AN ECONOMIC EVALUATION OF EQUIPMENT INSTALLATION FOR PRODUCTION OF STOKER COAL

by

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ABSTRACT

The Pontiki Coal Company in Lovely, Kentucky, a subsidiary of Mapco, Inc. produces steam and stoker coal. The company wants to improve the quality of its stoker coal product. Several suggestions to do this were made and evaluated.

Discounted Cash Flow Rate of Return (DCFROR), Net Present Value (NPV), and Payback Period were used to evaluate four proposed, mutually exclusive courses of actions that the Pontiki could take in its coal prep plant. The economic analysis is an incremental one in that only the incremental income and costs associated with each project are considered. The net cash flows used are those that are directly attributable to each project. All computations are totally dependent on cost and production estimates received from Mapco, Inc., Tulsa, Oklahoma, and explicit assumptions of the author.

The results of these evaluations show that the third course of action, Scenario 3, which includes installing a new clean coal screen, 1340' of new conveyor belts, and a 3,000 ton stoker coal storage silo is the best.

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INTRODUCTION

Installation of new equipment to improve efficiency and product quality and quantity in coal prep plants is an on-going concern for coal companies today. Projects must show a rate of return above a stated minimum percent, i*, and a positive Net Present Value (NPV) for a project to be considered (10). Without the use of proper economic evaluation methods, decisions concerning new equipment purchases can produce results ranging from very costly to highly profitable, depending on the intelligence, experience and luck of the person(s) making the decisions.

The Pontiki Coal Company, a wholly owned subsidiary of Mapco, Inc., Tulsa, Oklahoma, faced such equipment purchase decisions in the fall of 1980. The Pontiki Mine, located southeast of Inez in Martin County, Kentucky, in 1980 produced 1.3 million tons of highly desirable Eastern coal (+13,000 Btu, 6-6.26% ash, and 0.7% sulphur)(1). Of this 1.3 million tons, approximately 60,000 tons was stoker coal (2). The Pontiki is scheduled to boost production to 1.7 million tons in 1981 and 75,000 tons of stoker (1)(3).

Mining methods employed in the underground operation consist of room and pillar, continuous, and conventional (4). The Pontiki prep plant, with a design capacity of 720 tph raw coal, washes +¼" material in a heavy-media vessel and ¼"x28 mesh on Diester tables. A froth flotation system is also used. All ¼"x0" coal runs through a thermal dryer to bring moisture down from 14% to 6% (7). The handling systems include an 8,000 ton raw coal storage silo, two 8,000 tons clean coal storage silos, and a 3,400 tph unit-train loading facility (1).

Both steam and stoker coal are produced by the Pontiki, with steam coal being the major product (1.24 million tons out of 1.30 million total)(2). Steam coal is sized 1¼"x0" and "clean" stoker coal is sized 1¼"x¼", with less than 10%, -¼" fines. When stoker coal can meet these specifications it is estimated that it can be sold for $3/ton more than steam coal (5).

Most of the bituminous coal produced in the United States is burned in boilers or furnaces to obtain thermal energy for generating electricity, processing raw or manufactured materials, and heating industrial complexes. The electric utility industry is the largest consumer of bituminous coal, accounting for more than 66% of the total consumption in the U. S. in 1977. Another large direct-firing consumer of coal is the group of industries involved in the manufacturing of portland cement, lime, gypsum, alumina, and magnesia (8).

Coal can be burned on a grate, in suspension, or a combination of the two. Grate burning is the simplest way to burn coal but it is less efficient; it is also labor consuming and produces environmental problems such as smoke and soot emission. Grate stokers have been designed for firing boiler furnaces for commercial and industrial use and are designed as single retort, multiple retort chain, traveling grate, and spreader stokers (8). Stoker coal has to have a lower size limit so that the coal won't fall through the grates and/or clog up the mechanical feeders used with these types of furnaces.

Suspension burning provides more thermal energy per unit of furnace volume than other methods of firing. Electric generating facilities, which customarily have boilers that generate over 4 million lbs. of steam per hour and consume 200 tons of coal per hour, almost exclusively use the suspension burning method. In suspension burning, the coal is pulverized to the consistency of talc powder (200 mesh) and blown into the combustion zone with approximately 10% of the required air for combustion the remainder of the air being supplied as secondary air to complete the combustion in the furnace (7)(8). Another suspension method utilizes a primary cylindrical furnace called a cyclone furnace in which crushed coal (1/8"x0") is injected with air admitted tangentially, imparting a vortex motion to the coal and gases (8).

Because the coal is pulverized anyway there is no need for a lower size limit. In fact, the more fines, the better for the buyer. Since there is no extra sizing and screening, as with stoker coal, steam coal can be sold for less.

Presently the Pontiki can only produce a "modified" stoker product running approximately 20%, - ¼" material. A price premium of only $1.50 /ton can be realized on this product (6). Using "modified" stoker, which is not much different from steam coal, causes customers to blend Pontiki stoker with other stoker or use it as is. Neither situation is desirable, either for the customer or the Pontiki.

Screen tests (9) taken at various points in the prep plant, the storage silos, and the load-out tipple indicate that the excessive fines are generated in the prep plant. After being cleaned and sized, the stoker stream is dropped 65' through various metal chutes onto the stoker conveyor belt, causing the coal to break up, thus increasing the fines.

Another problem arises with stoker production. Stoker coal production is not a continuous process. Stoker coal is only produced when an order comes in, it is not sold under a long term contract. The rest of the time steam coal is the only product. Presently, clean coal storage consists of two, 8,000 tons storage silos (total effective capacity = 15,000 tons)(1). When a stoker order comes in, one of the silos must be emptied in order to have stoker storage. This limits steam coal storage to one 8,000 ton silo (effective capacity = 7,500 tons). If no trains are available to be loaded this gives the prep plant approximately 10½ hours of production capacity (7,500 tons/720tph). When the steam coal silo is full, this causes a block-off of the prep plant and diversion of the raw coal to the raw coal storage. If this silo fills up the coal is piled in the parking lot until storage becomes available. Block-offs account for approximately 75% of plant downtime. One of the contributing factors to block-offs was the unavailability of rail cars. Service by the railroad has improved in 1981 and block-offs due to this problem occur rather infrequently now (2).

The Pontiki has a sister mine, the Martiki, which can produce "clean" stoker coal. The reasons that all the stoker coal requirements aren't satisfied at the Martiki are, first, capacity restriction on stoker production at the Martiki and, second, there is no storage capacity at the Martiki, only a 150 ton surge bin. The Martiki loads directly into railcars with no intermediate storage.

Four possible scenarios are proposed to help solve the Pontiki stoker coal sizing problem. They are described below.

Scenario 1

Do nothing and continue to sell "modified" stoker for whatever price premium is possible (approximately $1.50/ton). As stated above, this will cause customers to blend Pontiki stoker or use as is. Also, continuing to operate as is will not completely solve the prep plant block-off problem.

Scenario 2

Sell only steam coal, since making a "clean" stoker is not possible and a "modified" stoker is not a desirable product to sell or buy. By selling only steam coal most of the remaining prep plant block-offs will be eliminated. But if only steam coal were sold, the Pontiki would not realize any differential income that it presently received from the "modified" stoker.

By following Scenario 1, the additional $1.50/ton price differential between "modified" and "clean" stoker will not be captured. By following Scenario 2 not even the $1.50/ton differential now being received will be captured.

Scenarios 3 and 4 involve installing various pieces of equipment to produce and store "clean" stoker coal.

