,194 | 627 | 1,121 | 5,942 | 4,661 | 1,281 |
| 45. Fee | | | 461 | 69 | 123 | 653 | 512 | 141 |
| TOTAL | | | 46,595 | 6,968 | 12,449 | 66,012 | 51,784 | 14,228 |
| **PROCESS PLANT FACILITIES** | | | | | | | | |
| 1. Stacker | 1 | 2,000 | 2,000 | 300 | 222 | 2,522 | 2,172 | 350 |
| 2. V-Slot Storage | 2 | 3,564 | 7,128 | -- | 572 | 7,700 | 572 | 7,128 |
| 3. Plow Feeder | 4 | 60 | 240 | 36 | 621 | 897 | 320 | 577 |
| 4. Belt Conveyor/Plow FDR | 2 | 525 | 1,050 | 160 | 2,718 | 3,928 | 1,402 | 2,526 |

Table 12-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT,

PROCESS PLANT FACILITIES CAPITAL COSTS

400MW FULL SCALE PLANT

(Costs in U.S. $1,000)

| | | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|---|
| 5. | Belt Conveyor/Transfer TWR | 2 | 300 | 600 | 90 | 1,553 | 2,243 | 800 | 1,443 |
| 6. | Belt Conveyor/Feed Bin | 2 | 300 | 600 | 90 | 1,553 | 2,243 | 800 | 1,443 |
| 7. | Diverter Valves | 4 | 20 | 80 | 12 | 207 | 299 | 128 | 171 |
| 8. | Feed Bin | 3 | 116 | 348 | 52 | 431 | 831 | 431 | 400 |
| 9. | Impactor Feeder | 3 | 75 | 225 | 35 | 582 | 842 | 400 | 442 |
| 10. | Impactor | 3 | 355 | 1,065 | 160 | 2,757 | 3,982 | 1,421 | 2,561 |
| 11. | Belt Conveyor/Screen | 3 | 295 | 885 | 135 | 2,291 | 3,311 | 1,181 | 2,130 |
| 12. | Screen | 6 | 180 | 1,080 | 160 | 2,796 | 4,036 | 1,440 | 2,596 |
| 13. | Belt Conveyor/Impactor | 3 | 295 | 885 | 135 | 2,291 | 3,311 | 1,181 | 2,130 |
| 14. | Belt Conveyor/Sampler | 3 | 82 | 246 | 34 | 637 | 917 | 327 | 590 |
| 15. | Sampler | 1 | 175 | 175 | 25 | 453 | 653 | 233 | 420 |
| 16. | Belt Conveyor/Storage | 1 | 220 | 220 | 30 | 570 | 820 | 292 | 528 |
| 17. | Belt Conveyor/Top of Silos | 1 | 154 | 154 | 26 | 398 | 578 | 207 | 371 |
| 18. | Diverter Valves | 4 | 20 | 80 | 12 | 207 | 299 | 107 | 192 |
| 19. | Storage Silos | 5 | 1,750 | 8,750 | -- | 304 | 9,054 | 804 | 8,250 |
| 20. | Reciprocating Feeders | 35 | 23 | 805 | 120 | 2,088 | 3,013 | 1,074 | 1,939 |

Table 12-2 (Cont)

MINE DEVELOPMENT, MINE EQUIPMENT

PROCESS PLANT FACILITIES CAPITAL COSTS

400MW FULL SCALE PLANT

(Costs in U.S. $1,000)

| | QUANTITY | UNIT COST | BASE COST | DELIVERY COST | ERECTION COST | TOTAL COST | FOREIGN | LOCAL |
|---|---|---|---|---|---|---|---|---|
| 21. Instrumentation & Controls | 3 Lot | 50 | 150 | 24 | 405 | 579 | 203 | 376 |
| 22. Dust Collector | 14 | 35 | 490 | 74 | 450 | 1,014 | 572 | 442 |
| 23. Electrics | 1 Lot | 520 | 520 | 61 | 897 | 1,478 | 640 | 838 |
| 24. Laboratory & Equipment | 1 Lot | 300 | 300 | 15 | 30 | 345 | 138 | 207 |
| Sub-Total | | | 28,076 | 1,786 | 25,033 | 54,895 | 16,845 | 38,050 |
| 25. Contingency | | | 2,808 | 179 | 2,503 | 5,490 | 1,685 | 3,805 |
| Sub-Total | | | 30,884 | 1,965 | 27,536 | 60,385 | 18,530 | 41,855 |
| 26. Fee | | | 309 | 20 | 275 | 604 | 185 | 419 |
| TOTAL | | | 31,193 | 1,985 | 27,811 | 60,989 | 18,715 | 42,274 |

TABLE 12-4

OPERATING COSTS

400 MW FULL SCALE PLANT

MINE AND PROCESS PLANT

Table 12-4

MINE AND PROCESSING PLANT OPERATING COSTS

400MW FULL SCALE PLANT

(Costs in US $1000)

| | | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| MINE EQUIPMENT | | | | | | | | | | | | |
| 1. | Scraper | 20.00 | 19.22 | 5.00 | 30.10 | 74.32 | 1488 | | | 111 | 59 | 52 |
| 2. | Bulldozer D10N | 25.00 | 3.05 | 3.45 | 15.48 | 46.98 | 12528 | | | 589 | 352 | 237 |
| 3. | Bulldozer D9N | 21.00 | 2.56 | 2.90 | 13.02 | 39.48 | 25056 | | | 989 | 590 | 399 |
| 4. | Blast Hole Drill | 34.13 | 6.83 | 1.92 | 11.00 | 53.88 | 13824 | | | 745 | 566 | 179 |
| 5. | Front End Loader | 8.85 | 16.52 | 1.42 | 19.93 | 46.72 | 6912 | | | 323 | 175 | 148 |
| 6. | Haul Truck | 20.00 | 13.00 | 3.00 | 17.20 | 53.20 | 82944 | | | 4413 | 2738 | 1675 |
| 7. | Portable Crusher | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 8. | Water Pump | 2.00 | 1.09 | 0.20 | 1.72 | 5.01 | 3504 | | | 18 | 11 | 7 |
| 9. | Compactor | 6.00 | 1.60 | 0.80 | 5.16 | 13.56 | 456 | | | 6 | 3 | 3 |
| 10. | Grader | 8.00 | 6.93 | 2.00 | 6.88 | 23.81 | 6144 | | | 146 | 91 | 55 |
| 11. | Water Truck | 12.81 | 8.56 | 2.32 | 13.76 | 37.45 | 9216 | | | 345 | 197 | 148 |
| 12. | ANFO Bulk Storage | -- | -- | -- | -- | -- | -- | 60 | 10 | 6 | -- | 6 |
| 13. | Truck-Powder | 1.50 | 1.26 | 0.50 | 1.72 | 4.98 | 3072 | | | 15 | 8 | 7 |
| 14. | Truck-Fuel | 2.66 | 2.44 | 0.90 | 2.04 | 8.04 | 9216 | | | 74 | 47 | 27 |
| 15. | Truck-Service/Lube | 2.25 | 2.10 | 0.86 | 3.01 | 8.22 | 9216 | | | 76 | 40 | 36 |
| 16. | Truck-Supply | 0.93 | 0.81 | 0.25 | 1.08 | 3.07 | 9216 | | | 28 | 16 | 12 |

Table 12-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

400MW FULL SCALE PLANT

(Costs in US $1000)

| | | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| 17. | Truck-Pickup | 0.44 | 0.39 | 0.20 | 1.29 | 2.32 | 28800 | | | 67 | 24 | 43 |
| 18. | Survey Vehicle | 0.90 | 0.78 | 0.20 | 1.51 | 3.39 | 1920 | | | 7 | 4 | 3 |
| 19. | Personnel Bus | 1.00 | 0.80 | 0.75 | 2.58 | 5.13 | 4320 | | | 22 | 8 | 14 |
| 20. | Low Bed & Tractor | 6.00 | 4.75 | 1.00 | 6.02 | 17.77 | 120 | | | 2 | 1 | 1 |
| 21. | Forklift | 5.00 | 2.38 | 0.42 | 2.58 | 10.38 | 13824 | | | 144 | 102 | 42 |
| 22. | Compressor | 1.71 | 0.22 | 0.26 | 1.47 | 3.66 | 3456 | | | 13 | 7 | 6 |
| 23. | Shop Tools | -- | -- | -- | -- | -- | -- | 200 | 15 | 30 | 20 | 10 |
| 24. | Light Plant | 0.85 | 0.21 | 0.10 | 0.26 | 1.42 | 51840 | | | 74 | 55 | 19 |
| 25. | Surface Miner | 42.00 | 6.00 | 1.50 | 36.00 | 85.50 | 8064 | | | 689 | 387 | 302 |
| 26. | Electric Shovel | 86.93 | 15.89 | 5.00 | 22.22 | 130.04 | 15552 | | | 2022 | 1599 | 423 |
| 27. | Dump Hopper | | | | | | -- | 180 | 5 | 9 | -- | 9 |
| 28. | Feeders | | | | | | -- | 240 | 10 | 24 | 18 | 6 |
| 29. | Belt Conveyor From Pit | | | | | | -- | 2360 | 20 | 472 | 354 | 118 |
| 30. | Belt Conveyor To Sampler | | | | | | -- | 330 | 20 | 66 | 49 | 17 |
| 31. | Belt Scale | | | | | | -- | 20 | 20 | 4 | 3 | 1 |
| 32. | Sampler | | | | | | -- | 175 | 15 | 26 | 13 | 13 |

Table 12-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

400MW FULL SCALE PLANT

(Costs in US $1000)

| | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| 33. Electrics | | | | | | -- | 1410 | 10 | 141 | 106 | 35 |
| 34. Truck-Mech/Weld | 2.50 | 2.40 | 0.90 | 3.44 | 9.24 | 2880 | | | 27 | 14 | 13 |
| 35. Truck-Electrician | 2.00 | 1.80 | 0.75 | 2.58 | 7.13 | 2880 | | | 21 | 11 | 10 |
| 36. Crane | 15.00 | 8.00 | 0.68 | 8.60 | 32.28 | 960 | | | 31 | 22 | 9 |
| 37. Core Drill | 25.00 | 5.86 | 1.65 | 9.46 | 41.97 | 960 | | | 40 | 29 | 11 |
| 38. Ambulance | 5.50 | 1.20 | 0.75 | 1.51 | 8.96 | 360 | | | 3 | 2 | 1 |
| 39. Fire Truck | 5.50 | 1.20 | 0.75 | 1.51 | 8.96 | 360 | | | 3 | 2 | 1 |
| 40. Farm Tractor & Accessories | 6.50 | 1.00 | 0.30 | 1.29 | 9.09 | 1344 | | | 12 | 10 | 2 |
| 41. Back Hoe | 13.00 | 5.00 | 4.29 | 12.90 | 35.19 | 960 | | | 34 | 17 | 17 |
| 42. Communication Equip. | | | | | | | 100 | 15 | 15 | 8 | 7 |
| 43. Cable Skidder | 4.13 | 6.50 | 1.00 | 4.29 | 15.90 | 3312 | | | 53 | 35 | 18 |
| Sub Total | | | | | | | | | 11935 | 7793 | 4142 |
| **PROCESS PLANT** | | | | | | | | | | | |
| 1. Travelling Stacker | | | | | | | 2000 | 15 | 300 | 200 | 100 |
| 2. Belt Conveyor to Feed Bin | | | | | | | 600 | 20 | 120 | 80 | 40 |

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Table 12-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

400MW FULL SCALE PLANT

(Costs in US $1000)

| | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST AS % BASE | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | COST, % | OPER. $ | FOREIGN | LOCAL |
| 3. Feed Bin | | | | | | | 348 | 15 | 52 | 10 | 42 |
| 4. Feeder | | | | | | | 225 | 15 | 34 | 30 | 4 |
| 5. Impactor | | | | | | | 1065 | 20 | 213 | 150 | 63 |
| 6. Belt Conveyor to Screen | | | | | | | 885 | 20 | 177 | 120 | 57 |
| 7. Screen | | | | | | | 1080 | 15 | 162 | 100 | 62 |
| 8. Belt Conveyor to Impactor | | | | | | | 885 | 20 | 177 | 120 | 57 |
| 9. Sampler | | | | | | | 175 | 15 | 26 | 13 | 13 |
| 10. Belt Conveyor to Storage | | | | | | | 220 | 20 | 44 | 30 | 14 |
| 11. Belt Conveyor Top of Storage | | | | | | | 154 | 20 | 31 | 20 | 11 |
| 12. Diverter Valve | | | | | | | 80 | 15 | 12 | 6 | 6 |
| 13. Feeder | | | | | | | 805 | 15 | 121 | 100 | 21 |
| 14. Electrics | | | | | | | 1500 | 15 | 225 | 175 | 50 |
| 15. Instrumentation & Controls | | | | | | | 600 | 15 | 90 | 60 | 30 |

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Table 12-4 (Cont)

MINE AND PROCESSING PLANT OPERATING COSTS

400MW FULL SCALE PLANT

(Costs in US $1000)

| | HOURLY MAINT & POWER/FUEL COST | | | | TOTAL | ANNUAL | BASE | OPER. COST | ANNUAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parts | Consumable | Lube | Power/Fuel | HOURLY $ | OPER. HRS. | COST $ | AS % BASE COST, % | OPER. $ | FOREIGN | LOCAL |
| 16. Dust Collectors | | | | | | | 1000 | 15 | 150 | 100 | 50 |
| 17. Laboratory Equip. | | | | | | | 300 | 15 | 45 | 40 | 5 |
| 18. Plow Feeder | | | | | | | 240 | 15 | 36 | 25 | 11 |
| 19. Plow Feeder Belt Conveyor | | | | | | | 1050 | 20 | 210 | 140 | 70 |
| 20. Belt Conveyor to Transfer Twr. | | | | | | | 600 | 20 | 120 | 80 | 40 |
| 21. Belt Conveyor to Sampler | | | | | | | 246 | 20 | 49 | 35 | 14 |
| Sub Total | | | | | | | | | 2394 | 1634 | 760 |
| **OTHERS** | | | | | | | | | | | |
| 1. Mine Services Building | | | | | | | 1500 | 10 | 150 | -- | 150 |
| Sub Total | | | | | | | | | 150 | | 150 |
| GRAND TOTAL | | | | | | | | | 14479 | 9427 | 5052 |

TABLE 12-5,6,7,8,9

LABOR FORCE AND COST

400 MW FULL SCALE PLANT

MINE AND PROCESS PLANT

Table 12-5

WORK FORCE SUMMARY
400 MW FULL SCALE PLANT

| | -3<br>2000 | -2<br>2001 | -1<br>2002 | 1<br>2003 | 2<br>2004 | 3<br>2005 | 4-25<br>2006-27 |
|---|---|---|---|---|---|---|---|
| SUMMARY - ANNUAL LABOR COST, US $ | | | | | | | |
| EXPATRIATE | 600,000 | 780,000 | 900,000 | 1,956,000 | 1,932,000 | 420,000 | 420,000 |
| SUPERVISOR /TECH/ADMIN | 124,200 | 124,200 | 151,200 | 313,200 | 412,200 | 514,800 | 514,800 |
| OPERATOR WORK FORCE | | | | 529,740 | 737,640 | 993,060 | 1,111,860 |
| MAINTENANCE WORK FORCE | | | | 382,320 | 447,120 | 583,200 | 583,200 |
| TOTAL | 724,200 | 904,200 | 1,051,200 | 3,181,260 | 3,728,960 | 2,511,060 | 2,629,860 |

| | -3<br>2000 | -2<br>2001 | -1<br>2002 | 1<br>2003 | 2<br>2004 | 3<br>2005 | 4-25<br>2006-27 |
|---|---|---|---|---|---|---|---|
| SUMMARY - NUMBER OF EMPLOYEES | | | | | | | |
| EXPATRIATE | 3 | 4 | 5 | 12 | 12 | 2 | 2 |
| SUPERVISOR/TECH/ADM. | 19 | 19 | 24 | 47 | 58 | 70 | 70 |
| OPERATOR WORK FORCE | | | | 101 | 136 | 188 | 201 |
| MAINTENANCE WORK FORCE | | | | 68 | 80 | 105 | 105 |
| TOTAL | 22 | 23 | 29 | 228 | 286 | 365 | 378 |

Table 12-6

EXPATRIATE WORK FORCE
400 MW PLANT

| CLASSIFICATION | NO. | SALARY $/YR. | ANNUAL COST - US $ -3 2000 | -2 2001 | -1 2002 | 1 2003 | 2 2004 | 3 2005 | 4-25 2006-27 |
|---|---|---|---|---|---|---|---|---|---|
| Mine Manager | | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| Deputy Mine Manager | | 75,000 | | | | 75,000 | 75,000 | | |
| Chief Mining Engineer | | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 | | | |
| Chief Electrical Engineer | | 75,000 | | 75,000 | 75,000 | 75,000 | | | |
| Chief Safety Engineer | | 50,000 | | | | 50,000 | | | |
| Chief Training Engineer | | 50,000 | | | 50,000 | 50,000 | | | |
| Chief Accounting Manager | | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 |
| Shift Foreman | | 60,000 | | | | 60,000 | 120,000 | | |
| Stripping Foreman | | 60,000 | | | | 60,000 | 120,000 | | |
| Load & Haul Foreman | | 60,000 | | | | 60,000 | 120,000 | | |
| Maintenance Mgr. | | 75,000 | | | | 75,000 | 75,000 | | |
| Maintenance Frm | | 60,000 | | | | 60,000 | 120,000 | | |
| SUBTOTAL | | | 250,000 | 325,000 | 375,000 | 815,000 | 805,000 | 175,000 | 175,000 |
| INDIRECTS 100% of Directs | | | 250,000 | 325,000 | 375,000 | 815,000 | 805,000 | 175,000 | 175,000 |
| SUBTOTAL | | | 500,000 | 650,000 | 750,000 | 1,630,000 | 1,610,000 | 350,000 | 350,000 |
| CONTINGENCY 20% | | | 100,000 | 130,000 | 150,000 | 326,000 | 322,000 | 70,000 | 70,000 |
| TOTAL | | | 600,000 | 780,000 | 900,000 | 1,956,000 | 1,932,000 | 420,000 | 420,000 |

Table 12-7

SUPERVISION/TECHNICAL/ADMINISTRATIVE
400 MW PLANT

| CLASSIFICATION | NO. | SALARY $/YR. | ANNUAL COST - US $ -3 2000 | -2 2001 | -1 2002 | 1 2003 | 2 2004 | 3 2005 | 4-25 2006-27 |
|---|---|---|---|---|---|---|---|---|---|
| Deputy Mine Manager | | 9,000 | | | | | | 9,000 | 9,000 |
| Chief Mining Engineer | | 8,000 | | | | | 8,000 | 8,000 | 8,000 |
| Mining Engineer | | 6,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 |
| Geologist | | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 |
| Chief Electrical Eng. | | 8,000 | | | | | 8,000 | 8,000 | 8,000 |
| Electrical Engineer | | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 | 6,000 |
| Chief Safety Engineer | | 5,000 | | | | | 5,000 | 5,000 | 5,000 |
| Safety Engineer | | 4,000 | | | | 8,000 | 8,000 | 8,000 | 8,000 |
| Chief Training Officer | | 5,000 | | | | | 5,000 | 5,000 | 5,000 |
| Training Instructor | | 4,000 | | | | 8,000 | 8,000 | 8,000 | 8,000 |
| Shift Foreman | | 5,000 | | | | 5,000 | 10,000 | 15,000 | 15,000 |
| Stripping Foreman | | 5,000 | | | | 5,000 | 10,000 | 15,000 | 15,000 |
| Oil Shale Mining Frm | | 5,000 | | | | 5,000 | 10,000 | 15,000 | 15,000 |
| Maintenance Manager | | 8,000 | | | | | | 8,000 | 8,000 |
| Shop Foreman | | 5,000 | | | | 5,000 | 10,000 | 15,000 | 15.000 |
| Field Maintenance Frm | | 5,000 | | | | 5,000 | 10,000 | 15,000 | 15,000 |
| Surveyor | | 3,000 | 9,000 | 9,000 | 9,000 | 9,000 | 9,000 | 18,000 | 18,000 |
| Draftsman | | 3,000 | 3,000 | 3,000 | 3,000 | 3,000 | 3,000 | 6,000 | 6,000 |
| Personnel Manager | | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 |
| Personnel Staff | | 4,000 | | | 4,000 | 8,000 | 8,000 | 8,000 | 8,000 |
| Procurement Manager | | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 |
| Procurement Staff | | 4,000 | | | 4,000 | 8,000 | 8,000 | 8,000 | 8,000 |
| Warehouse Staff | | 3,000 | | | 3,000 | 12,000 | 12,000 | 12,000 | 12,000 |
| Secretary | | 2,000 | 2,000 | 2,000 | 4,000 | 6,000 | 8,000 | 8,000 | 8,000 |
| Accountant | | 2,000 | 4,000 | 4,000 | 6,000 | 8,000 | 10,000 | 10,000 | 10,000 |
| Cook | | 3,000 | 3,000 | 3,000 | 3,000 | 6.000 | 6,000 | 9,000 | 9,000 |
| Janitor | | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 |
| Chemist | | 6,000 | | | | 6,000 | 6,000 | 6,000 | 6,000 |
| Assistant Chemist | | 5,000 | | | | 10,000 | 10,000 | 10,000 | 10,000 |
| Sampler | | 3,000 | | | | 9,000 | 9,000 | 9,000 | 9,000 |
| Security Guard | | 3,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 |
| SUB-TOTAL | | | 69,000 | 69,000 | 84,000 | 174,000 | 229,000 | 286,000 | 286,000 |
| Indirects 50% of Directs | | | 34,500 | 34,500 | 42,000 | 87,000 | 114,500 | 143,000 | 143,000 |
| SUB-TOTAL | | | 103,500 | 103,500 | 126,000 | 261,000 | 343,500 | 429,000 | 429,000 |
| Contingency 20% | | | 20,700 | 20,700 | 25,200 | 52,200 | 68,700 | 85,800 | 85,800 |
| TOTAL | | | 124,200 | 124,200 | 151,200 | 313,200 | 412,200 | 514,800 | 514,800 |

Table 12-8

MINE AND PROCESS PLANT OPERATOR WORK FORCE
400 MW PLANT

| CLASSIFICATION | NO. | SALARY $/YR. | ANNUAL COST - US $ -3 2000 | -2 2001 | -1 2002 | 1 2003 | 2 2004 | 3 2005 | 4-25 2006-27 |
|---|---|---|---|---|---|---|---|---|---|
| MINE | | | | | | | | | |
| Blast Hole Driller | | 3,600 | | | | 10,800 | 21,600 | 32,400 | 32,400 |
| Blast Hole Helper | | 2,700 | | | | 8,100 | 16,200 | 24,300 | 24,300 |
| Shot Loader | | 3,000 | | | | 3,000 | 3,000 | 6,000 | 6,000 |
| Shot Loader Helper | | 2,700 | | | | 5,400 | 5,400 | 10,800 | 10,800 |
| Shot Firer | | 3,000 | | | | 3,000 | 3,000 | 6,000 | 6,000 |
| Bulldozer Operator | | 3,000 | | | | 36,000 | 45,000 | 54,000 | 72,000 |
| Front End Loader Opr. | | 3,000 | | | | 9,000 | 9,000 | 9,000 | 18,000 |
| Electric Shovel Opr. | | 4,200 | | | | 12,600 | 25,200 | 37,800 | 37,800 |
| Truck Driver | | 3,000 | | | | 45,000 | 81,000 | 123,000 | 162,000 |
| Scraper Operator | | 3,000 | | | | 3,000 | 3,000 | 3,000 | 3,000 |
| Portable Crusher Opr. | | -- | | | | -- | -- | -- | -- |
| Surface Miner Opr. | | 3,600 | | | | 10,800 | 10,800 | 21,600 | 21,600 |
| Belt Tender | | 2,500 | | | | 22,500 | 22,500 | 22,500 | 22,500 |
| Water Truck Driver | | 3,000 | | | | 9,000 | 18,000 | 18,000 | 18,000 |
| Grader Operator | | 3,000 | | | | 9,000 | 12,000 | 12,000 | 12,000 |
| Powder Truck Driver | | 2,700 | | | | 2,700 | 5,400 | 5,400 | 5,400 |
| Fuel Truck Driver | | 2,700 | | | | 8,100 | 8,100 | 16,200 | 16,200 |
| Service/Lube Truck Dr. | | 2,700 | | | | 8,100 | 8,100 | 16,200 | 16,200 |
| Supply Truck Driver | | 2,700 | | | | 8,100 | 8,100 | 16,200 | 16,200 |
| Crane Operator | | 3,000 | | | | 6,000 | 6,000 | 9,000 | 9,000 |
| Back Hoe Operator | | 3,000 | | | | 3,000 | 3,000 | 3,000 | 3,000 |
| Core Drill Operator | | 3,000 | | | | 3,000 | 3,000 | 3,000 | 3,000 |
| Core Drill Helper | | 2,700 | | | | 2,700 | 2,700 | 2,700 | 2,700 |
| Utility Operator | | 3,000 | | | | 9,000 | 18,000 | 27,000 | 27,000 |
| Electric Shovel Oiler | | 2,700 | | | | 8,100 | 16,200 | 24,300 | 24,300 |
| Process Plant | | | | | | | | | |
| Operator | | 3,600 | | | | 10,800 | 10,800 | 10,800 | 10,800 |
| Operator Helper | | 2,700 | | | | 8,100 | 8,100 | 8,100 | 8,100 |
| Belt Tender | | 2,500 | | | | 15,000 | 15,000 | 15,000 | 15,000 |
| Laborer | | 2,400 | | | | 14,400 | 14,400 | 14,400 | 14,400 |
| SUB-TOTAL | | | | | | 294,300 | 409,800 | 551,700 | 617,700 |
| Indirects 50% of Directs | | | | | | 147,150 | 204,900 | 275,850 | 308,850 |
| SUB-TOTAL | | | | | | 441,450 | 614,700 | 827,550 | 926,550 |
| Contingency 20% | | | | | | 88,290 | 122,940 | 165,510 | 185,310 |
| TOTAL | | | | | | 529,740 | 737,640 | 993,060 | 1,111,860 |

Table 12-9
MINE AND PROCESS PLANT MAINTENANCE WORK FORCE
400 MW PLANT

| CLASSIFICATION | NO. | SALARY $/YR. | ANNUAL COST - US $ -3 2000 | -2 2001 | -1 2002 | 1 2003 | 2 2004 | 3 2005 | 4-25 2006-27 |
|---|---|---|---|---|---|---|---|---|---|
| Lead Mechanic - Mine | | 4,200 | | | | 4,200 | 4,200 | 4,200 | 4,200 |
| Lead Mechanic - Truck | | 4,200 | | | | 4,200 | 4,200 | 4,200 | 4,200 |
| Lead Mechanic - Plant | | 4,200 | | | | 4,200 | 4,200 | 4,200 | 4,200 |
| Mechanic - Mine & Plt. | | 3,600 | | | | 21,600 | 28,800 | 36,000 | 36,000 |
| Mechanic Helper | | 2,700 | | | | 32,400 | 43,200 | 54,000 | 54,000 |
| Truck Mechanic | | 3,600 | | | | 21,600 | 28,800 | 36,000 | 36,000 |
| Truck Mechanic Hlp. | | 2,700 | | | | 32,400 | 43,200 | 54,000 | 54,000 |
| Welder | | 3,600 | | | | 14,400[4] | 14,400 | 21,600 | 21,600 |
| Shop Journeyman | | 3,600 | | | | 14,400[4] | 14,400 | 21,600 | 21,600 |
| Machine Shop Helper | | 2,700 | | | | 10,800[4] | 10,800 | 16,200 | 16,200 |
| Lead Electrician | | 4,200 | | | | 4,200 | 4,200 | 4,200 | 4,200 |
| Electrician | | 3,600 | | | | 14,400 | 14,400 | 21,600 | 21,600 |
| Electrician Helper | | 2,700 | | | | 16,200 | 16,200 | 21,600 | 21,600 |
| Instrument Maint. | | 3,600 | | | | 7,200 | 7,200 | 7,200 | 7,200 |
| Carpenter/Painter | | 3,000 | | | | 3,000 | 3,000 | 3,000 | 3,000 |
| Laborer | | 2,400 | | | | 7,200 | 7,200 | 14,400 | 14,400 |
| SUB-TOTAL | | | | | | 212,400 | 248,400 | 324,000 | 324,000 |
| Indirects 50% of Directs | | | | | | 106,200 | 124,200 | 162,000 | 162,000 |
| SUB-TOTAL | | | | | | 318,600 | 372,600 | 486,000 | 486,000 |
| Contingency 20% | | | | | | 63,720 | 74,520 | 97,200 | 97,200 |
| TOTAL | | | | | | 382,320 | 447,120 | 583,200 | 583,200 |