Scenario 3

a. Install a new clean coal screen at the stoker conveyor belt to screen the stoker stream just before it goes on the conveyor belt to the silos.

b. Erect a new 3,000 ton storage silo to store stoker coal only.

c. Install two new conveyor belts, one from the transfer point to the new silo (1,140') and one from the silo to the load-out tipple (200').

Installing the new screen will insure a "clean" stoker product leaving the prep plant for storage in the silo. The new silo provides dedicated stoker storage and will eliminate some of the prep plant block-offs. Some breakage of coal does occur when it is deposited in the silo but not enough to affect stoker quality (9).

Scenario 4

a. Install a new clean coal screen, as in 3-a above.

b. Lay 210' of new side track.

c. Rebuild a remote-controlled switch engine.

d. Install a new conveyor belt from the transfer point to the load-out tipple (1,302').

e. Hire two new employees (1/shift) to operate the engine.

The rationale behind this scenario is to use rail cars as stoker storage instead of a silo. The 210' of track is a new siding to park the full cars on before they are shipped. An engine is needed to move the cars around since the railroad does not have an engine dedicated to the Pontiki load out facility.

Scenario 5 was run to determine the minimum breakeven production. A 10,000 tpy sales increment and a $3/ton price differential were used.

Scenario 6 was run to determine the minimum price differential needed. A 15,000 tpy sales differential was used.

Choosing the correct scenario can be difficult without the aid of proper economic evaluation methods. It can be an expensive decision both in real and opportunity costs if the wrong scenario is chosen and implemented. The following chapter discusses the three methods used to evaluate these scenarios.