TABLE 12-10

CASH FLOW ANALYSIS

400 MW FULL SCALE PLANT

MINE AND PROCESS PLANT

Table 12-10
MINING AND PROCESSING PLANT CASH FLOW ANALYSIS
400 MW FULL SCALE PLANT
(All Costs in US $1000 unless otherwise noted)

| | -3 2000 | -2 2001 | -1 2002 | 1 2003 | 2 2004 | 3 2005 | 4 2006 | 5 2007 | 6 2008 | 7 2009 | 8 2010 | 9 2011 | 10 2012 | 11 2013 | 12 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, MW | -- | -- | -- | 100 | 200 | 300 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 |
| II. OIL SHALE, TONNE/ YR x 1000 | -- | -- | -- | 1946 | 3891 | 5837 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | | | |
| 50/50 Debt/Equity Ratio | | | | | | | | | | | | | | | |
| Mine Development | 5936 | 9777 | 13119 | 1055 | 1028 | | | | | | | | | | |
| Mine Equipment | | | 36201 | 17727 | 12084 | | | | | | | | | | |
| Process Plant Fac. | | | 21266 | 16754 | 12869 | | | | | | | | | | |
| Spare Parts | | | | 2000 | 1500 | 1500 | | | | | | | | | |
| Working Capital | | | | 4000 | 3000 | 3000 | | | | | | | | | |
| SUBTOTAL | 5936 | 9777 | 70586 | 22754 | 23282 | 30481 | | | | | | | | | |
| Capitalized Interest | 4315 | 4315 | 4315 | 3826 | 3826 | 3826 | | | | | | | | | |
| TOTAL | 10251 | 14092 | 74901 | 26580 | 27108 | 34307 | | | | | | | | | |
| 80/20 Debt/Equity | | | | | | | | | | | | | | | |
| Capitalized Interest | 6904 | 6904 | 6904 | 6121 | 6121 | 6121 | | | | | | | | | |
| TOTAL | 12840 | 16681 | 77490 | 28875 | 29403 | 36602 | | | | | | | | | |
| IV. OPERATING COST | | | | | | | | | | | | | | | |
| Parts, Sup,Fuel/Power | | | | 4706 | 8687 | 11945 | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 |
| Wages and Fringes | 724 | 904 | 1051 | 3181 | 3729 | 2511 | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 |
| Explosives | | | | 63 | 125 | 187 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| Insurance | | | | 371 | 460 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 |
| TOTAL | 724 | 904 | 1051 | 8321 | 13001 | 15228 | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 |

Table 12-10 (Cont)

| | -3 2000 | -2 2001 | -1 2002 | 1 2003 | 2 2004 | 3 2005 | 4 2006 | 5 2007 | 6 2008 | 7 2009 | 8 2010 | 9 2011 | 10 2012 | 11 2013 | 12 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V INTEREST EXPENSE | | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | | | | 4962 | 4631 | 4301 | 8370 | 7745 | 7121 | 6497 | 5874 | 5249 | 4625 | 4001 | 3376 |
| 80/20 D/E Ratio | | | | 8561 | 7990 | 7419 | 14439 | 13362 | 12285 | 11209 | 10132 | 9055 | 7978 | 6902 | 5825 |
| VI DEPRECIATION & AMORTIZATION | | | | | | | | | | | | | | | |
| Depreciation | | | | 3409 | 6294 | 8654 | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 |
| Amortization 50/20 | | | | 3053 | 3053 | 3053 | 3818 | 3818 | 3818 | 3818 | 3818 | 3818 | 3818 | 3818 | 3818 |
| Amortization 80/20 | | | | 3571 | 3571 | 3571 | 4795 | 4795 | 4795 | 4795 | 4795 | 4795 | 4795 | 4795 | 4795 |
| TOTAL 50/50 | | | | 6462 | 9347 | 11707 | 14308 | 14308 | 14308 | 14308 | 14308 | 14308 | 14308 | 14308 | 14308 |
| TOTAL 80/20 | | | | 6980 | 9865 | 12225 | 15285 | 15285 | 15285 | 15285 | 15285 | 15285 | 15285 | 15285 | 15285 |
| VII MANAGEMENT FEE | | | | 973 | 1946 | 2919 | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 |
| VIII RETURN ON EQUITY | | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | | | | 12582 | 15293 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 |
| 80/20 D/E Ratio | | | | 5435 | 6612 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 |
| IX ROYALTY | | | | 545 | 1089 | 1634 | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 |
| X COST-PROCESSED OIL SHALE | | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | | | | 33845 | 45307 | 54513 | 65417 | 64792 | 64168 | 63544 | 62921 | 62296 | 61672 | 61048 | 60423 |
| 80/20 D/E Ratio | | | | 30815 | 40503 | 47501 | 61815 | 60738 | 59661 | 58585 | 57508 | 56431 | 55354 | 54278 | 53201 |
| XI COST - $/TONNE | | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | | | | 17.39 | 11.64 | 9.34 | 8.41 | 8.32 | 8.24 | 8.16 | 8.08 | 8.00 | 7.92 | 7.84 | 7.76 |
| 80/20 D/E Ratio | | | | 15.84 | 10.41 | 8.14 | 7.94 | 7.80 | 7.67 | 7.53 | 7.39 | 7.25 | 7.11 | 6.97 | 6.84 |
| XII COST - $/10$^6$ BTU | | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | | | | 3.51 | 2.35 | 1.88 | 1.69 | 1.68 | 1.66 | 1.65 | 1.63 | 1.61 | 1.60 | 1.58 | 1.56 |
| 80/20 D/E Ratio | | | | 3.19 | 2.10 | 1.64 | 1.60 | 1.57 | 1.55 | 1.52 | 1.49 | 1.46 | 1.43 | 1.41 | 1.38 |

Table 12-10
MINING AND PROCESSING PLANT CASH FLOW ANALYSIS
400 MW FULL SCALE PLANT
(All Costs in US $1000 unless otherwise noted)

| | 13<br>2015 | 14<br>2016 | 15<br>2017 | 16<br>2018 | 17<br>2019 | 18<br>2020 | 19<br>2021 | 20<br>2022 | 21<br>2023 | 22<br>2024 | 23<br>2025 | 24<br>2026 | 25<br>2027 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, MW | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | |
| II. OIL SHALE, TONNES/YR x 1000 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 | 7783 | 182900 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | | |
| 50/50 Debt/Equity Ratio | | | | | | | | | | | | | | |
| Mine Development | | | | | | | | | | | | | | |
| Mine Equipment | | | | | | | | | | | | | | |
| Process Plant Fac. | | | | | | | | | | | | | | |
| Spare Parts | | | | | | | | | | | | | | |
| Working Capital | | | | | | | | | | | | | | |
| SUBTOTAL | | | | | | | | | | | | | | |
| Capitalized Interest | | | | | | | | | | | | | | |
| TOTAL | | | | | | | | | | | | | | 187239 |
| 80/20 Debt/Equity | | | | | | | | | | | | | | |
| Capitalized Interest | | | | | | | | | | | | | | |
| TOTAL | | | | | | | | | | | | | | 201891 |
| IV. OPERATING COST | | | | | | | | | | | | | | |
| Parts, Sup,Fuel/Power | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 | 14479 | |
| Wages and Fringes | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 | 2630 | |
| Explosives | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | |
| Insurance | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | 585 | |
| TOTAL | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 | 17944 | |

Table 12-10 (Cont)

| | 13<br>2015 | 14<br>2016 | 15<br>2017 | 16<br>2018 | 17<br>2019 | 18<br>2020 | 19<br>2021 | 20<br>2022 | 21<br>2023 | 22<br>2024 | 23<br>2025 | 24<br>2026 | 25<br>2027 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V INTEREST EXPENSE | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 2752 | 2129 | 1504 | 880 | 587 | 293 | -- | -- | -- | -- | -- | -- | -- | |
| 80/20 D/E Ratio | 4248 | 3672 | 2612 | 1518 | 1012 | 506 | -- | -- | -- | -- | -- | -- | -- | |
| VI DEPRECIATION & AMORTIZATION | | | | | | | | | | | | | | |
| Depreciation | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 | 10490 | |
| Amortization 50/20 | 3818 | 3818 | 3818 | 825 | 825 | 825 | 825 | 60 | 60 | 60 | 60 | 60 | 60 | |
| Amortization 80/20 | 4795 | 4795 | 4795 | 1284 | 1284 | 1284 | 1284 | 1284 | 60 | 60 | 60 | 60 | 60 | |
| TOTAL 50/50 | 14308 | 14308 | 14308 | 11315 | 11315 | 11315 | 11315 | 10550 | 10550 | 10550 | 10550 | 10550 | 10550 | |
| TOTAL 80/20 | 15285 | 15285 | 15285 | 11774 | 11774 | 11774 | 11774 | 10550 | 10550 | 10550 | 10550 | 10550 | 10550 | |
| VII MANAGEMENT FEE | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 | 3892 | |
| VIII RETURN ON EQUITY | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | 18724 | |
| 80/20 D/E Ratio | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | 8076 | |
| IX ROYALTY | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 | 2179 | |
| X COST-PROCESSED OIL SHALE | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 59799 | 59176 | 58551 | 54934 | 54621 | 54347 | 54054 | 53289 | 53289 | 53289 | 53289 | 53289 | 53289 | 1415162 |
| 80/20 D/E Ratio | 52124 | 51048 | 49971 | 45323 | 44817 | 44311 | 43805 | 42641 | 42641 | 42641 | 42641 | 42641 | 42641 | 1223635 |
| XI COST - $/TONNE | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 7.68 | 7.60 | 7.52 | 7.06 | 7.02 | 6.98 | 6.95 | 6.85 | 6.85 | 6.85 | 6.85 | 6.85 | 6.85 | 7.74 |
| 80/20 D/E Ratio | 6.70 | 6.56 | 6.42 | 5.82 | 5.76 | 5.69 | 5.63 | 5.48 | 5.48 | 5.48 | 5.48 | 5.48 | 5.48 | 6.69 |
| XII COST - $/10$^6$ BTU | | | | | | | | | | | | | | |
| 50/50 D/E Ratio | 1.55 | 1.53 | 1.52 | 1.42 | 1.41 | 1.40 | 1.40 | 1.40 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | 1.56 |
| 80/20 D/E Ratio | 1.35 | 1.32 | 1.29 | 1.17 | 1.16 | 1.15 | 1.13 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.35 |

TABLE 12-12,13

DEPRECIATION AND AMORTIZATION

400 MW FULL SCALE PLANT

MINE AND PROCESS PLANT

Table 12-12

MINE EQUIPMENT AND PROCESS PLANT DEPRECIATION

400 MW FULL SCALE PLANT

(Costs in US $1000)

| | | Quantity | Total Cost | Salvage Value | Deprec Value | Economic Life,Hrs | Availa % | Utilizat'n % | Effic % | Annual SchedHrs | Annual OprHrs | Deprec $/Hr | Deprec $/Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MINE EQUIPMENT | | | | | | | | | | | | | |
| 1. | Scraper | 1 | 1045 | 78 | 967 | 17000 | 78 | 80 | 62 | 2400 | 1488 | 57 | 85 |
| 2. | Bull Dozer D10N | 3 | 1644 | 123 | 1521 | 15000 | 73 | 80 | 58 | 7200 | 4176 | 101 | 423 |
| 3. | Bull Dozer D9N | 6 | 2472 | 185 | 2287 | 15000 | 73 | 80 | 58 | 7200 | 4176 | 152 | 637 |
| 4. | Blast Hole Drill | 3 | 1864 | 140 | 1724 | 40000 | 80 | 80 | 64 | 7200 | 4608 | 43 | 199 |
| 5. | Front End Loader | 2 | 1828 | 137 | 1691 | 18000 | 80 | 60 | 48 | 7200 | 3456 | 94 | 325 |
| 6. | Haul Truck | 20 | 18851 | 1414 | 17437 | 30000 | 80 | 80 | 64 | 7200 | 4608 | 581 | 2678 |
| 7. | Portable Crusher | - | - | - | - | - | - | - | - | - | - | - | - |
| 8. | Water Pump | 8 | 170 | 13 | 157 | 20000 | 95 | 5 | 5 | 8760 | 438 | 8 | 3 |
| 9. | Compactor | 1 | 384 | 29 | 355 | 20000 | 95 | 20 | 19 | 2400 | 456 | 18 | 8 |
| 10. | Grader | 2 | 664 | 50 | 614 | 20000 | 80 | 80 | 64 | 4800 | 3072 | 31 | 94 |
| 11. | Water Truck | 2 | 1296 | 97 | 1199 | 35000 | 80 | 80 | 64 | 7200 | 4608 | 34 | 158 |
| 12. | ANFO Bulk Storage | 2 | 75 | 6 | 69 | 20000 | 100 | 10 | 10 | 2400 | 240 | 3 | 1 |
| 13. | Truck-Powder | 2 | 133 | 10 | 123 | 15000 | 80 | 80 | 64 | 2400 | 1536 | 8 | 13 |
| 14. | Truck-Fuel | 2 | 216 | 16 | 200 | 15000 | 80 | 80 | 64 | 7200 | 4608 | 13 | 61 |
| 15. | Truck-Service/Lube | 2 | 174 | 13 | 161 | 15000 | 80 | 80 | 64 | 7200 | 4608 | 3 | 12 |
| 16. | Truck-Supply | 2 | 80 | 6 | 74 | 15000 | 80 | 80 | 64 | 7200 | 4608 | 3 | 12 |

Table 12-12 (Cont'd.)

MINE EQUIPMENT AND PROCESS PLANT DEPRECIATION

400 MW FULL SCALE PLANT

(Costs in US $1000)

| | Quantity | Total Cost | Salvage Value | Deprec Value | Economic Life,Hrs | Availa % | Utilizat'n % | Effic % | Annual SchedHrs | Annual OprHrs | Deprec $/Hr | Deprec $/Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MINE EQUIPMENT (Cont'd.) | | | | | | | | | | | | |
| 17. Truck-Pick-up | 10 | 160 | 12 | 148 | 9000 | 80 | 50 | 40 | 7200 | 2880 | 16 | 47 |
| 18. Survey Vehicle | 2 | 53 | 4 | 49 | 9000 | 80 | 50 | 40 | 2400 | 960 | 5 | 5 |
| 19. Personnel Bus | 3 | 68 | 5 | 63 | 15000 | 80 | 25 | 20 | 7200 | 1440 | 4 | 6 |
| 20. Low Bed & Tractor | 1 | 177 | 13 | 164 | 25000 | 95 | 5 | 5 | 2400 | 120 | 7 | 1 |
| 21. Fork Lift | 4 | 322 | 23 | 299 | 10000 | 80 | 60 | 48 | 7200 | 3456 | 30 | 103 |
| 22. Compressor | 2 | 56 | 4 | 52 | 20000 | 95 | 25 | 24 | 7200 | 1728 | 3 | 4 |
| 23. Shop Tools | - | 267 | 20 | 247 | 40000 | 100 | 50 | 50 | 7200 | 3600 | 6 | 22 |
| 24. Light Plants | 12 | 280 | 21 | 259 | 20000 | 90 | 100 | 90 | 4800 | 4320 | 13 | 56 |
| 25. Surface Miner | 2 | 4000 | 300 | 3700 | 40000 | 80 | 70 | 56 | 7200 | 4032 | 93 | 373 |
| 26. Electric Shovel | 3 | 13199 | 990 | 12209 | 120000 | 90 | 80 | 72 | 7200 | 5184 | 102 | 327 |
| 27. Dump Hopper | 2 | 462 | 18 | 444 | 120000 | 100 | 70 | 70 | 7200 | 5040 | 4 | 19 |
| 28. Feeders | 2 | 997 | 24 | 973 | 120000 | 80 | 90 | 72 | 7200 | 5184 | 8 | 42 |
| 29. Belt Conveyer from Pit | 1 | 9802 | 236 | 9566 | 120000 | 90 | 80 | 72 | 7200 | 5184 | 80 | 413 |
| 30. Belt Conveyor to Sampler | 1 | 1381 | 33 | 1348 | 120000 | 90 | 80 | 72 | 7200 | 5184 | 11 | 58 |
| 31. Belt Scale | 1 | 63 | 2 | 61 | 40000 | 95 | 90 | 86 | 7200 | 6192 | 2 | 9 |

Table 12-12 (Cont'd.)

MINE EQUIPMENT AND PROCESS PLANT DEPRECIATION

400 MW FULL SCALE PLANT

(Costs in US $1000)

| | Quantity | Total Cost | Salvage Value | Deprec Value | Economic Life,Hrs | Availa % | Utilizat'n % | Effic % | Annual SchedHrs | Annual OprHrs | Deprec $/Hr | Deprec $/Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MINE EQUIPMENT (Cont'd) | | | | | | | | | | | | |
| 32. Sampler | | 700 | 18 | 682 | 60000 | 90 | 80 | 72 | 7200 | 5184 | 11 | 59 |
| 33. Electrics | | 3624 | 141 | 3483 | 120000 | 95 | 90 | 86 | 7200 | 6192 | 29 | 180 |
| 34. Truck-Mech/Weld | | 103 | 8 | 95 | 15000 | 80 | 50 | 40 | 7200 | 2880 | 6 | 18 |
| 35. Truck-Elec | | 72 | 6 | 66 | 15000 | 80 | 50 | 40 | 7200 | 2880 | 4 | 13 |
| 36. Crane | | 463 | 35 | 428 | 15000 | 80 | 50 | 40 | 2400 | 960 | 29 | 27 |
| 37. Core Drill | | 407 | 31 | 376 | 40000 | 80 | 50 | 40 | 2400 | 960 | 9 | 9 |
| 38. Ambulance | | 114 | 9 | 105 | 40000 | 100 | 5 | 5 | 7200 | 360 | 3 | 1 |
| 39. Fire Truck | | 117 | 9 | 108 | 40000 | 100 | 5 | 5 | 7200 | 360 | 3 | 1 |
| 40. Farm Tractor & Accessories | | 53 | 4 | 49 | 20000 | 80 | 70 | 56 | 2400 | 1344 | 2 | 2 |
| 41. Back Hoe | | 414 | 31 | 383 | 20000 | 80 | 50 | 40 | 2400 | 960 | 19 | 18 |
| 42. Communication Equip | | 133 | 10 | 123 | 80000 | 95 | 100 | 95 | 7200 | 6840 | 2 | 11 |
| 43. Cable Skidder | | 174 | 13 | 161 | 40000 | 90 | 25 | 23 | 7200 | 1656 | 4 | 7 |
| Sub-Total | | | | | | | | | | | | 6778 |
| PROCESS PLANT FACILITIES | | | | | | | | | | | | |
| 1. Stacker | | 2522 | 200 | 2322 | 60000 | 90 | 80 | 72 | 7200 | 5184 | 39 | 201 |
| 2. V-Slot Storage | | 7700 | - | 7700 | 120000 | 100 | 75 | 75 | 7200 | 5400 | 64 | 347 |

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Table 12-12 (Cont'd.)

MINE EQUIPMENT AND PROCESS PLANT DEPRECIATION

400 MW FULL SCALE PLANT

(Costs in US $1000)

| PROCESS PLANT FACILITIES (Cont'd.) | Quantity | Total Cost | Salvage Value | Deprec Value | Economic Life,Hrs | Availa % | Utilizat'n % | Effic % | Annual SchedHrs | Annual OprHrs | Deprec $/Hr | Deprec $/Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3. Belt Conveyor to Feed Bin | | 2243 | 24 | 2219 | 60000 | 95 | 60 | 57 | 7200 | 4104 | 37 | 152 |
| 4. Feed Bin | | 831 | 35 | 796 | 60000 | 95 | 70 | 67 | 7200 | 4824 | 13 | 64 |
| 5. Feeder | | 842 | 23 | 819 | 60000 | 95 | 70 | 67 | 7200 | 4824 | 14 | 66 |
| 6. Impactor | | 3982 | 107 | 3875 | 60000 | 95 | 70 | 67 | 7200 | 4824 | 65 | 312 |
| 7. Belt Conveyor to Screen | | 3311 | 89 | 3222 | 60000 | 95 | 70 | 67 | 7200 | 4824 | 54 | 259 |
| 8. Screen | | 4036 | 108 | 3928 | 60000 | 95 | 70 | 67 | 7200 | 4824 | 65 | 316 |
| 9. Belt Conveyor to Impactor | | 3311 | 89 | 3222 | 60000 | 95 | 70 | 67 | 7200 | 4824 | 54 | 259 |
| 10. Sampler | | 653 | 18 | 635 | 60000 | 95 | 100 | 95 | 7200 | 6840 | 11 | 72 |
| 11. Belt Conveyor to Storage | | 820 | 22 | 798 | 60000 | 95 | 100 | 95 | 7200 | 6840 | 13 | 91 |
| 12. Belt Conveyor Top of Storage | | 578 | 15 | 563 | 60000 | 95 | 100 | 95 | 7200 | 6840 | 9 | 64 |
| 13. Diverter Valve | | 599 | 16 | 582 | 60000 | 95 | 50 | 48 | 7200 | 3456 | 10 | 34 |
| 14. Storage Bin | | 9054 | - | 9054 | 120000 | 100 | 70 | 70 | 8760 | 6132 | 75 | 463 |
| 15. Feeder | | 3013 | 81 | 2932 | 60000 | 95 | 70 | 70 | 8760 | 6132 | 49 | 300 |
| 16. Electrics | | 1500 | 40 | 1460 | 120000 | 100 | 70 | 70 | 7200 | 5040 | 12 | 62 |
| 17. Instrumentation & Controls | | 600 | 15 | 585 | 120000 | 100 | 70 | 70 | 7200 | 5040 | 5 | 25 |
| 18. Dust Collectors | | 1000 | 40 | 960 | 60000 | 100 | 70 | 70 | 7200 | 5040 | 16 | 81 |
| 19. Laboratory Equipment | | 382 | 30 | 352 | 60000 | 95 | 50 | 48 | 7200 | 3456 | 6 | 20 |
| 20. Plow Feeder | | 897 | 24 | 873 | 60000 | 100 | 50 | 50 | 7200 | 3600 | 15 | 52 |
| 21. Belt Conveyors (Additional) | | 7088 | 190 | 6898 | 60000 | 95 | 60 | 57 | 7200 | 4104 | 115 | 472 |
| Sub-Total | | | | | | | | | | | | 3712 |

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Table 12-13
AMORTIZATION SCHEDULE
400MW FULL SCALE PLANT
(Cost in US $1000)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| **400MW PLANT 5/50** | | | | | | | | | | | | | | | | |
| 1. Mine Development | 1951 | 1951 | 1951 | 1951 | 1951 | 1951 | 1951 | 1951 | 1951 | 1951 | 1951 | 1951 | 1951 | 1951 | 1951 | - |
| 2. Mine Service Facilities | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| 3. Pre-Op Labor | 179 | 179 | 179 | 179 | 179 | 179 | 179 | 179 | 179 | 179 | 179 | 179 | 179 | 179 | 179 | - |
| 4. Sub-Total | 2190 | 2190 | 2190 | 2190 | 2190 | 2190 | 2190 | 2190 | 2190 | 2190 | 2190 | 2190 | 2190 | 2190 | 2190 | 60 |
| 5. PH1 Cap. Int. | 863 | 863 | 863 | 863 | 863 | 863 | 863 | 863 | 863 | 863 | 863 | 863 | 863 | 863 | 863 | - |
| 6. PH2 Cap. Int. | - | - | - | 765 | 765 | 765 | 765 | 765 | 765 | 765 | 765 | 765 | 765 | 765 | 765 | 765 |
| 7. TOTAL: | 3053 | 3053 | 3053 | 3818 | 3818 | 3818 | 3818 | 3818 | 3818 | 3818 | 3818 | 3818 | 3818 | 3818 | 3818 | 825 |
| **400MW PLANT 8/20** | | | | | | | | | | | | | | | | |
| 8. PH1 Cap. Int | 1381 | 1381 | 1381 | 1381 | 1381 | 1381 | 1381 | 1381 | 1381 | 1381 | 1381 | 1381 | 1381 | 1381 | 1381 | - |
| 9. PH2 Cap. Int. | - | - | - | 1224 | 1224 | 1224 | 1224 | 1224 | 1224 | 1224 | 1224 | 1224 | 1224 | 1224 | 1224 | 1224 |
| 10. TOTAL: | 3571 | 3571 | 3571 | 4795 | 4795 | 4795 | 4795 | 4795 | 4795 | 4795 | 4795 | 4795 | 4795 | 4795 | 4795 | 1284 |

Table 12-13 (Cont)
AMORTIZATION SCHEDULE
400MW PROTOTYPE PLANT
(Cost in US $1000)

| | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
| **400MW PLANT 50/50** | | | | | | | | | |
| 1. Mine Development | - | - | - | - | - | - | - | - | - |
| 2. Mine Service Facilities | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| 3. EXP | - | - | - | - | - | - | - | - | - |
| 4. Sub-Total | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| 5. PH1 Cap. Int. | - | - | - | - | - | - | - | - | - |
| 6. PH2 Cap. Int. | 765 | 765 | 765 | - | - | - | - | - | - |
| 7. TOTAL: | 825 | 825 | 825 | 60 | 60 | 60 | 60 | 60 | 60 |
| **400MW PLANT 80/20** | | | | | | | | | |
| 8. PH1 Cap. Int. | - | - | - | - | - | - | - | - | - |
| 9. PH2 Cap. Int. | 1224 | 1224 | 1224 | - | - | - | - | - | - |
| 10. TOTAL: | 1284 | 1284 | 1284 | 60 | 60 | 60 | 60 | 60 | 60 |

# 13.0 SPENT SHALE DISPOSAL

## 13.1 Disposal Plan

### 13.1.1 General

For the purpose of this prefeasibility study, it is assumed that the spent shale is non-toxic and that the leachates will not be harmful to the ground water. The spent shale will be mixed with the overburden in the out-of-pit waste storage pile or mixed with the overburden in the backfilling of the pit. If the spent shale is classified as toxic, different measures for its disposal will be required.

It is also assumed that the spent shale will be mixed with adequate water in a pug mill at the power plant and that special measures will not be required to suppress fugitive dust when the spent shale is dumped from a truck.

### 13.1.2 Spent Shale Disposal from the 20 MW Plant

It is estimated that the distance between the power plant and the out-of-pit waste pile is 4 kilometres and that the distance to the pit dump area is approximately the same. A Caterpillar 777 truck will be used for hauling the spent shale to the disposal area. This will be one of the trucks used for hauling overburden or oil shale from the pit. Six trucks are assigned for oil shale operation, five operating and one spare. The oil shale operation requires 4.3 trucks per shift; therefore, the excess hauling capacity can be used for hauling the spent shale. Spent shale is continuously produced and pugged whenever the power plant is in operation. The disposal of the spent shale will be done on the first and second shift, seven days per week. Since the mine operates only one shift, six days per week, the mine trucks will be available for hauling spent shale.



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It is anticipated that the spent shale retention time in the pug mill for proper mixing will not allow for a batch operation. The pugging operation for this feasibility study is considered to be continuous and the pugged materials will be conveyed to a dump area near the power plant site. A Caterpillar 992 C front end loader will load the Caterpillar 777 trucks from this dump area. When the power plant operates at 100 percent capacity, approximately 40 tonnes per hour of spent shale will be produced (59.5 tonnes per hour of oil shale with 67 percent ash equals 40 tonnes). Mixing the spent shale with 20 percent water by weight will yield 50 tonnes per hour of pugged spent shale, or approximately two thirds of a truck per hour.

One truck will make a round trip in 22 minutes including a 78 percent operation efficiency. The dumping of the spent shale will not require any special handling and it will be mixed with the overburden at the dumping site. The spent shale and overburden will be leveled by a bulldozer at the dump sites.

### 13.1.3 Spent Shale Disposal from the 50 MW Plant

Since the oil shale pit and waste pile for the 50 MW plant will be the same as the of the 20 MW plant, the distances to the disposal areas will be the same. It is estimated that at peak operating conditions, the power plant will produce approximately 100 tonnes per hour of spent shale. After mixing with 20 percent water by weight, 125 tonnes per hour of pugged material will be produced. Based on a 22 minute round trip, this material can be hauled by one Caterpillar 777 truck



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operating two shifts per day. The pugged material will be loaded into the truck by a Caterpillar 992C front end loader. A spare truck and front end loader are not required since there is adequate time to maintain this equipment properly and the backup will be from the mine fleet which include spare units.

### 13.1.4 Spent Shale Disposal from the 400 MW Plant

At peak operation of the 400 MW plant, it is estimated that the disposal of approximately 1000 tonnes per hour of pugged wetted spent shale ash will be required. This material will be transported for several years to the out-of-pit waste storage located approximately 4 kilometres from the power plant. A fleet of 4 Caterpillar 785 trucks (136 tonne capacity) will be used for this purpose, three operating and one spare. Two Caterpillar 992 C high lift front end loaders will load the pugged spent shale into trucks.

When the excavation in the pit is sufficiently large to permit backfilling, the spent shale will be hauled to the pit. The spent shale will be mixed with overburden at the upper backfill level.