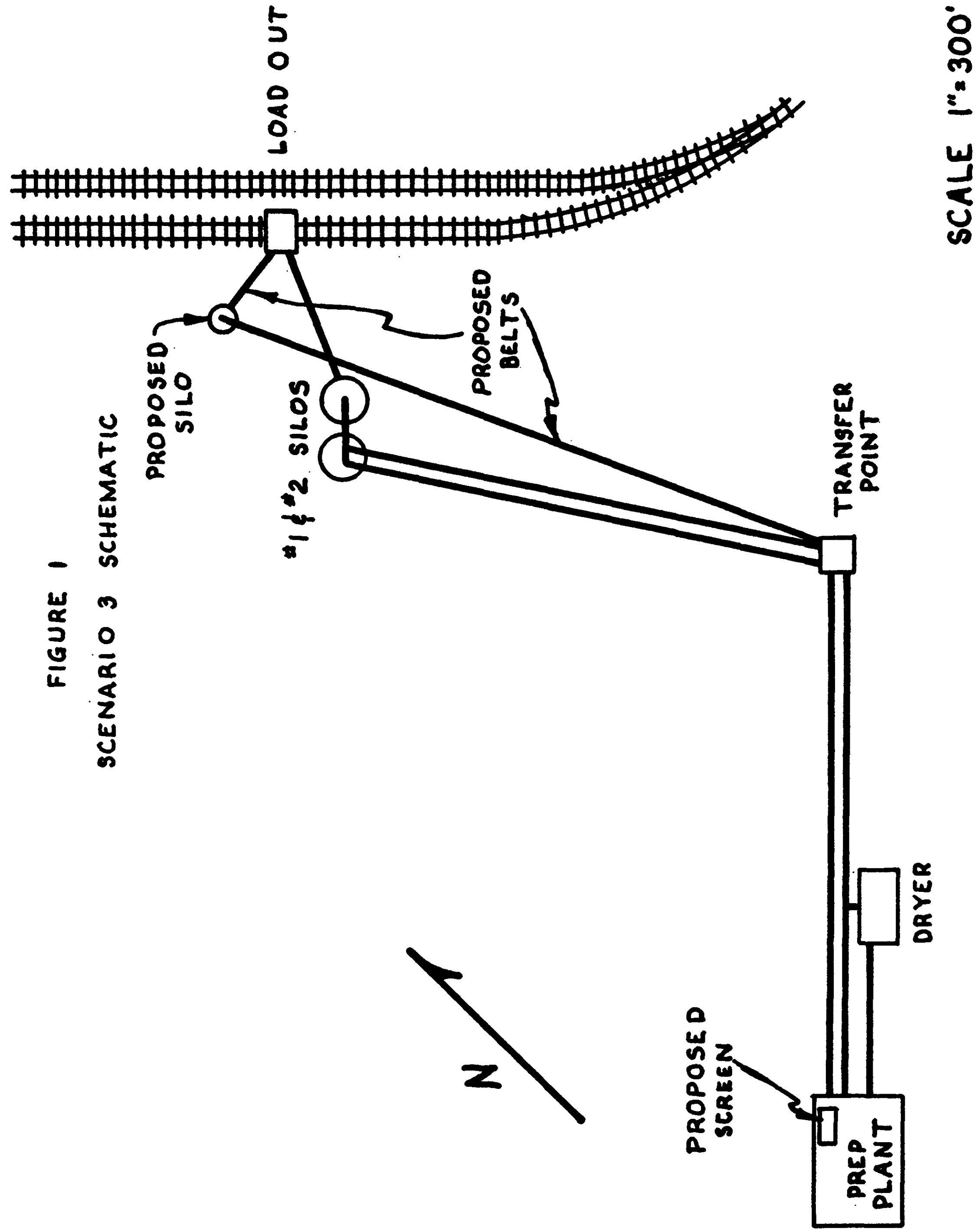


FIGURE I

SCENARIO 3 SCHEMATIC

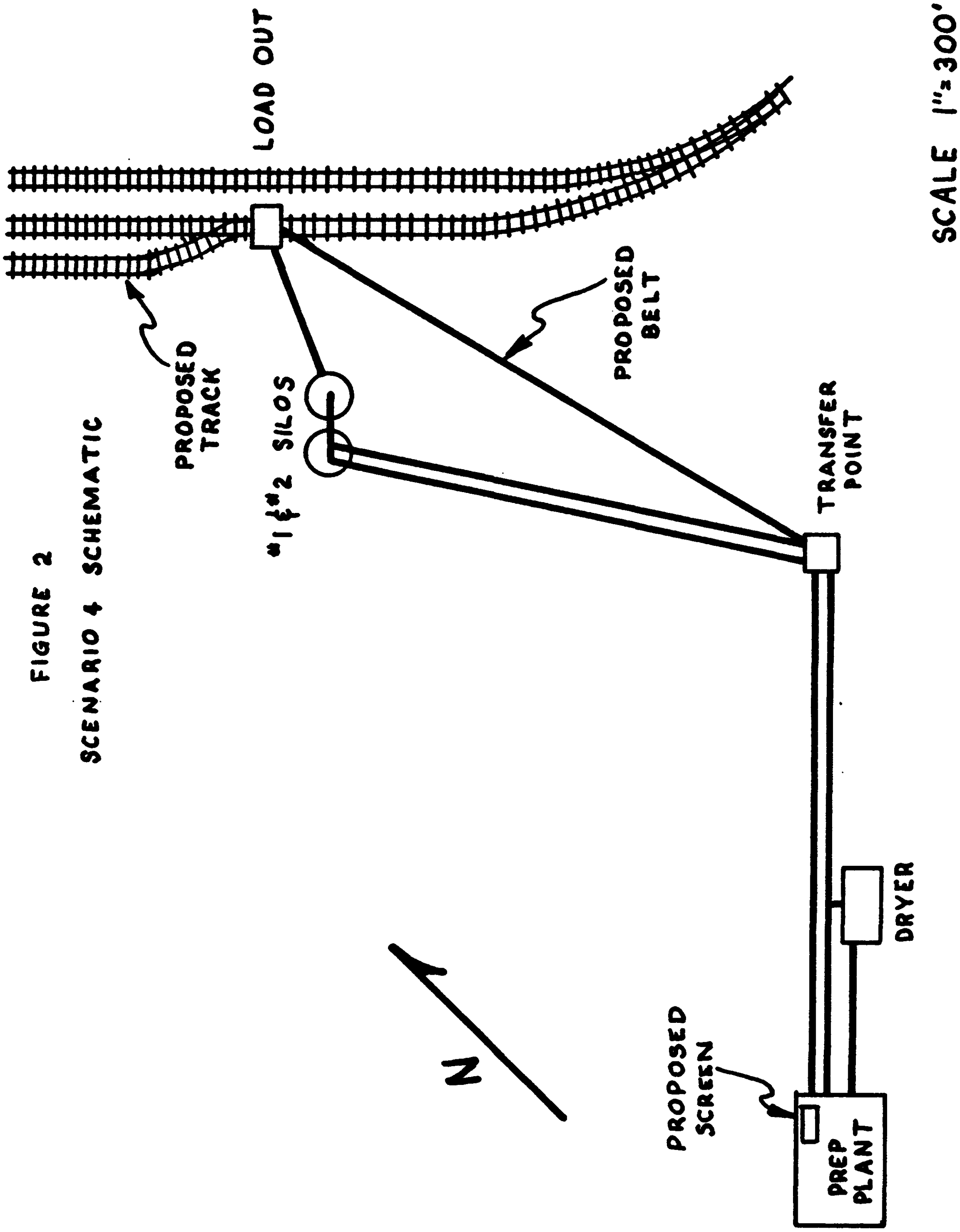


FIGURE 2

SCENARIO 4 SCHEMATIC

DISCUSSION OF EVALUATION METHODS

Many techniques can be used to determine the economic feasibility of mutually exclusive projects. Some are chosen because of a company's preference of one method over another, others because they are the best method for the purpose of the evaluation. The methods used and discussed in this thesis are:

1. Net Present Value (NPV)
2. Discounted Cash Flow Rate of Return (DCFROR)
3. Payback Period

There are several other methods available to evaluate mutually exclusive projects but they are either redundant, not applicable, or no longer in use so they will not be presented here.

NET PRESENT VALUE (NPV)

Net Present Value (NPV) is the present worth of projected cash flows minus the present worth of projected costs calculated at some predetermined minimum rate of return, i.

NET PRESENT VALUE (NPV) = present worth revenue @ i
- present worth costs @ i

When using NPV, the alternative with the largest positive NPV is the one preferred with respect to profitability(10).

The present value of an investment may be described as the maximum amount a firm would pay for the opportunity of making the investment without being financially worse off (11).

The major merit of NPV is that it will always lead to correct results for the evaluation of alternatives of equal or unequal lives. It reduces the stream of cash flows and costs to one present valued sum that can be compared to other NPV's for determining the ranking of alternatives. NPV also considers the time value of money, is easy to calculate and easy to understand (10).

The main deficiency of NPV lies in determining the minimum rate of return, i. It is usually defined as a company's cost of capital or the opportunity cost of alternative investment opportunities in which corporate funds could be invested (10)(12). The problem of determining the firm's cost of capital is complicated by several factors: the company's funds usually come from various sources, such as preferred and common stocks, bonds, retained earnings, banks, or by selling assets. All of these incur costs which fluctuate markedly from time to time (12)(11). For certain types of these sources of cash, such as bank loans, there is a generally accepted definition of the cost of funds obtained. For other sources, such as funds generated by operations, there is less agreement (11).

The cost of capital of a firm may be defined as a weighted average of the cost of each type of capital. The weight for each type of capital is the ratio of the market value of the securities representing that source of capital to the market value of all securities issued by the company. (The term security includes all common and preferred stocks and all interest-bearing liabilities, including notes payable)(11).

The opportunity cost of money is the best return which can be obtained, with comparable risks, by investing the firm's available funds either internally or externally (12). A firm would not usually invest money in a project that has a lower NPV than other projects except for extreme necessity or emergency or politics.

The minimum rate of return, i, however calculated, has no effect on the ranking of projects so long as the same i is applied to all projects. The minimum rate of return only affects the NPV sums which are used to rank the projects (10).

DISCOUNTED CASH FLOW RATE OF RETURN (DCFROR)

Discounted Cash Flow Rate of Return (DCFROR) is the rate of return that equates the present value of negative cash flows with the present value of positive cash flows, i.e., it is the discount rate, i, that produces a zero present value. Using this technique the investment alternative with the highest rate of return is preferred on the basis of expected profitability. The rate of return, i, must usually be determined by the trial and error method (10)(11)(13).

The major merit of DCFROR is the ability to reduce a stream of cash flows down to a single measure that can be used to compare the expected profitabilities of investment alternatives. It is considered the truest measure of profitability (10)(13).

The main deficiency of DCFROR is that the alternatives being evaluated must have equal evaluation lives. Also, it is an implicit assumption that the returns generated can be reinvested in opportunities offering a comparable rate of return. This can be a valid assumption in many investment situations but for those companies engaged in relatively specialized projects, the rate of return for individual investments may be highly variable. In addition, the magnitude of the projects is not indicated. Large or small investments give large or small DCFROR's (10).

PAYBACK PERIOD

Payback period is simply the time required for a project to generate sufficient revenues above the operating expenses, to equal (payback) the original investment (14). On the surface it seems that the shorter the payback period, the more attractive the project.

Payback is very simple to calculate. It also gives a quick indication of go, no-go projects based on the financial situation of the company. In small enterprises it is common to use some variant of the payout (or payback) period as the primary criterion to compare the merits of proposed investments, particularly when the comparisons are made at the level of capital budgeting (15). Also, if companies are operating in politically and/or economically unstable environments, they may want to look at only those projects with short payback periods. The reciprocal of the payback period, 1/years, can be quickly interpreted as a crude measure of the average rate of return on original investments, assuming no salvage value (16).

The main deficiency of payback period is that it only considers part of project life. Project life beyond the payback period is neglected. It also fails to take into account the differences in the rate at which the investment is returned over the payback period. It partially neglects the time value of money, and its effect on the cash flows and the timing of investments and returns. By itself Payback cannot be used to economically rank projects (10)(13)(14)(15)(16).

> "Except for the special case where funds are so limited that no outlay can be made unless money can be recovered in an extremely short time, the payout period is never an appropriate way to compare a group of proposed investments. The objection is that the payout period fails to give weight to the difference in consequences of different investment proposals after the date of payout."
>
> "Sometimes the payout technique is combined with the stipulation that no proposal will be accepted unless it has an extremely short payout period, such as one or two years. Such a stipulation, if rigidly adhered to, tends to block approval of projects that would earn excellent returns" (15, p. 521).

COMPUTATIONAL RESULTS

Economic evaluations were run on Scenarios 2, 3, and 4 to see which was the best alternative to the present situation. Three decision parameters were calculated for Scenarios 3 and 4. They are:

1. Discounted Cash Flow Rate of Return(DCFROR).
2. Net Present Value (NPV)
3. Payback Period

For Scenario 2 a Present Worth calculation of the lost cash flows was made since no equipment costs are incurred in this scenario. For Scenario 5, the breakeven production which gave a DCFROR greater than 15% and a positive NPV was determined. Scenario 6 determined the minimum price differential which gave a DCFROR greater than 15% and a positive NPV.