There are other methods of moving the spent shale into the backfill of the pit, but exploring these methods is beyond the scope of work for this conceptual feasibility study. One method is the use of an overland conveyor with a traveling spreader and shiftable conveyor. This method, besides being capital intensive, has operational problems that will need to be worked out to make the power plant and the conveying system independent of each other. Trucks are flexible and independent of the power plant and is the preferred method for this study.



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## 13.2 Waste Disposal Capital Cost

The capital cost for each of the three different sized power plants is based on loading the pugged spent shale with a front end loader into a truck and hauling it to an out-of-pit waste pile or to the pit backfill. The capital cost includes front end loaders, haul trucks and bulldozers. The costs will be based on a debt-equity ratio of 50-50 and 80-20 for each of the three cases.

### 13.2.1 Capital Cost for 20 MW Plant

The disposal of spent shale for the 20 MW plant will be loaded by a Caterpillar 922C front end loader and hauled by a Caterpillar 777 truck, which is part of the mine fleet, and spread at the disposal area by a Caterpillar D9N bulldozer which will be shared with the mine. All costs are in thousand dollars.

| Equipment | Quantity | Base Cost | Delivery Cost | Preparation Cost | Subtotal Cost | Total Cost |
|---|---|---|---|---|---|---|
| Front End Loader | 1 | 665 | 100 | 33 | 798 | |
| Haul Truck | 1/2 | 243 | 37 | 12 | 292 | |
| Bulldozer | 1/2 | 165 | 25 | 8 | 198 | |
| Sub Total | | | | | 1288 | |
| Contingency | | | | | 129 | |
| Sub Total | | | | | 1417 | |
| Management Fee | | | | | 14 | |
| Sub Total | | | | | 1431 | |
| Capitalized Interest for 50/50 Debt-Equity | | | | | 72 | |
| Total for 50/50 Debt/Equity | | | | | | 1503 |
| Capitalized Interest for 80/20 Debt/Equity | | | | | 115 | |
| Total for 80/20 Debt-Equity | | | | | | 1546 |



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### 13.2.2 Capital Cost for 50 MW Plant

The front-end loader, haul truck and bulldozer for the 50 MW plant spent shale disposal are required on a full time basis. All costs are in U.S. thousand dollars.

| Equipment | Quantity | Base Cost | Delivery Cost | Preparation Cost | Subtotal Cost | Total Cost |
|---|---|---|---|---|---|---|
| Front End Loader | 1 | 665 | 100 | 33 | 798 | |
| Haul Truck | 1 | 486 | 73 | 24 | 583 | |
| Bulldozer | 1 | 309 | 46 | 15 | 370 | |
| Sub Total | | | | | 1751 | |
| Contingency | | | | | 175 | |
| Sub Total | | | | | 1926 | |
| Management Fee | | | | | 19 | |
| Sub Total | | | | | 1945 | |
| Capitalized Interest for 50/50 Debt-Equity | | | | | 97 | |
| Total for 50/50 Debt/Equity | | | | | | 2042 |
| Capitalized Interest for 80/20 Debt/Equity | | | | | 156 | |
| Total for 80/20 Debt-Equity | | | | | | 2101 |

### 13.2.3 Capital Cost for 400 MW Plant
(All costs in U.S. $1000)

| Equipment | Quantity | Base Cost | Delivery Cost | Preparation Cost | Subtotal Cost | Total Cost |
|---|---|---|---|---|---|---|
| Front End Loader | 2 | 1330 | 200 | 67 | 1597 | |
| Haul Truck | 4 | 2828 | 424 | 141 | 3393 | |
| Bulldozer | 2 | 618 | 93 | 31 | 742 | |
| Sub Total | | | | | 5732 | |
| Contingency | | | | | 573 | |
| Sub Total | | | | | 6305 | |
| Management Fee | | | | | 63 | |
| Sub Total | | | | | 6368 | |
| Capitalized Interest for 50/50 Debt-Equity | | | | | 318 | |
| Total for 50/50 Debt/Equity | | | | | | 6686 |
| Capitalized Interest for 80/20 Debt/Equity | | | | | 509 | |
| Total for 80/20 Debt-Equity | | | | | | 6877 |



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## 13.3 Operating Cost

The operating cost for each of the three differnt size plants include repair parts, consumables, lubricants, and fuel, operating and maintenance labor, and insurance. Supervision of the sent shale disposal will be by the shift foreman from either the power plant or oil shale process plant.

### 13.3.1 20 MW Demonstration Plant

**Equipment Operating Cost/Year**

| | Parts $/Hr | Consumables $/Hr | Lube $/Hr | Fuel $/Hr | Total $/Hr | Operating Hrs/Yr | Operating Cost $/Yr |
|---|---|---|---|---|---|---|---|
| Front End Loader | 8.85 | 16.52 | 1.42 | 19.93 | 46.72 | 429 | 20,000 |
| Haul Truck | 10.50 | 9.50 | 1.37 | 10.50 | 31.87 | 1586 | 50,500 |
| Bulldozer | 21.00 | 2.56 | 2.90 | 13.02 | 39.48 | 700 | 27,600 |
| Total | | | | | | | 98,100 |

**Labor Cost/Year**

| Classification | Number | Wages $/Yr | Total $/Yr |
|---|---|---|---|
| Front End Loader Opr. | 1.0 | 3,000 | 3,000 |
| Truck Driver | 1.5 | 3,000 | 4,500 |
| Bulldozer Operator | .5 | 3,000 | 1,500 |
| Mechanic | .5 | 3,600 | 1,800 |
| Mechanic Helper | 1.0 | 2,700 | 2,700 |
| Supervision | .25 | 5,000 | 1,250 |
| Sub Total | | | 14,750 |
| Indirects @ 50% of Directs | | | 7,375 |
| Total | | | $22,125 |



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**Insurance Cost/Year**

Equipment Base Cost X 0.5 percent

$1,073,000 X 0.005 = $5365

**Total Operating Cost/Year**

| | |
|---|---|
| Parts and Supplies | $ 98,100 |
| Labor | 22,125 |
| Insurance | 5,365 |
| Total | $125,590 |

13.3.2 50 MW Prototype Plant

**Equipment Operating Cost/Year**

| | Parts $/Hr | Consumables $/Hr | Lube $/Hr | Fuel $/Hr | Total $/Hr | Operating Hrs/Yr | Operating Cost $/Yr |
|---|---|---|---|---|---|---|---|
| Front End Loader | 8.85 | 16.52 | 1.42 | 19.93 | 46.72 | 1167 | 54,525 |
| Haul Truck | 10.50 | 9.50 | 1.37 | 10.50 | 31.87 | 3600 | 114,730 |
| Bulldozer | 21.00 | 2.56 | 2.90 | 13.02 | 39.48 | 1750 | 69,090 |
| Total | | | | | | | 238,345 |

**Labor Cost/Year**

| Classification | Number | Wages $/Yr | Total $/Yr |
|---|---|---|---|
| Front End Loader Opr. | 2 | 3,000 | 6,000 |
| Truck Driver | 2 | 3,000 | 6,500 |
| Bulldozer Operator | 1 | 3,000 | 3,500 |
| Mechanic | 1 | 3,600 | 3,600 |
| Mechanic Helper | 2 | 2,700 | 5,400 |
| Supervision | 0.5 | 5,000 | 2,500 |
| Sub Total | | | 26,500 |
| Indirects @ 50% of Directs | | | 13,250 |
| Total | | | $39,750 |



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**Insurance Cost/Year**

Equipment Base Cost X 0.5 percent

$1,460,000 X .005 = $7300

**Total Operating Cost/Year**

| | |
|---|---|
| Parts and Supplies | $238,345 |
| Labor | 39,750 |
| Insurance | 7,300 |
| Total | $285,395 |

### 13.3.3 400 MW Full Scale Plant

**Equipment Operating Cost/Year**

| | Parts $/Hr | Consumables $/Hr | Lube $/Hr | Fuel $/Hr | Total $/Hr | Operating Hrs/Yr | Operating Cost $/Yr |
|---|---|---|---|---|---|---|---|
| Front End Loader | 8.85 | 16.52 | 1.42 | 19.93 | 46.72 | 8970 | 419,080 |
| Haul Truck | 20.00 | 13.00 | 3.00 | 17.20 | 53.20 | 16595 | 882,855 |
| Bulldozer | 21.00 | 2.56 | 2.90 | 13.02 | 39.48 | 8970 | 354,135 |
| Total | | | | | | | 1,656,070 |

**Labor Cost/Year**

| Classification | Number | Wages $/Yr | Total $/Yr |
|---|---|---|---|
| Front End Loader Opr. | 8 | 3,000 | 24,000 |
| Truck Driver | 12 | 3,000 | 36,000 |
| Bulldozer Operator | 8 | 3,000 | 24,000 |
| Mechanic | 4 | 3,600 | 14,400 |
| Mechanic Helper | 8 | 2,700 | 21,600 |
| Supervision | 4 | 5,000 | 20,000 |
| Sub Total | | | 140,000 |
| Indirects @ 50% of Directs | | | 70,000 |
| Total | | | $210,000 |



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**Insurance Cost/Year**

Equipment Base Cost X 0.5 percent

$4,776,000 X .005 = $23,880

**Total Operating Cost/Year**

| | |
|---|---|
| Parts and Supplies | $1,656,000 |
| Labor | 210,000 |
| Insurance | 23,880 |
| Total | $1,889,880 |

## 13.4 Summary of Spent Shale Disposal Costs

The cash flow analysis for the spent shale disposal of the 20 MW Demonstration Plant, the 50 MW Prototype Plant and the 400 MW Full Scale Plant are shown on Table 13-1, 13-2, 13-3, respectively. These analyses are based on a 25 year operating period with debt-equity ratios of 50:50 and 80:20. In addition to the capital and operating costs and the capitalized interest, other costs include spare parts, working capital, interest expense, depreciation, management fee, and return on equity. All taxes are excluded from the analysis.

The basis for the capital and operating costs are presented in Sections 13.2 and 13.3, respectively. The basis for the remaining costs are as follows:

- Spare parts cost are equivalent to approximately 5 percent of the base capital cost of the equipment.

- Working capital represents three months of operating costs and other unforseen costs.

- Interest expenses are based on a rate of 10 percent for a loan term of 15 years for both debt-equity cases.



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- Depreciation costs are based on estimates of equipment annual operating hours and their economic life.

- Management fee is based on $0.10 per tonne of pugged spent shale disposed.

- Return on equity for both cases is based on a 20 percent return.

The weighted costs of spent shale disposal for each of the three plants are listed below:

Table 13-4

SUMMARY OF UNIT COSTS FOR SPENT SHALE DISPOSAL

| Plant Size | Spent Shale T/Y x 1000 | 50:50 Debt-Equity $/Tonne | 80:20 Debt-Equity $/Tonne |
|---|---|---|---|
| 20 MW | 327 | 1.20 | 0.97 |
| 50 MW | 815 | 1.01 | 0.87 |
| 400 MW | 6518 | 1.04 | 0.98 |

The amount of spent shale listed above is a pugged product with 20 percent water by weight. The 50 MW plant has lower unit costs than the 400 MW plant because of lower capital cost. Spare units for the 50 MW plant are shared with the mine; whereas, the large volume of materials handled in the full scale plant, spare units are desirable for the spent shale disposal operation.



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TABLE 13-1

CASH FLOW ANALYSIS

20 MW DEMONSTRATION PLANT

SPENT SHALE DISPOSAL

Table 13-1
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
20 MW DEMONSTRATION PLANT
(All costs in US $1000 unless otherwise noted)

| | -2 1991 | -1 1992 | 1 1993 | 2 1994 | 3 1995 | 4 1996 | 5 1997 | 6 1998 | 7 1999 | 8 2000 | 9 2001 | 10 2002 | 11 2003 | 12 2004 | 13 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, MW | | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| II. SPENT SHALE W/20% WATER, TONNES X 1000 | | | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 327 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | | | | | | | | | | | | | | |
| Equipment | | 1431 | | | | | | | | | | | | | |
| Spare Parts | | 50 | | | | | | | | | | | | | |
| Working Capital | | 60 | | | | | | | | | | | | | |
| Sub-Total | | 1541 | | | | | | | | | | | | | |
| Capitalized Interest | | 77 | | | | | | | | | | | | | |
| Total | | 1618 | | | | | | | | | | | | | |
| 80/20 Debt Equity | | | | | | | | | | | | | | | |
| Capitalized Interest | | 123 | | | | | | | | | | | | | |
| Total | | 1664 | | | | | | | | | | | | | |
| IV. OPERATING COST | | | | | | | | | | | | | | | |
| Parts, Supplies, Fuel | | | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 |
| Wages & Fringes | | | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| Insurance | | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Total | | | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 |
| V. INTEREST EXPENSE | | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | | 81 | 76 | 70 | 65 | 59 | 54 | 49 | 43 | 38 | 32 | 27 | 22 | 16 |
| 80/20 Debt-Equity | | | 133 | 124 | 115 | 107 | 98 | 89 | 80 | [illegible] | [illegible] | [illegible] | 4[illegible] | 36[illegible] | 27[illegible] |

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Table 13-1 (Cont)
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
20 MW DEMONSTRATION PLANT

| | | -2 1991 | -1 1992 | 1 1993 | 2 1994 | 3 1995 | 4 1996 | 5 1997 | 6 1998 | 7 1999 | 8 2000 | 9 2001 | 10 2002 | 11 2003 | 12 2004 | 13 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI. | DEPRECIATION | | | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| VII. | MANAGEMENT FEE | | | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| VIII. | RETURN ON EQUITY | | | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | | | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 |
| | 80/20 Debt-Equity | | | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 |
| IX. | COST - SPENT SHALE DISPOSAL | | | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | | | 449 | 444 | 438 | 433 | 427 | 422 | 417 | 411 | 406 | 400 | 395 | 390 | 384 |
| | 80/20 Debt-Equity | | | 406 | 397 | 388 | 380 | 371 | 362 | 353 | 344 | 335 | 326 | 317 | 309 | 298 |
| X. | COST - $/TONNE, SPENT SHALE | | | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | | | 1.37 | 1.36 | 1.34 | 1.32 | 1.31 | 1.29 | 1.28 | 1.27 | 1.24 | 1.22 | 1.21 | 1.19 | 1.17 |
| | 80/20 Debt-Equity | | | 1.24 | 1.21 | 1.19 | 1.16 | 1.13 | 1.11 | 1.08 | 1.05 | 1.02 | 1.00 | 0.99 | 0.94 | 0.91 |