Discounted Cash Flow Rate of Return and Net Present Value were chosen because they are the two evaluation methods most widely used today for mutually exclusive projects. Payback Period was used because it is one of the main project selection criteria used by Mapco (5), in spite of its inherent weaknesses. No other methods can give us any more or better ranking criteria than these three. Table 1 summarizes the computational results.

Several assumptions and forecasts had to be made before any evaluations could be run. A rate or return of 15% was used as the minimum ROR for Mapco projects. Forecasts for Pontiki stoker coal start at 75,000 tpy, go to 90,000 tpy in 1982 and escalate at 15,000 tpy until 1989 when sales are expected to be 210,000 tpy (3). This is a revised forecast from the original one in which stoker coal sales only escalated at 10,000 tpy in 1992. Scenario 3a evaluates the original forecast.

It was decided to leave the steam-stoker price differential constant at $3/ton. This was done because this price differential is very demand-related and it is not possible to accurately forecast any changes in it in the future (5).

Maintenance costs for the belts and screens were estimated at $500/year each. Screen panels have to be replaced every 2 to 3 months at a cost of $225/panel, with four panels needed each time (1). For cost projections, screens were replaced every 3 months at a cost of $900 ($3,600/year). Maintenance on the switch engine was estimated at $700 in year one, $1,500/year in years 2 to 4, and $2,500/year thereafter. Depreciation figures were based on a 20 year, straight-line basis. Accelerated depreciation was not used in order to minimize the effects of depreciation.

Two variations of Scenario 3 were evaluated. Scenario 3a uses the original forecast of 10,000 tpy sales increment and a 12 year life. Scenario 3b uses the same forecast but only a 9 year life in order to compare Scenario 3 with the original forecast to Scenario 4 with the revised forecast, both with 9 year lives.

Scenario 5 was run to determine the minimum level of sales needed, using Scenario 3's equipment requirements and a 15,000 tpy sales increment, to make Scenario 3 feasible. Scenario 6 was run to determine the minimum price differential needed to make Scenario 3 feasible.

In addition to running Scenarios 3 - 6 at a 15% minimum ROR, runs were made on Scenarios 3, 3a, 3b, and 4 at 12% and 20%. This was done to bracket a wide range in which the ROR might vary in the future.

The results (see Appendix 1) clearly show that Scenario 3 (screen, belts, silo) is the only feasible course of action. The DCFROR is 20.77% (greater than the minimum 15%), the NPV (at 15%) is $217,986 and the Payback Period is 4.43 years. Compared to this Scenario 4 (screen, belts, track, engine, employees) has a DCFROR of only 13.64%, an NPV (at 15%) of -$48,523 and a Payback Period of 5.61 years. For Scenario 4 to have a positive NPV, the minimum ROR would have to be between 13 - 14% (see ROR/NPV Summary, Scenario 4 printout). This scenario with its present cost/income stream will never have a DCFROR greater than Mapco's minimum 15%.

Scenario 3a was run using the original sales escalation of 10,000 tpy up to 200,000 tpy at 12%, 15%, and 20% minimum ROR. In the 12 years it takes this scenario to reach maximum production, the DCFROR increases to 22.25%, the NPV (at 15%) increases to $334,659 and Payback Period increases slightly to 4.59 years. The reason for the increases in DCFROR and NPV is the additional revenue generated in years 10 - 12. Scenario 3 reaches maximum production in only 9 years while Scenario 3a takes 12 years. Scenario 3a shows that if sales only escalate at 10,000 tpy instead of the predicted 15,000 tpy, the project is still feasible.

Scenario 3b was run to compare the original sales increment but only a 9 year life in order to compare equal lives with Scenario 4. Even with the original sales increment and only a 9 year life the DCFROR is 18.62%, NPV (at 15%) is $130,523, and Payback Period is 4.59 years. This is still a feasible scenario and is also more favorable than Scenario 4.

Several runs were made to determine what the minimum stoker sales would have to be, assuming a 10,000 tpy sales increment, to still make Scenario 3 feasible. This minimum level was determined to be 110,000 tpy by 1983, remaining constant the last 6 years. The DCFROR is 15.21%, NPV (at 15%) is $ 9,453, and Payback Period is 4.77 years.

Other runs were made to determine the minimum price differential needed to make Scenario 3 feasible. This was done using the forecasted sales increment of 15,000 tpy for 9 years. The lowest the price differential between steam and stoker coal could drop to is approximately $2.40/ton. At this price, the DCFROR is 15.87%, NPV (at 15%) is $35,171, and Payback Period is 5.12 years.

A warning is in order. The sales forecast received from Mapco marketing only covered 9 years (1981-1989)(3), at which time stoker sales are expected to have reached their maximum (210,000 tpy). For a reduced sales forecast (10,000 tpy increment, 12 year life) Scenario 3a was run. By producing less, longer both the DCFROR and NPV were greatly increased. The DCFROR and NPV are both greatly affected by evaluation life and only NPV can be used to compare scenarios of uneven lives.

TABLE 1

SCENARIO	DESCRIPTION	YEAR 1 OPERATING COSTS	TOTAL INITIAL INVESTMENT	i	DCFROR	NPV	PAYBACK	PRESENT WORTH	BENEFIT/COST RATIO (initial invest/ NPV)
2	sell steam coal only	-----	----------	15%	------	---	-------	$-486,668	
3	screen, belts, silo, 15,000 tpy incr, 9-year life	$4,600	$849,600		20.77%		4.43		
3-1	"			12%		$363,514		---------	.428
3-2	"			15%		$217,986		---------	.257
3-3	"			20%		$ 27,746		---------	.033
3-a	screen, belts, silo, 10,000 tpy incr, 12-year life	$4,600	$849,600		22.25%		4.59		
3-a-1	"			12%		$531,826		---------	.626
3-a-2	"			15%		$334,659		---------	.394
3-a-3	"			20%		$ 89,410		---------	.105
3-b	screen, belts, silo, 10,000 tpy incr, 9-year life	$4,600	$849,600		18.62%		4.59		
3-b-1	"			12%		$259,209		---------	.305
3-b-2	"			15%		$130,523		---------	.154
3-b-3	"			20%		$-38,454		---------	.---
4	screen, belts, track, engine, employees, 15,000 tpy incr, 9-year life	$82,280	$911,756		13.64%		5.61		
4-1	"			12%		$ 73,049		---------	.080
4-2	"			15%		$ -48,523		---------	.---
4-3	"			20%		$-406,907		---------	.---
5	screen, belts, silo, breakeven production	$4,600	$849,600	15%	15.21%	$ 9,453	4.77	---------	.011
6	screen, belts, silo, breakeven price differential ($.240/ton)	$4,600	$849,600	15%	15.87%	$ 35,171	5.21	---------	.041

STOKER COAL MARKET STUDY

In an effort to determine whether the Mapco stoker coal forecasts were realistic a stoker coal market study was conducted. Stoker coal data is virtually unobtainable and a stoker coal classfication cannot be found in the literature. The closest classification in the histroical data was Retail Deliveries in the Bureau of Mines Minerals Yearbook (21). An assumption was made that the major portion of Retail Deliveries is stoker coal and the historical data from this category were used in the forecasting model below.

The Department of Energy was contacted to see if they had any forecasts for stoker coal but since stoker is such a small part of the market they had no forecasts. The National Coal Association had forecasts for Commercial and Retail Consumption for 1985 and 1990 (see Table 5) (20). This category encompasses more than stoker coal but was used to check the relative change between 1985 and 1990 in Total Retail Deliveries in the forecasting model developed below.

A literature review gives some insights into the direction that stoker coal may go. Historically demand for stoker and commercial coal has steadily declined (see Figures 3 and 4). Between 1965 and 1976 total demand in this sector declined at an average annual reate of nearly 6.5% - deliveries of coal were more than halved (17).