Table 13-1 (Cont)
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
20 MW DEMONSTRATION PLANT

| | 14<br>2006 | 15<br>2007 | 16<br>2008 | 17<br>2009 | 18<br>2010 | 19<br>2011 | 20<br>2012 | 21<br>2013 | 22<br>2014 | 23<br>2015 | 24<br>2016 | 25<br>2017 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, MW | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | |
| II. SPENT SHALE W/20% WATER X 1000 TONNES | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 327 | 8175 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | | | | | | | | | | | | |
| Equipment | | | | | | | | | | | | | |
| Spare Parts | | | | | | | | | | | | | |
| Working Capital | | | | | | | | | | | | | |
| Sub-Total | | | | | | | | | | | | | |
| Capitalized | | | | | | | | | | | | | |
| Interest | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | |
| 80/20 Debt-Equity | | | | | | | | | | | | | 1618 |
| Capitalized | | | | | | | | | | | | | |
| Interest | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | |
| IV. OPERATING COST | | | | | | | | | | | | | 1664 |
| Parts, Supplies, Fuel | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | 98 | |
| Wages & Fringes | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | |
| Insurance | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | |
| Total | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | |
| V. INTEREST EXPENSE | | | | | | | | | | | | | |
| 50/50 Debt-Equity | 11 | 5 | | | | | | | | | | | |
| 80/20 Debt-Equity | 18 | 9 | | | | | | | | | | | |

Table 13-1 (Cont)
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
20 MW DEMONSTRATION PLANT

| | | 14 2006 | 15 2007 | 16 2008 | 17 2009 | 18 2010 | 19 2011 | 20 2012 | 21 2013 | 22 2014 | 23 2015 | 24 2016 | 25 2017 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI. | DEPRECIATION | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | |
| VII. | MANAGEMENT FEE | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | |
| VIII. | RETURN ON EQUITY | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | 162 | |
| | 80/20 Debt-Equity | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | |
| IX. | COST-SPENT SHALE DISPOSAL | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | 379 | 373 | 368 | 368 | 368 | 368 | 368 | 368 | 368 | 368 | 368 | 368 | 9848 |
| | 80/20 Debt-Equity | 291 | 282 | 273 | 273 | 273 | 273 | 273 | 273 | 273 | 273 | 273 | 273 | 7889 |
| X. | COST - $/TONNE, SPENT SHALE | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | 1.16 | 1.14 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.20 |
| | 80/20 Debt-Equity | 0.89 | 0.86 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.97 |

TABLE 13-2

CASH FLOW ANALYSIS

50 MW PROTOTYPE PLANT

SPENT SHALE DISPOSAL

Table 13-2
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
50 MW PROTOTYPE PLANT
(All costs are in US $1000 unless otherwise noted)

| | -2 1996 | -1 1997 | 1 1998 | 2 1999 | 3 2000 | 4 2001 | 5 2002 | 6 2003 | 7 2004 | 8 2005 | 9 2006 | 10 2007 | 11 2008 | 12 2009 | 13 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, MW. | | | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| II. SPENT SHALE W/20% WATER, TONNES X 1000 | | | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | | | | | | | | | | | | | | |
| Equipment | 1945 | | | | | | | | | | | | | | |
| Spare Parts | 120 | | | | | | | | | | | | | | |
| Working Capital | 140 | | | | | | | | | | | | | | |
| Sub-Total | 2205 | | | | | | | | | | | | | | |
| Capitalized Interest | 110 | | | | | | | | | | | | | | |
| Total | 2315 | | | | | | | | | | | | | | |
| 80/20 Debt-Equity | | | | | | | | | | | | | | | |
| Capitalized Interest | 176 | | | | | | | | | | | | | | |
| Total | 2381 | | | | | | | | | | | | | | |
| IV. OPERATING COST | | | | | | | | | | | | | | | |
| Parts, Supplies, Fuel | | | 238 | 238 | 238 | 238 | 238 | 238 | 238 | 238 | 238 | 238 | 238 | 238 | 238 |
| Wages & Fromges | | | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Insurance | | | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Total | | | 285 | 285 | 285 | 285 | 285 | 285 | 285 | 285 | 285 | 285 | 285 | 285 | 285 |
| V. INTEREST EXPENSE | | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | | 116 | 108 | [illegible] | 93 | 85 | 77 | 70 | 62 | 54 | 46 | 39 | 31 | 23 |
| 80/20 Debt-Equity | | | 190 | 178 | [illegible] | 152 | 140 | 127 | 114 | 102 | 89 | 76 | 64 | 51 | 38 |

Table 13-2 (Cont)
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
50 MW PROTOTYPE PLANT

| | | -2 1996 | -1 1997 | 1 1998 | 2 1999 | 3 2000 | 4 2001 | 5 2002 | 6 2003 | 7 2004 | 8 2005 | 9 2006 | 10 2007 | 11 2008 | 12 2009 | 13 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI. | DEPRECIATION | | | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 |
| VII. | MANAGEMENT FEE | | | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 |
| VIII. | RETURN ON EQUITY | | | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | | | 232 | 232 | 232 | 232 | 232 | 232 | 232 | 232 | 232 | 232 | 232 | 232 | 232 |
| | 80/20 Debt-Equity | | | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 |
| IX. | COST-SPENT SHALE DISPOSAL | | | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | | | 902 | 894 | 886 | 879 | 871 | 863 | 856 | 848 | 840 | 832 | 825 | 817 | 809 |
| | 80/20 Debt-Equity | | | 839 | 827 | 814 | 801 | 789 | 776 | 763 | 751 | 738 | 725 | 713 | 700 | 687 |
| X. | COST - $/TONNE, SPENT SHALE | | | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | | | 1.11 | 1.10 | 1.09 | 1.08 | 1.07 | 1.06 | 1.05 | 1.04 | 1.03 | 1.02 | 1.01 | 1.00 | 0.99 |
| | 80/20 Debt-Equity | | | 1.03 | 1.01 | 1.00 | 0.98 | 0.97 | 0.95 | 0.94 | 0.92 | 0.91 | 0.89 | 0.87 | 0.86 | 0.84 |

Table 13-2 (Cont)
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
50 MW PROTOTYPE PLANT

| | 14 2011 | 15 2012 | 16 2013 | 17 2014 | 18 2015 | 19 2016 | 10 2017 | 21 2018 | 22 2019 | 23 2020 | 24 2021 | 25 2022 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, MW. | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | |
| II. SPENT SHALE w/20% WATER, X 1000 TONNES | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 815 | 20375 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | | | | | | | | | | | | |
| Equipment | | | | | | | | | | | | | |
| Spare Parts | | | | | | | | | | | | | |
| Working Capital | | | | | | | | | | | | | |
| Sub-Total | | | | | | | | | | | | | |
| Capitalized | | | | | | | | | | | | | |
| Interest | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | |
| 80/20 Debt-Equity | | | | | | | | | | | | | 2315 |
| Capitalized | | | | | | | | | | | | | |
| Interest | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | 2381 |
| IV. OPERATING COST | | | | | | | | | | | | | |
| Parts, Supplies, Fuel | 238 | 238 | 238 | 238 | 238 | 238 | 238 | 238 | 238 | 238 | 238 | 238 | |
| Wages & Fringes | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | |
| Insurance | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | |
| Total | 285 | 285 | 285 | 285 | 285 | 285 | 285 | 285 | 285 | 285 | 285 | 285 | |
| V. INTEREST EXPENSE | | | | | | | | | | | | | |
| 50/50 Debt-Equity | 15 | 8 | | | | | | | | | | | |
| 80/20 Debt-Equity | 25 | 13 | | | | | | | | | | | |

Table 13-2 (Cont)
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
50 MW PROTOTYPE PLANT

| | | 14 2011 | 15 2012 | 16 2013 | 17 2014 | 18 2015 | 19 2016 | 10 2017 | 21 2018 | 22 2019 | 23 2020 | 24 2021 | 25 2022 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI. | DEPRECIATION | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | 187 | |
| VII. | MANAGEMENT FEE | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | 82 | |
| VIII. | RETURN ON EQUITY | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | 232 | 232 | 232 | 232 | 232 | 232 | 232 | 232 | 232 | 232 | 232 | 232 | |
| | 80/20 Debt-Equity | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | |
| IX. | COST-SPENT SHALE DISPOSAL | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | 801 | 794 | 786 | 786 | 786 | 786 | 786 | 786 | 786 | 786 | 786 | 786 | 20577 |
| | 80/20 Debt-Equity | 674 | 662 | 649 | 649 | 649 | 649 | 649 | 649 | 649 | 649 | 649 | 694 | 17949 |
| X. | COST-$/TONNE, SPENT SHALE | | | | | | | | | | | | | |
| | 50/50 Debt-Equity | 0.98 | 0.97 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 1.01 |
| | ..80/20 Debt-Equity | 0.83 | 0.81 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.87 |

TABLE 13-3

CASH FLOW ANALYSIS

400 MW FULL SCALE PLANT

SPENT SHALE DISPOSAL

Table 13-3
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
400 MW FULL SCALE PLANT
(All costs in US $1000 unless otherwise noted)

| | -3 2000 | -2 2001 | -1 2002 | 1 2003 | 2 2004 | 3 2005 | 4 2006 | 5 2007 | 6 2008 | 7 2009 | 8 2010 | 9 2011 | 10 2012 | 11 2013 | 12 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, MW. | | | | 100 | 200 | 300 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 |
| II. SPENT SHALE W/20% WATER, TONNES | | | | 1629 | 3259 | 4888 | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | | | | | | | | | | | | | | |
| Equipment | | | 3184 | | | 3184 | | | | | | | | | |
| Spare Parts | | | 400 | | | 400 | | | | | | | | | |
| Working Capital | | | 450 | | | 450 | | | | | | | | | |
| Sub-Total | | | 4034 | | | 4034 | | | | | | | | | |
| Capitalized Interest | | | 202 | | | 202 | | | | | | | | | |
| Total | | | 4236 | | | 4236 | | | | | | | | | |
| 80/20 Debt-Equity | | | | | | | | | | | | | | | |
| Capitalized Interest | | | 323 | | | 323 | | | | | | | | | |
| Total | | | 4357 | | | 4357 | | | | | | | | | |
| IV. OPERATING COST | | | | | | | | | | | | | | | |
| Parts, Supplies, Fuel | | | | 414 | 828 | 1242 | 1656 | 1656 | 1656 | 1656 | 1656 | 1656 | 1656 | 1656 | 1656 |
| Wages & Fringes | | | | 53 | 105 | 158 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 210 |
| Insurance | | | | 12 | 12 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| Total | | | | 479 | 945 | 1424 | 1890 | 1890 | 1890 | 1890 | 1890 | 1890 | 1890 | 1890 | 1890 |

Table 13-3 (Cont)
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
400 MW FULL SCALE PLANT
(All costs in US $1000 unless otherwise noted)

| | -3 2000 | -2 2001 | -1 2002 | 1 2003 | 2 2004 | 3 2005 | 4 2006 | 5 2007 | 6 2008 | 7 2009 | 8 2010 | 9 2011 | 10 2012 | 11 2013 | 12 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V. INTEREST EXPENSE | | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | | | 212 | 198 | 184 | 381 | 353 | 325 | 297 | 269 | 240 | 212 | 184 | 155 |
| 80/20 Debt-Equity | | | | 349 | 325 | 302 | 627 | 581 | 535 | 488 | 442 | 395 | 349 | 302 | 256 |
| VI. DEPRECIATION | | | | 808 | 1616 | 2425 | 3233 | 3233 | 3233 | 3233 | 3233 | 3233 | 3233 | 3233 | 3233 |
| VII. MANAGEMENT FEE | | | | 163 | 326 | 489 | 652 | 652 | 652 | 652 | 652 | 652 | 652 | 652 | 652 |
| 50/50 Debt-Equity | | | | 424 | 424 | 847 | 847 | 847 | 847 | 847 | 847 | 847 | 847 | 847 | 847 |
| 80/20 Debt-Equity | | | | 174 | 174 | 349 | 349 | 349 | 349 | 349 | 349 | 349 | 349 | 349 | 349 |
| IX. COST-SPENT SHALE DISPOSAL | | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | | | 2086 | 3509 | 5369 | 7003 | 6975 | 6947 | 6919 | 6890 | 6862 | 6834 | 6806 | 6777 |
| 80/20 Debt-Equity | | | | 1973 | 3386 | 4989 | 6751 | 6705 | 6659 | 6612 | 6566 | 6519 | 6473 | 6426 | 6380 |
| X. COST-$/TONNE SPENT SHALE | | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | | | 1.28 | 1.08 | 1.10 | 1.07 | 1.07 | 1.07 | 1.06 | 1.06 | 1.05 | 1.05 | 1.04 | 1.04 |
| 80/20 Debt-Equity | | | | 1.21 | 1.04 | 1.02 | 1.04 | 1.03 | 1.02 | 1.01 | 1.01 | 1.00 | 0.99 | 0.99 | 0.98 |

Table 13-3 (Cont)
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
400 MW FULL SCALE PLANT

| | 13<br>2015 | 14<br>2016 | 15<br>2017 | 16<br>2018 | 17<br>2019 | 18<br>2020 | 19<br>2021 | 20<br>2022 | 21<br>2023 | 22<br>2024 | 23<br>2025 | 24<br>2026 | 25<br>2027 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. POWER GENERATION, MW | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | |
| II. SPENT SHALE W/20% WATER, TONNES | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 | 6518 | 153170 |
| III. CAPITAL EXPENDITURE | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | | | | | | | | | | | | | |
| Equipment | | | | | | | | | | | | | | |
| Spare Parts | | | | | | | | | | | | | | |
| Working Capital | | | | | | | | | | | | | | |
| Sub-total | | | | | | | | | | | | | | |
| Capitalized Interest | | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | | 8472 |
| 80/20 Debt-Equity | | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | | | 8714 |
| IV. OPERATING COST | | | | | | | | | | | | | | |
| Parts, Supplies, Fuel | | 1656 | 1656 | 1656 | 1656 | 1656 | 1656 | 1656 | 1656 | 1656 | 1656 | 1656 | 1656 | |
| Wages & Fringes | | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | 210 | |
| Insurance | | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | |
| Total | | 1890 | 1890 | 1890 | 1890 | 1890 | 1890 | 1890 | 1890 | 1890 | 1890 | 1890 | 1890 | |
| V. INTEREST EXPENSE | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | | 127 | 99 | 71 | 42 | 28 | 14 | | | | | | | |
| 80/20 Debt-Equity | | 209 | 163 | 116 | 70 | 47 | 23 | | | | | | | |

Table 13-3 (Cont)
SPENT SHALE DISPOSAL CASH FLOW ANALYSIS
400 MW FULL SCALE PLANT

| | 13 2015 | 14 2016 | 15 2017 | 16 2018 | 17 2019 | 18 2020 | 19 2021 | 20 2022 | 21 2023 | 22 2024 | 23 2025 | 24 2026 | 25 2027 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VI. DEPRECIATION | | 3233 | 3233 | 3233 | 3233 | 3233 | 3233 | 3233 | 3233 | 3233 | 3233 | 3233 | 3233 | |
| II. MANAGEMENT FEE | | 652 | 652 | 652 | 652 | 652 | 652 | 652 | 652 | 652 | 652 | 652 | 652 | |
| II. RETURN ON EQUITY | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | 847 | 847 | 847 | 847 | 847 | 847 | 847 | 847 | 847 | 847 | 847 | 847 | 847 | |
| 80/20 Debt-Equity | 349 | 349 | 349 | 349 | 349 | 349 | 349 | 349 | 349 | 349 | 349 | 349 | 349 | |
| IX. COST-SPENT SHALE DISPOSAL | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | 6749 | 6721 | 6693 | 6664 | 6650 | 6636 | 6622 | 6622 | 6622 | 6622 | 6622 | 6622 | 6622 | 159444 |
| 80/20 Debt-Equity | 6333 | 6287 | 6240 | 6194 | 6171 | 6147 | 6124 | 6124 | 6124 | 6124 | 6124 | 6124 | 6124 | 149679 |
| X. COST - $/TONNE SPENT SHALE | | | | | | | | | | | | | | |
| 50/50 Debt-Equity | 1.0 | 1.03 | 1.03 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.04 |
| 80/20 Debt-Equity | 0.97 | 0.96 | 0.96 | 0.95 | 0.95 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.98 |

# 14.0 INFRASTRUCTURE REQUIREMENTS

## 14.1 Electric Power

### 14.1.1 20 MW Demonstration Plant

The portable crusher at the mine will be powered by a diesel generator. All other equipment is diesel powered; therefore, electric power will not be extended to the pit area. The mine service facilities will receive power from the main substation located at the process plant.