This decline has largely been the result of a shift by manufacturers to oil and natural gas as the primary fuel in industrial boilers. These fuels are cleaner and more conveniently used. Relatively inexpensive oil and gas-fired boilers became available about 1960 accelerating this shift (see Figures 3 and 4). These boilers were much smaller, required a minimum of know-how and attention and could be installed for 25% of the cost of a coal-fired unit (17).

With deregulation of oil the price is now around $36/bbl ($6/million Btu) which make oil much more expensive than coal. Coal can now be landed in Rotterdam for $75/ton ($3.26/million Btu, assuming 11,500 Btu/lb. coal) from the eastern coal fields. At this price stoker coal is very competitive along the eastern seaboard where demand for stoker would be the greatest (18).

An upswing in stoker and boiler coal is expected in the not too distant future. A dampening of this upswing may be caused by the recent change in the natural gas well drilling seccess ratio (number of discoveries ÷ number of wells drilled). In the past it was between 1:8 and 1:15 but just recently, especially in Virginia and West Virginia it has risen to 1:2 and sometimes higher. Approximately 5,000 are expected to be drilled in this area in 1981.

A large surge in the natural gas supply, whether the price is regulated or not, will more than likely forestall conversion to coal (18).

A study done by the Office of Technology Assessment (OTA), U. S. Congress (19), foresees a tripling of coal production and use by the year 2000 but only if coal offers a large cost advantage. Many people still prefer oil and natural gas as long as they are available because of their greater convenience and lower capital investment requirements. The study goes on to say that even if demand does triple, several supply constraints could still interfere with achieving a tripling of coal supply. These include upgrading and expanding mine-to-market transportation systems, escalating of conflicts between labor and management and environmental regulations. In addition, the study speculates that no significant increase in Eastern coal (all types) production is anticipated before 1985, although substantial production gains should occur thereafter (19).

In the residential and commercial markets recent concerns over the price and availability of oil and gas have sparked a flurry of inquiries, though not yet substantial orders, to manufacturers of coal-fired equipment. Although improvements in equipment, such as automatic stokers, and improvements in combustion technology could increase residential use of coal. The various energy scenarios developed in the OTA study do not anticipate much growth (19).

The National Coal Association forecasted a rise in industrial and retail coal use through 1990 (see Table 5) (20). As stated before, this category includes more than just stoker coal and was used as a check for the forecasting model because it was the closest category to stoker coal.

Historically data on total and Kentucky retail deliveries from 1960 to 1980 (21)(22) were used to develop a forecasting model. The SIBYL/RUNNER interactive forecasting package of Makridakis and Wheelwright (23) was used to prepare a forecast based on historical data. The plots of the original data show a pronounced decline in retail deliveries (see Figures 3 and 4)..

A linear exponential smoothing method (23) was found to best fit the data of both total and Kentucky retail deliveries (see Table 2 and 3) and was used to forecast both categories (see Table 4). The forecast for total retail sales shows a definite increase between 1981 and 1990. A comparison of the relative change from 1985 to 1990 of this forecast and the National Coal Association's most likely forecasts for the same years shows very similar results (1.481 vs. 1.495) (see Tables 4 and 5). The model checks quite closely with the only available forecast.

The forecast for Kentucky retail sales shows a continuing decline from 1981 to 1989 down to almost zero. If the forecast continued it would indicate that stoker coal would have to be imported into Kentucky. This forecast is strongly suspect but is based on the only available data. However, qualitative projections based on rising oil and gas prices (18) and the Office of Technology Assessment's study (19) suggest a near-future upswing in the stoker market.

All the data and literature available indicate that the stoker market will show an increase in demand in the future but not a large surge. This brief market study suggests that Scenarios 3 and 4, based on Mapco's anticipated tripling of stoker coal sales in the next 10 years, may be invalid. Scenario 1 may be the correct choice instead.

TABLE 2
TOTAL RETAIL DELIVERIES
ACTUAL VS FORECAST
1960-1980

(TONSX10^4)

YEAR	ACTUAL	FORECAST	ERROR	% ERROR
1960	3040.50			
1961	2773.50	2652.95	120.55	4.35%
1962	2862.90	2736.12	126.78	4.43%
1963	2354.80	2793.90	-439.10	-18.65%
1964	2291.10	2247.77	43.33	1.89%
1965	2282.70	2108.95	173.76	7.61%
1966	2066.40	2132.88	-66.48	-3.22%
1967	1878.90	1939.40	-60.50	-3.22%
1968	1767.60	1731.14	36.46	2.06%
1969	1562.80	1613.76	-50.96	-3.26%
1970	1478.20	1408.56	69.64	4.71%
1971	1114.40	1324.29	-209.89	-18.83%
1972	953.00	943.98	9.02	0.95%
1973	801.50	745.04	56.46	7.04%
1974	679.20	603.11	76.09	11.20%
1975	504.30	501.90	2.40	0.48%
1976	413.70	341.41	72.29	17.47%
1977	226.40	261.37	-34.97	-15.45%
1978	163.90	82.54	81.36	49.64%
1979	180.40	24.97	155.43	86.16%
1980	584.50	78.27	506.23	86.61%

MEAN SQUARED ERROR (MSE) = 30947.8
MEAN ABSOLUTE PC ERROR (MAPE) = 17.4%
MEAN PC ERROR (MPE) OR BIAS = 11.10%

TABLE 3
KENTUCKY RETAIL DELIVERIES
ACTUAL VS FORECASTED
1960-1980

(TONS X 1000)

YEAR	ACTUAL	FORECAST	ERROR	% ERROR
1960	699.00			
1961	831.00	840.50	-9.50	-1.14%
1962	644.00	767.64	-123.64	-19.20%
1963	795.00	712.27	82.73	10.41%
1964	645.00	755.85	-110.85	-17.19%
1965	520.00	704.37	-184.37	-35.46%
1966	552.00	607.16	-55.16	-9.99%
1967	498.00	564.68	-66.68	-13.39%
1968	560.00	512.48	47.52	8.49%
1969	540.00	515.15	24.85	4.60%
1970	602.00	509.25	92.75	15.41%
1971	341.00	540.34	-199.34	-58.46%
1972	319.00	425.81	-106.81	-33.48%
1973	314.00	345.92	-31.92	-10.17%
1974	267.00	297.75	-30.75	-11.52%
1975	187.00	248.03	-61.03	-32.64%
1976	169.00	180.49	-11.49	-6.80%
1977	330.00	134.58	195.42	59.22%
1978	191.00	195.49	-4.49	-2.35%
1979	316.00	165.66	150.34	47.58%
1980	164.00	216.03	-52.03	-31.73%

MEAN SQUARED ERROR (MSE) = 10397.6
MEAN ABSOLUTE PC ERROR (MAPE) = 21.5%
MEAN PC ERROR (MPE) OR BIAS = -6.89%

TABLE 4
FORECASTS OF RETAIL DELIVERIES

YEAR	TOTAL (TONS X 10^3)	KENTUCKY (TONS X 10^3)
1981	5819.8	171.34
1982	6730.7	150.18
1983	7641.5	129.03
1984	8552.3	107.87
1985	9463.2	86.71
1986	10374.0	65.56
1987	11284.8	44.40
1988	12105.7	23.24
1989	13106.5	2.09
1990	14017.4	

Relative change (1990÷1985)

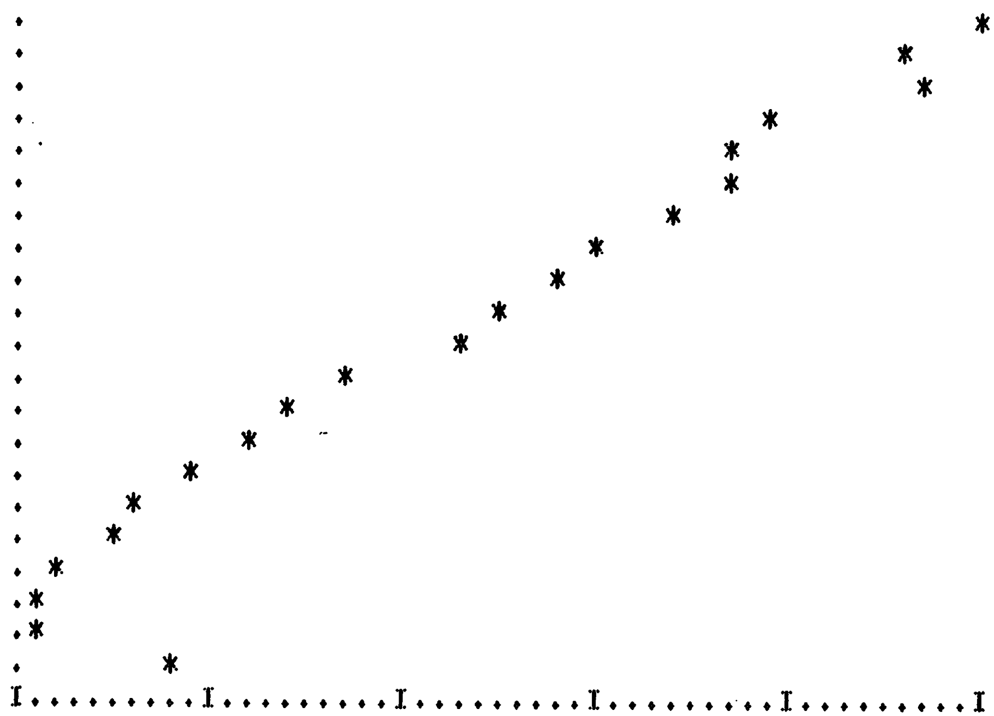
TABLE 5
NATIONAL COAL ASSOCIATION
FORECAST OF INDUSTRIAL AND RETAIL DEMAND
1985 and 1990

(TONS X 10^6)

	LOW	MOST LIKELY	HIGH
1985	87	107	120
1990	113	160	196
Relative Change (1990 ÷ 1985)	1.299	1.495	1.633

FIGURE 3
TOTAL RETAIL DELIVERIES
PLOT OF DATA
1960-1980

(TONS X 10^4)

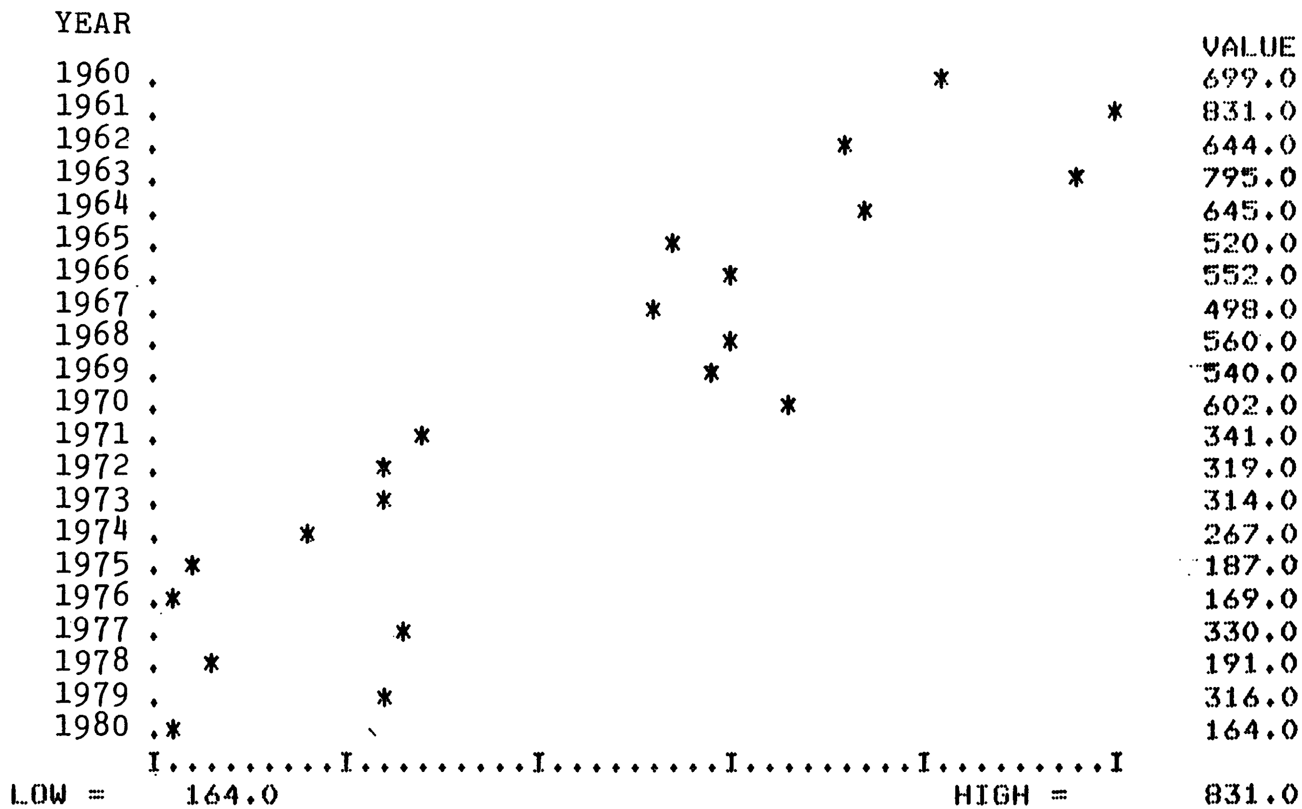


YEAR	VALUE
1960	3040.5
1961	2773.5
1962	2862.9
1963	2354.8
1964	2291.1
1965	2282.7
1966	2066.4
1967	1878.9
1968	1767.6
1969	1562.8
1970	1478.2
1971	1114.4
1972	953.0
1973	801.5
1974	679.2
1975	504.3
1976	413.7
1977	226.4
1978	163.9
1979	180.4
1980	584.5

LOW = 163.9 HIGH = 3040.5

FIGURE 4
KENTUCK RETAIL DELIVERIES
PLOT OF DATA
1960-1980

(TONS X 1000)



CONCLUSIONS

It is clear that Scenario 3 (screen, belts, and silo) is the best alternative for the Pontiki to take if it wants to make a clean stoker product. This scenario is economic anytime the price differential between steam and stoker coal is $2.40/ton or greater. This naturally assumes that Pontiki stoker coal sales do, in fact, reach or surpass Mapco's forecasted figures.