A 2250 kVA transformer will step-down the incoming 132 kV power to 6 kV. This power will supply three-750 kVA, 500 V transformers to power the process plant and mine service facilities. The demand power requirement is expected to be approximately 1000 kW.

### 14.1.2 50 MW Prototype Plant

The mine will require lighting for the second and third shift operation which will be provided by lighting plants that have their own generators. The power requirements for the 50 MW plant will be the same as the 20 MW plant. The demand power will increase about 20 kW because the storage bins are higher and more power is required to lift the oil shale.

### 14.1.3 400 MW Full Scale Plant

The mine will require three portable transformers each with a capacity of 3 MVA or 5 MVA to handle the erratic demand of the electric power shovels. The incoming 132 kV power will be transformed to 7.2 kV for the shovels. The 5 MVA transformers are required if the blast hole drills and surface miners are electrified; otherwise, a 3 MVA transformer is



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required for each shovel. The power demand requirements will be 7200 kW for the shovels or 11,000 kW if the drills and surface miners are electrified.

The power demand for the process plant, mine service facilities, stockpiling and reclaiming, and belt conveying from the pit is expected to be approximately 10,000 kW. A 12 MVA transformer will transform the incoming 132 kV power to 6 kV which will suppy the large impactor motors and pit conveyor and five-1000 kVA to 500 V transformers will supply power to the smaller motors.

The entire power demand for the mine and processing plant will be purchased from the National grid.

## 14.2 Water-Raw and Potable

### 14.2.1 20 MW Demonstration Plant

The raw water will be pumped from a well at a rate of 2000 litres per minute to a storage tank, 500,000 litre capacity. The bottom one third of the tank will be stored for fire protection and the remaining capacity will be for dust suppression of the haul roads and for use in making potable water. This operation will require 1.5 million litres of raw water per day and 15 thousand litres of potable water per day.

### 14.2.2 50 MW Prototype Plant

This operation will have the same facilities as the 20 MW plant. More water will be required because of the three shift operation at the mine. It is expected that 2.5 million litres per day will be required, including that for dust suppression of the haul roads and 33 thousand litres of potable water per day to accomodate the larger work force.

14.2.3 400 MW Full Scale Plant

Fewer haul roads will be required for the 400 MW plant than for the 50 MW plant but there will be more activity within the pit that will require dust suppresion. It is estimated that this operation will require 2.5 million litres per day of raw water and 75 thousand litres per day of potable water.

If water is in short supply, chemical additives can be substitued for water on the haul roads to keep fugitive dust under control.

## 14.3 Housing Requirements for Work Force

14.3.1 20 MW Demonstration Plant

The housing requirements for the permanent work force of the 20 MW plant will be for the following personnel:

| Classification | Number of Personnel | |
|---|---|---|
| | Mine & Plant | Spent Shale |
| Expatriates | 2 | - |
| Supervisory/Professional/ Administrative | 27 | - |
| Manual Work Force | 46 | 4 |

A minimum of eight expatriate employees will be required during start-up operations.

14.3.2 50 MW Prototype Plant

The housing requirements for the permanent work force of the 50 MW plant will be for the following personnel:



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| Classification | Number of Personnel Mine & Plant | Spent Shale |
|---|---|---|
| Expatriates | 2 | - |
| Supervisory/Professional/ Administrative | 58 | - |
| Manual Work Force | 103 | 8 |

A minimum of 20 expatriate employees will be required during start-up operations.

### 14.3.3 400 MW Full Scale Plant

The housing requirements for the permanent work force of the 400 MW plant will be for the following personnel:

| Classification | Number of Personnel Mine & Plant | Spent Shale |
|---|---|---|
| Expatriates | 2 | - |
| Supervisory/Professional/ Administrative | 70 | 4 |
| Manual Work Force | 306 | 40 |

A minimum of 12 expatriate employees will be required during start-up operations. Because of the gradual build-up of power units from 100 MW to 400 MW, local personnel are trained to take over supervisory positions and fewer expatriate personnel are required.



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## 15.0 COMPARISON OF MINING COST WITH CONTRACTORS PRICE

### 15.1 General

Information received on the contractors quotation does not define his scope of work. It appears that the contractor will load and haul materials for the prices quoted and nothing else. The quoted price doesn't mention the volume of materials to be moved or length of contract which are important factors for the basis of a contractor's pricing. Another unknown is the condition of existing equipment and any needs for rehabilitation. Without knowledge of the basis of the quoted prices, a meaningful comparison is difficult to make. In spite of this difficulty, two versions of the mining costs were prepared. The first is a breakout of the mining cost only from the final fuel cost of the processed oil shale in storage excluding mine development cost and shale processing costs. The second represents only those mining costs we believe to be in the contractors scope of work; namely, drilling, blasting, loading and hauling.

### 15.2 Mining Cost Excluding Development and Shale Processing

These mining costs exclude all development work plus shale processing and reflect those costs of an operating mine for each of the three power plant case studies. The interface between mining and processing is the point where the truck dumps the oil shale because it is assumed that the contractors responsibility ends at this point. Table 15-1 Summary of Mining Costs Excluding Development and Shale Processing Cost as estimated by Bechtel is presented on the following page.

The 80/20 debt-equity ratio was used in Table 15-1, because this ratio yields a lower cost than the 50/50 debt-equity ratio. Interest expense is a weighted average for the 25 year operating period.

In the determination of the contractors mining cost, a rate of exchange of US $3 = 1 JD, a 1.8 specific gravity for the oil shale, a stripping ratio of 1.3 bank cubic metres per 1.0 tonne of oil shale, and a maximum distance of 3 km for transporting the overburden and oil shale were used.



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Table 15-1

SUMMARY OF MINING COSTS EXCLUDING DEVELOPMENT
AND SHALE PROCESSING COSTS

| | 20 MW Plant US $1000 | 50 MW Plant US $1000 | 400 MW Plant US $1000 |
|---|---|---|---|
| CAPITAL COST | 13705 | 15695 | 82082 |
| ANNUAL TONNES X 1000 | 390 | 973 | 7783 |
| OPERATING COST/YEAR | | | |
| Parts, Supplies, Fuel/Elec. | 828 | 2651 | 11935 |
| Labor | 499 | 872 | 1974 |
| Explosives | 14 | 31 | 250 |
| Insurance | 55 | 61 | 330 |
| Depreciation | 652 | 2122 | 6778 |
| Interest Expense | 426 | 488 | 2553 |
| Management Fee | 146 | 365 | 2919 |
| Return on Equity | 548 | 628 | 3283 |
| TOTAL | 3168 | 7218 | 30022 |
| Bechtel Cost Per Tonne, $/t | 8.12 | 7.42 | 3.86 |
| Contractor's Cost per Tonne, $/t (per JEA) | 4.58 | 4.58 | 4.10-4.41 |

## 15.3 Mining Cost for Drill, Blast, Load and Haul

These mining costs include only those selected costs associated with drilling, blasting, loading and hauling oil shale and overburden. Excluded from these costs are the mine development costs, shale processing costs and other costs of mining for those activities that normally performed such as maintaining the haulroads, waste dumps and sedimentation ponds, top-soil removal and reclamation, in-pit road and ramp construction and crushing.

Other criteria used in this determination are the same as those used in Section 15.2



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The mining costs reflected in Table 15-2 represent the cost of drilling, blasting, loading and hauling as determined in this report by Bechtel to parallel the scope of work assumed to be represented in the contractors quoted price.

Table 15-2

SUMMARY OF MINING COSTS FOR DRILL, BLAST, LOAD AND HAUL

| | 20 MW Plant US $1000 | 50 MW Plant US $1000 | 400 MW Plant US $1000 |
|---|---|---|---|
| CAPITAL COST | 9566 | 10580 | 54446 |
| ANNUAL TONNES X 1000 | 390 | 973 | 7783 |
| OPERATING COST/YEAR | | | |
| Parts, Supplies, Fuel/Elec. | 549 | 1673 | 10153 |
| Labor | 279 | 554 | 1417 |
| Explosives | 14 | 31 | 250 |
| Insurance | 38 | 40 | 215 |
| Depreciation | 316 | 1336 | 5484 |
| Interest Expense | 221 | 244 | 1258 |
| Management Fee | 98 | 243 | 1946 |
| Return on Equity | 383 | 423 | 2178 |
| TOTAL | 1819 | 4544 | 22901 |
| Bechtel Cost per Tonne, $/t | 4.66 | 4.67 | 2.94 |
| Contractor's Cost per Tonne, $/t (per JEA) | 4.58 | 4.58 | 4.10-4.41 |

The mining cost for the 20 MW and 50 MW plants as developed by Bechtel for this report are believed to be similar to the contractor's price. The high cost of the two expatriate personnel as compared to local managers contributes to the cost differential in the comparison for these plants. As for the 400 MW plant, the Bechtel estimate of cost per tonne is lowered when the higher volume of material is handled whereas, the contractor's price is



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only marginally lower than for the 20 MW and 50 MW plants. It appears that the contractor's price may be based on the lesser volumes associated with the 20 MW and 50 MW plants.

The difference in the cost as determined by Bechtel 15.2 and 15.3 are usually done under a force account by the mine contractor. The Owner would pay the contractor additional money to perform those activities mentioned in 15.3 such as maintaining the haulroads, waste dumps and sedimentation ponds, topsoil removal and reclamation, etc.

In summary, a more detailed definition of the scope of work covered by the quoted contractors costs is needed.



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# APPENDIX A

# PRELIMINARY MINING PLAN

The Preliminary Mining Plan is superimposed on the oil shale isopach in Figure A-1 and on the overburden isopach in Figure A-2. The mine plan is made up of 35 cuts that are 80 metres wide and between one and three metres long oriented in a NNW direction. The mine is opened with a box-cut at Cut #1 and an incline south of the cut. The mine progresses from Cut #1 to Cut #35.

A mining schedule shown in Table A-1 was made for the 20 MW Demonstration Plant and the 400 MW Full Scale Plant on the assumption of continuing the operation of the 20 MW Plant in the event the 400 MW Plant were constructed. The schedule shows the phasing-in and phasing-out of each generating unit over their assumed 35 year life. For each year a total amount of oil shale mined and overburden removed is scheduled by cut. The mining of oil shale and the removal of overburden must be synchronized. If too much overburden is removed, the operation becomes oil shale bound and overburden will require hauling to the out-of-pit waste pile. This should be avoided as much as possible because of higher cost.

The schedule was used in the timing of procuring quipment and bringing on new personnel for the operation of the mine and process plant for the 400 MW plant. It was assumed that the 100 MW power units would be constructed at the rate of one per year. Equipment and personnel were added when required for the mine and process plant.