APPENDIX A

Installation Cost - Scenario 3 and 4

SCENARIO 3 INSTALLATION COSTS

*3,000 ton storage bin		$300,000
*Conveyor belts (2)		
Transfer point to new storage bin	(1,140')	
Storage bin to load out tipple	(200')	
	1,340'	
	@ $270.25/ft.	362,675
*Coal Screen		169,675
Engineering work, changing motors, surveying, calculations		17,250
Total Installation Costs		$849,600

YEARLY COSTS

Screen Panels	$ 3,600
Screen Maintenance	500
Belt Maintenance	500

*Depreciable costs = $832,350

20 year, straight line = $41,418/year

SCENARIO 4 INSTALLATION COSTS

*Coal Screen	$169,675
*Side track, switches, etc.@ $54/ft.	22,540
*Rebuild switch engine	224,250
10% spare parts	22,425
Freight	6,000
Subgrade, earthwork, shoot and haul 1,500 cu. yds. @ $11.50/cu.yd.	17,250
Engineering work, changing motors, surveying, calculations	17,250
*Electrical lines, controls, starter changes	57,500
Concrete	23,000
*Conveyor belt (1) Transfer point to load out tipple (1,302') @ $270.25/ft.	351,866
Total Installation Costs	$911,756

YEARLY COSTS

New Employees (2, 1/shift) Salary and benefits	$ 77,880
Engine Maintenance	
Year 1	700
Years 2 - 4 (each year)	1,500
Years 5 - 9 (each year)	2,500
Screen Panels	3,600
Screen Maintenance	500
Belt Maintenance	500

*Depreciable costs = $825,831

20 year, straight line = $41,292/year

APPENDIX B

Cash Flow Calculations
and
Time Diagrams
and
Sample Calculations

SCENARIO - 2

Cash Flow Calculations

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989
Sales (TPY)	75,000	100,000	115,000	130,000	145,000	160,000	175,000	190,000	210,000
Incremental Income ($1.50/ton)	$112,500	$150,000	$172,500	$195,000	$217,500	$240,000	$262,500	$285,000	$315,000
-Royalities (6.5%)	- 7,313	- 9,750	- 11,213	- 12,675	- 14,138	- 15,600	- 17,063	- 18,525	- 20,475
-Severance Tax (4.5%)	- 5,063	- 6,750	- 7,763	- 8,775	- 9,788	- 10,800	- 11,813	- 12,825	- 14,175
-Depreciation (St. line-20 yr)									
Taxable Income Before Depletion	$100,124	$133,500	$153,524	$173,550	$193,574	$213,600	$233,624	$253,650	$280,350
-10% Depletion (.1x(Income-Royalty)	- 10,519	- 14,025	- 16,129	- 18,233	- 20,336	- 22,440	- 24,544	- 26,648	- 29,453
Taxable Income	$ 89,605	$119,475	$137,395	$155,317	$173,238	$191,160	$209,080	$227,002	$250,897
-Tax (46%)	- 41,218	- 54,960	- 63,202	- 71,446	- 79,689	- 87,934	- 96,177	-104,421	-115,413
Net Profit	$ 48,387	$ 64,515	$ 74,193	$ 83,871	$ 93,549	$103,226	$112,903	$122,581	$135,484
+ Depletion	10,519	14,025	16,129	18,233	20,336	22,440	24,544	26,648	29,452
+ Investment Tax Credit (10%)									
NET CASH FLOW	$ 58,906	$ 78,540	$ 90,322	$102,104	$113,885	$125,666	$137,447	$149,229	$164,936

SCENARIO - 3

Cash Flow Calculations
(15,000 TPY Sales Increment)

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989
Sales (TPY)	75,000	100,000	115,000	130,000	145,000	160,000	175,000	190,000	210,000
Incremental Income ($3/ton)	$225,000	$300,000	$345,000	$390,000	$435,000	$480,000	$525,000	$570,000	$630,000
-Royalties (6.5%)	- 14,625	- 19,500	- 22,425	- 25,350	- 28,275	- 31,200	- 34,125	- 37,050	- 40,950
-Severance Tax (4.5%)	- 10,125	- 13,500	- 15,525	- 17,550	- 19,575	- 21,600	- 23,625	- 25,650	- 28,350
-Depreciation (St. line-20 yr)	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618
-Operating Costs	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600
Taxable Income Before Depletion	$154,032	$220,782	$260,832	$300,882	$340,932	$380,982	$421,032	$461,082	$514,482
-10% Depletion (.1x(Income-Royalty))	- 21,037	- 28,050	- 32,256	- 36,465	- 40,672	- 44,880	- 49,987	- 53,295	- 58,905
Taxable Income	$132,995	$192,732	$228,576	$264,417	$300,260	$336,102	$371,945	$407,787	$455,577
-Tax (46%)	- 61,178	- 88,657	-105,145	-121,632	-138,120	-154,607	-171,095	-187,582	-209,565
Net Profit	$ 71,817	$104,075	$123,431	$142,785	$162,140	$181,495	$200,850	$220,205	$246,012
+ Depreciation	41,618	41,618	41,618	41,618	41,618	41,618	41,618	41,618	41,618
+ Depletion	21,037	28,050	32,257	36,465	40,672	44,880	49,087	53,295	58,905
+ Investment Tax Credit (10%)	16,967								
NET CASH FLOW	$151,439	$173,743	$197,306	$220,868	$244,430	$267,993	$291,555	$315,118	$346,535

SCENARIO - 3a

Cash Flow Calculations
(10,000 TPY Sales Increment)

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Sales (TPY)	75,000	100,000	110,000	120,000	130,000	140,000	150,000	160,000	170,000	180,000	190,000	200,000
Incremental Income ($3/ton)	$225,000	$300,000	$330,000	$360,000	$390,000	$420,000	$450,000	$480,000	$510,000	$540,000	$570,000	$600,000
-Royalties (6.5%)	- 14,625	- 19,500	- 21,450	- 23,400	- 25,350	- 27,300	- 29,250	- 31,200	- 33,150	- 35,100	- 37,050	- 39,000
-Severance Tax (4.5%)	- 10,125	- 13,500	- 14,850	- 16,200	- 17,550	- 18,900	- 20,250	- 21,600	- 22,950	- 24,300	- 25,650	- 27,000
-Depreciation (St. line-20 yr)	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618
-Operating Costs	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600
Taxable Income Before Depletion	$154,032	$220,782	$247,482	$274,182	$300,882	$327,582	$354,282	$380,982	$407,682	$434,382	$361,082	$487,782
-10% Depletion (.1x(Income-Royalty))	- 21,038	- 28,050	- 30,855	- 33,660	- 36,465	- 39,270	- 42,075	- 44,880	- 47,685	- 50,490	- 53,295	- 56,100
Taxable Income	$132,995	$192,732	$216,627	$240,522	$264,417	$288,312	$312,207	$336,102	$359,997	$383,892	$407,787	$431,682
-Tax (46%)	- 61,178	- 88,657	- 99,648	-110,640	-121,632	-132,624	-143,615	-154,607	-165,599	-176,590	-187,582	-198,574
Net Profit	$ 71,817	$104,075	$116,979	$129,882	$142,785	$155,688	$168,592	$181,495	$194,398	$207,302	$220,205	$233,108
+ Depreciation	41,618	41,618	41,618	41,618	41,168	41,618	41,618	41,618	41,618	41,618	41,618	41,618
+ Depletion	21,038	28,050	30,855	33,660	36,465	39,270	42,075	44,880	47,685	50,490	53,295	56,100
+ Investment Tax Credit (10%)	16,968											
NET CASH FLOW	$151,439	$173,743	$118,452	$205,160	$220,868	$236,576	$252,285	$267,993	$285,701	$299,410	$315,118	$330,826

SCENARIO - 3b

Cash Flow Calculations
(10,000 TPY Sales Increment)