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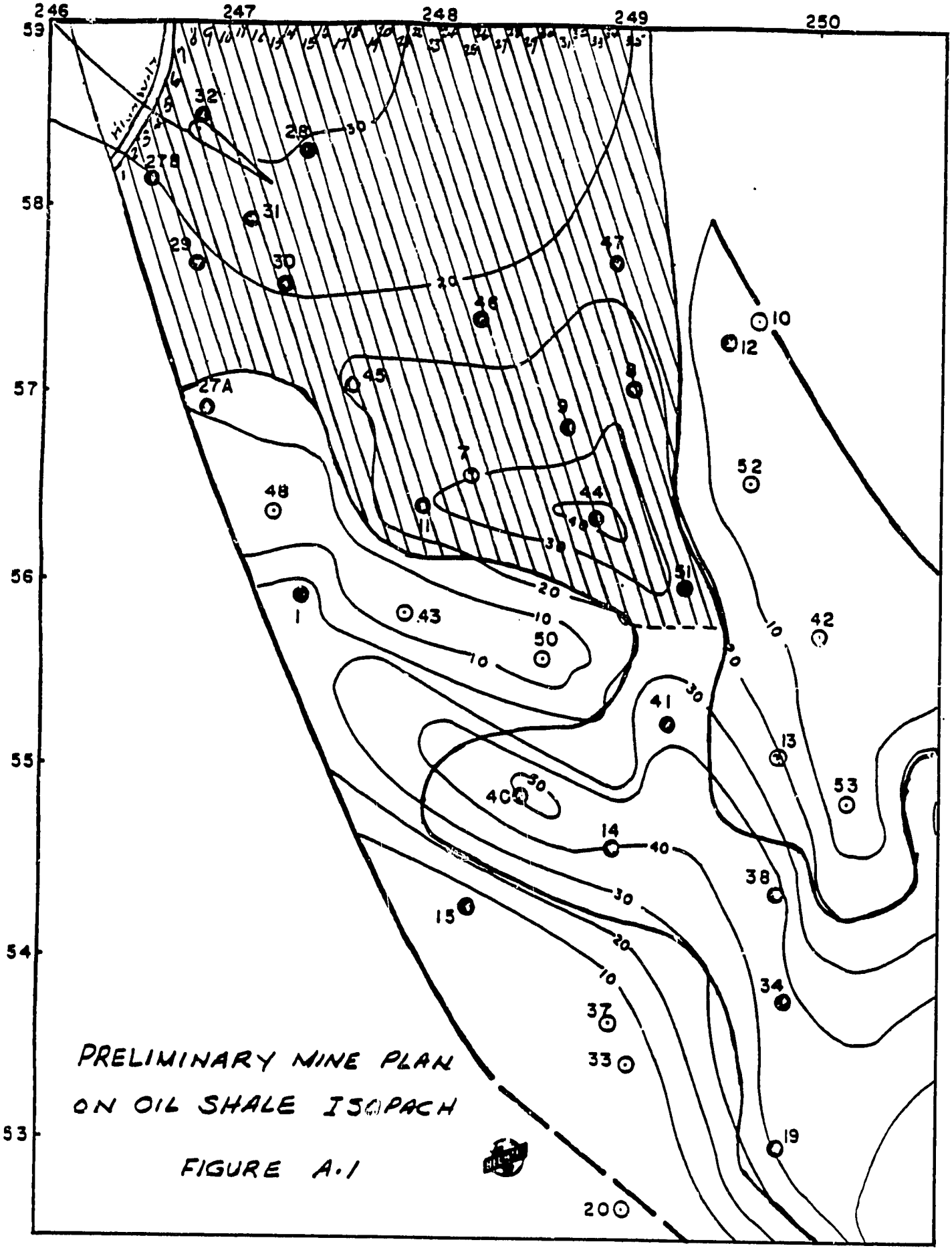
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PRELIMINARY MINE PLAN
ON OIL SHALE ISOPACH
FIGURE A.1

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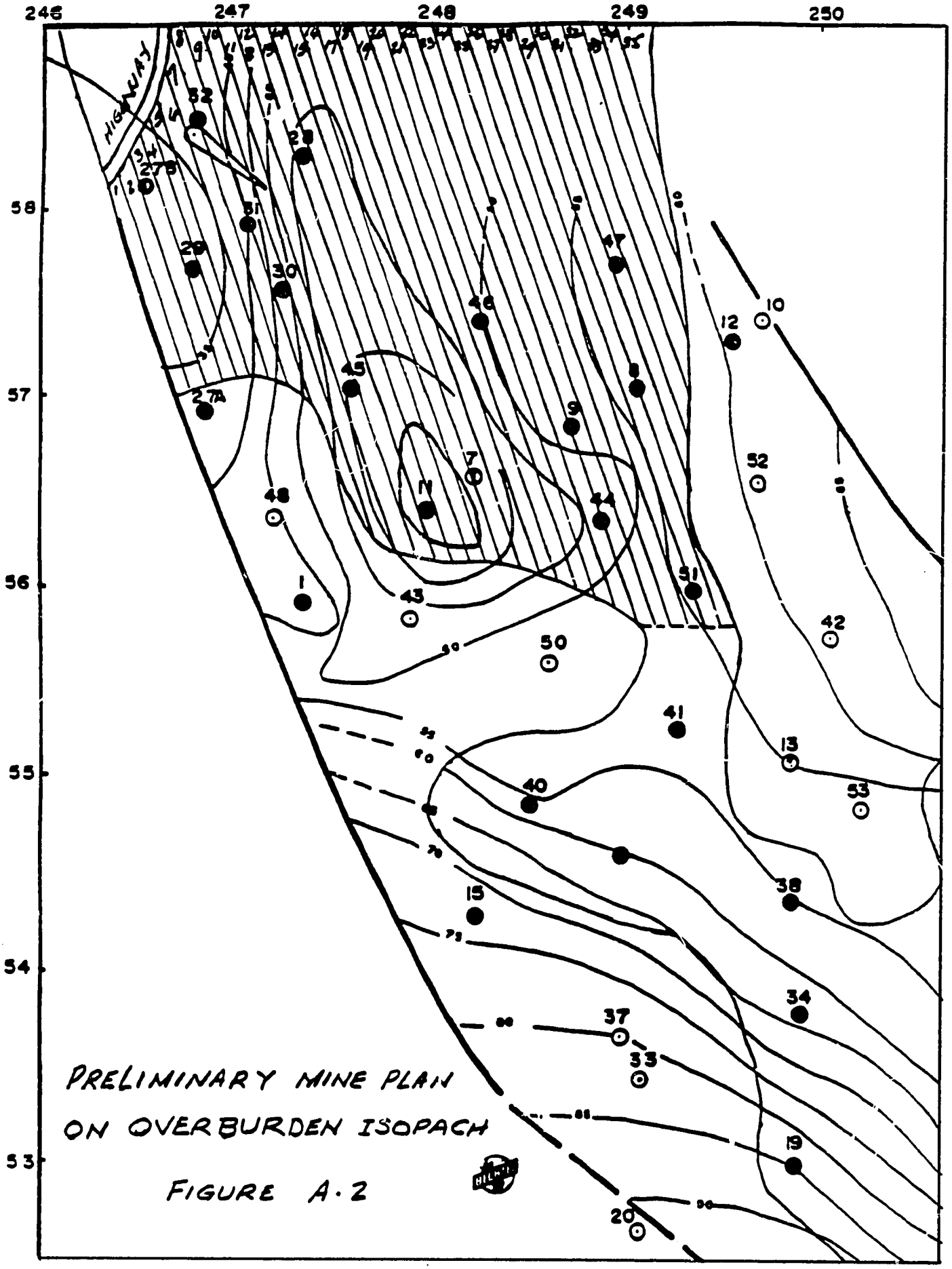


PRELIMINARY MINE PLAN
ON OVERBURDEN ISOPACH

FIGURE A·2

# TABLE A-1

## MINING SCHEDULE FOR 20 MW DEMONSTRATION AND 400 MW FULL SCALE PLANTS

| Year | Demo Pit $m^3$ | Unit 01 $m^3$ | Unit 02 $m^3$ | Unit 03 $m^3$ | Unit 04 $m^3$ | Total $m^3$ | O.B. Cut # | O.B. Cut # | O.B. Cut # | O.B. Cut # | O.B. Cut # | Total $m^3$ | O.B. Cut # | O.B. Cut # | O.B. Cut # | O.B. Cut # | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1993 | 390 | | | | | 390 | 4 | 390/4 | | | 604 | 207 | 757/4 | 161/4 | | 500 x $10^3$ $m^3$ from mine development included | | | | |
| 94 | 390 | | | | | 390 | 5 | 390/5 | | | 504 | 207 | 232/5 | 252/5 | | | | | | |
| 95 | 390 | | | | | 390 | 4 | 390/4 | | | 404 | 207 | 232/4 | 257/4 | | | | | | |
| 96 | 390 | | | | | 390 | 6 | 390/6 | | | 605 | 207 | 232/6 | 257/5 | | | | | | |
| 97 | 390 | | | | | 390 | 5 | 390/5 | | | 504 | 207 | 232/5 | 257/4 | | | | | | |
| 98 | 390 | | | | | 390 | 4 | 390/4 | | | 404 | 207 | 232/4 | 257/4 | | | | | | |
| 99 | 390 | | | | | 390 | 6 | 390/6 | | | 605 | 207 | 232/6 | 257/5 | | | | | | |
| 2000 | 390 | | | | | 390 | 5/Demo | 390/5 | [illegible] | | 5 | 207 | 232/5 | | | | | | | |
| 01 | 390 | | | | | 390 | 4/1 | 390/4 | 225/1 | | 1 | 2700 | 3200/1 | | | $2.4 \times 10^6$ $m^3$ from last cut | | | | |
| 02 | 390 | | | | | 390 | 1 | 390/1 | | | 1 | 2700 | 3200/1 | | | | | | | |
| 03 | 390 | 1946 | | | | 2336 | 1 | 2336/1 | | | 10203 | 6300 | 1232/1 | 2336/1 | 1312/1 | | | | | |
| 04 | 390 | 1946 | 1945 | | | 4281 | 10203 | 150/1 | 2405/1 | 1726/1 | 30426 | 7800 | 2119/1 | 2110/1 | 2121/1 | | | | | |
| 05 | 390 | 1946 | 1945 | 1946 | | 6227 | 30426 | 1198/1 | 2321/4 | 1808/5 | 52452 | 7500 | 1642/5 | 2204/6 | [illegible] | | | | | |
| 06 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 52452 | 1652/6 | 4623/6 | 1884/7 | 7[illegible] | 9000 | 7610/7 | 2322/8 | | | | | | |
| 07 | 390 | 1946 | 1946 | 1946 | 1946 | 8173 | 7[illegible]8 | 1916/7 | 2247/8 | | 8[illegible]7 | 10500 | 6172/8 | 4327/9 | | | | | | |
| 08 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 8[illegible]7 | 4209/8 | 2246/9 | | 9[illegible]10 | 10500 | 6276/9 | 3624/10 | | | | | | |
| 09 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 9[illegible]10 | 4953/9 | 3246/10 | | 10[illegible]11 | 12000 | 9164/10 | 2884/11 | | | | | | |
| 10 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 10[illegible]11 | 5[illegible]/10 | 3646/11 | | 11[illegible]12 | 12500 | 12364/11 | 1184/12 | | | | | | |
| 11 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 11 | 5173/11 | | | 12 | 12500 | 12500/12 | | | | | | | |
| 12 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 11[illegible]12 | 1364/11 | 3043/12 | | 12[illegible]13 | 12500 | 9[illegible]/12 | 12332/13 | | | | | | |
| 13 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 12[illegible]13 | 2786/12 | 4332/13 | | 13[illegible]14 | 12500 | 8218/13 | 10332/14 | | | | | | |
| 14 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 13[illegible]14 | 6207/13 | 1264/14 | | 14[illegible]15 | 12500 | 2862/14 | 9564/15 | | | | | | |
| 15 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 14 | 8173/14 | | | 15[illegible]16 | 12500 | 5122/15 | 9561/16 | | | | | | |
| 16 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 14[illegible]15 | 1803/14 | 6530/15 | | 16[illegible]17 | 12500 | 6672/16 | 2802/17 | | | | | | |
| 17 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 15[illegible]16 | 3905/15 | 4261/16 | | 17[illegible]18 | 12000 | 7796/17 | 4204/18 | | | | | | |
| 18 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 16[illegible]17 | 5786/16 | 2417/17 | | 18[illegible]19 | 12000 | 8132/18 | 3662/19 | | | | | | |
| 19 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 17 | 8173/17 | | | 19[illegible]20 | 12000 | 10[illegible]/19 | 1064/20 | | | | | | |
| 20 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 17[illegible]18 | 562/17 | 7611/18 | | 20 | 12000 | 12000/20 | | | | | | | |
| 21 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 18[illegible]19 | 4943/18 | 4130/19 | | 20[illegible]21 | 12000 | 6[illegible]/20 | 11372/21 | | | | | | |
| 22 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 19[illegible]20 | 7336/19 | 836/20 | | 21[illegible]22 | 12000 | 7[illegible]/21 | 11172/22 | | | | | | |
| 23 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 20 | 8173/20 | | | 22[illegible]23 | 12500 | 3015/22 | 7[illegible]/23 | | | | | | |
| 24 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 20[illegible]21 | 2[illegible]/20 | 5720/21 | | 23[illegible]24 | 10500 | 7061/23 | 3[illegible]/24 | | | | | | |
| 25 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 21[illegible]22 | 4400/21 | 3773/22 | | 23 | 10500 | [illegible] | | | | | | | |
| 26 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 22 | 8173/22 | | | 24[illegible]25 | 10500 | 5[illegible]/24 | 9946/25 | | | | | | |
| 27 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 22[illegible]23 | 1[illegible]/22 | 3059/23 | | 25[illegible]26 | 10500 | 3618/25 | 6682/26 | | | | | | |
| 28 | 390 | 1946 | 1945 | 1946 | 1946 | 8173 | 23[illegible]24 | 4159/23 | 3[illegible]/24 | | 26 | 9000 | 9000/26 | | | | | | | |

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TABLE A-1 (Continued)

MINING SCHEDULE FOR 20 MW DEMONSTRATION AND 400 MW FULL SCALE PLANTS

| Year | Demo Pit $10^3$ | Unit 01 $10^3$ | Unit 03 $10^3$ | Unit 02 $10^3$ | Unit 04 $10^3$ | Total $10^3$ | OS Cu % | [illegible] Cu % | [illegible] Cu % | [illegible] Cu % | OC Cu % | Total $10^3$ t | [illegible] Cu % | [illegible] Cu % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 29 | – | 1946 | 1945 | 1946 | 1946 | 7783 | 24 | 7783/24 | | | 26127 | 9000 | 232/26 | 8777/27 |
| 30 | – | 1946 | 1945 | 1946 | 1946 | 7783 | 24125 | 1802/24 | 6511/25 | | 27128 | 9000 | 5541/27 | 3456/28 |
| 31 | – | 1946 | 1945 | 1946 | 1946 | 7783 | 25026 | 4477/25 | 3306/26 | | 28 | 9000 | 9000/28 | |
| 32 | – | 1946 | 1945 | 1946 | 1946 | 7783 | 26 | 7783/26 | | | 26129 | 9000 | 3641/28 | 5359/29 |
| 33 | – | 1946 | 1945 | 1946 | 1946 | 7783 | 26127 | 2786/26 | 4996/27 | | 29130 | 9000 | 5701/29 | 3299/30 |
| 34 | – | 1946 | 1945 | 1946 | 1946 | 7783 | 27128 | 5770/27 | 1813/28 | | 30131 | 7500 | 5993/29 | 1507/31 |
| 35 | – | 1946 | 1945 | 1946 | 1946 | 7783 | 28 | 7783/28 | | | 31 | 7500 | 7500/31 | |
| 36 | – | 1946 | 1945 | 1946 | 1946 | 7783 | 28129 | 460/28 | 7323/29 | | 31132 | 7500 | 587/31 | 6913/32 |
| 37 | – | 1946 | 1945 | 1946 | 1946 | 7783 | 29[illegible] | 383/29 | 5076/30 | 2325/31 | 32133 | 6000 | 497/32 | 5504/33 |
| 38 | – | – | 1945 | 1946 | 1946 | 5837 | 31132 | 2245/31 | 3592/32 | | 33134 | 4500 | 479/33 | 4021/34 |
| 39 | – | – | – | 1946 | 1946 | 3892 | 32133 | 859/32 | 3033/33 | | 34135 | 3784 | 67/34 | 3667/35 |
| 40 | – | – | – | – | 1946 | 1946 | 33134 | 596/33 | 1372/34 | | | – | | |

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