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989
Sales (TPY)	75,000	100,000	110,000	120,00	130,00	140,000	150,000	160,000	170,000
Incremental Income ($3/ton)	$225,000	$300,000	$330,000	$360,000	$390,000	$420,000	$450,000	$480,000	$510,000
-Royalties (6.5%)	- 14,625	- 19,500	- 21,450	- 23,400	- 25,350	- 27,300	- 29,250	- 31,200	- 33,150
-Severance Tax (4.5%)	- 10,125	- 13,500	- 14,850	- 16,200	- 17,550	- 18,900	- 20,250	- 21,600	- 22,950
-Depreciation (St. line-20 yr)	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618
-Operating Costs	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600
Taxable Income Before Depletion	$154,032	$220,782	$247,482	$274,182	$300,882	$327,582	$354,282	$380,982	$407,682
-10% Depletion (.1x(Income-Royalty))	- 21,037	- 28,050	- 30,855	- 33,660	- 36,465	- 39,270	- 42,075	- 44,880	- 47,685
Taxable Income	$132,995	$192,732	$216,627	$240,552	$264,417	$288,312	$312,207	$336,102	$359,997
-Tax (46%)	- 61,178	- 88,657	- 99,648	-110,654	-121,632	-132,624	-143,615	-154,607	-165,599
Net Profit	$ 71,817	$104,075	$116,979	$129,898	$142,785	$155,688	$168,592	$181,495	$194,398
+ Depreciation	41,618	41,618	41,618	41,618	41,618	41,618	41,618	41,618	41,618
+ Depletion	21,037	28,050	30,855	33,660	36,465	39,270	42,075	44,880	47,685
+ Investment Tax Credit (10%)	16,967								
NET CASH FLOW	$151,439	$173,743	$189,452	$205,176	$220,868	$236,576	$242,285	$267,993	$283,701

SCENARIO - 4

Cash Flow Calculations
(15,000 TPY Sales Increment)

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989
Sales (TPY)	75,000	100,000	115,000	130,000	145,000	160,000	175,000	190,000	210,000
Incremental Income ($3/ton)	$225,000	$300,000	$345,000	$390,000	$435,000	$480,000	$525,000	$570,000	$630,000
-Royalties (6.5%)	- 14,625	- 19,500	- 22,425	- 25,350	- 28,275	- 31,200	- 34,125	- 37,050	- 40,950
-Severance Tax (4.5%)	- 10,125	- 13,500	- 15,525	- 17,550	- 19,575	- 21,600	- 23,625	- 25,650	- 28,350
-Depreciation (St. line-20 yr)	- 41,292	- 41,292	- 41,292	- 41,292	- 41,292	- 41,292	- 41,292	- 41,292	- 41,292
Operating Costs	- 83,180	- 83,980	- 83,980	- 83,980	- 84,980	- 84,980	- 84,980	- 84,980	- 84,980
Taxable Income Before Depletion	$ 75,778	$141,728	$181,778	$221,828	$260,878	$300,928	$340,978	$381,028	$434,428
-10% Depletion (.1x(Income-Royalty))	- 21,037	- 28,050	- 32,257	- 36,465	- 40,672	- 44,880	- 49,087	- 53,295	- 58,905
Taxable Income	$ 54,741	$113,678	$149,521	$185,363	$220,206	$256,048	$291,891	$327,733	$375,523
- Tax (46%)	- 25,181	- 52,292	- 68,780	- 85,267	-101,295	-117,782	-134,270	-150,757	-172,741
Net Profit	$ 29,560	$ 61,386	$ 80,741	$100,096	$118,911	$138,266	$157,621	$176,976	$202,782
+ Depreciation	41,292	41,292	41,292	41,292	41,292	41,292	41,292	41,292	41,292
+ Depletion	21,037	28,050	32,257	36,465	40,674	44,880	49,087	53,295	58,905
+ Investment Tax Credit (10%)	16,967								
NET CASH FLOW	$109,182	$131,054	$154,616	$178,179	$201,203	$224,764	$248,326	$271,889	$303,305

SCENARIO 5

Cash Flow Calculations
Breakeven Production

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989
Sales (TPY)	75,000	100,000	110,000	110,000	110,000	110,000	110,000	110,000	110,000
Incremental Income ($1.50/ton)	$225,000	$300,000	$330,000	$330,000	$330,000	$330,000	$330,000	$330,000	$330,000
-Royalities (6.5%)	- 14,625	- 19,500	- 21,450	- 21,450	- 21,450	- 21,450	- 21,450	- 21,450	- 21,450
-Severance Tax (4.5%)	- 10,125	- 13,500	- 14,850	- 14,850	- 14,850	- 14,850	- 14,850	- 14,850	- 14,850
-Depreciation (st. line-20 yr)	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618
-Operating Costs	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600	- 4,600
Taxable Income Before Depletion	$154,032	$220,782	$247,482	$247,482	$247,482	$247,482	$247,482	$247,482	$247,482
-10% Depletion (.1x(Income-Royalty))	- 21,038	- 28,050	- 30,855	- 30,855	- 30,855	- 30,855	- 30,855	- 30,855	- 30,855
Taxable Income	$132,995	$192,732	$216,627	$216,627	$216,627	$216,627	$216,627	$216,627	$216,627
-Tax (46%)	- 61,180	- 88,657	- 99,648	- 99,648	- 99,648	- 99,648	- 99,648	- 99,648	- 99,648
Net Profit	$ 71,815	$104,075	$116,979	$116,979	$116,979	$116,979	$116,979	$116,979	$116,979
+ Depreciation	41,618	41,618	41,618	41,618	41,618	41,618	41,618	41,618	41,618
+ Depletion	21,038	28,050	30,855	30,885	30,855	30,885	30,855	30,855	30,855
+ Investment Tax Credit (10%)	16,968								
NET CASH FLOW	$151,439	$173,743	$189,452	$189,452	$189,452	$189,452	$189,452	$189,452	$189,452

SCENARIO - 6

Cash Flow Calculations

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989
Sales (TPY)	75,000	100,000	115,000	130,000	145,000	160,000	175,000	190,000	210,000
Incremental Income ($2.40/ton)	$180,000	$240,000	$276,000	$312,000	$348,000	$384,000	$420,000	$456,000	$504,000
-Royalties (6.5%)	- 11,700	- 15,600	- 17,940	- 20,280	- 22,620	- 24,960	- 27,300	- 29,640	- 32,760
-Severance Tax (4.5%	- 8,100	- 10,800	- 12,420	- 14,040	- 15,660	- 17,280	- 18,900	- 20,520	- 22,680
-Depreciation (St. line-20 yr)	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618	- 41,618
Taxable Income Before Depletion	$118,582	$171,982	$204,022	$236,062	$268,102	$330,142	$332,182	$364,222	$406,942
-10% Depletion (.1x(Income-Royalty))	- 16,830	- 22,440	- 25,806	- 29,172	- 32,528	- 35,904	- 39,270	- 42,636	- 47,124
Taxable Income	$101,752	$149,542	$178,216	$206,890	$235,574	$264,238	$292,912	$321,586	$359,818
-Tax (46%)	- 46,806	- 68,789	- 81,979	- 95,169	-108,364	-121,549	-134,740	-147,930	-165,516
Net Profit	$ 54,946	$ 80,753	$ 96,237	$111,721	$127,210	$147,689	$158,172	$173,656	$194,302
+ Depreciation	41,618	41,618	41,618	41,618	41,618	41,618	41,618	41,618	41,618
+ Depletion	16,830	22,440	25,806	29,172	32,528	35,904	39,270	42,636	47,124
+ Investment Tax Credit (10%)	16,968								
NET CASH FLOW	$130,362	$144,811	$163,661	$182,511	$201,356	$220,211	$239,060	$257,910	$282,044

TIME DIAGRAMS

SCENARIO - 2

NET CASH FLOW	-0-	$-58,906	$-78,540	$-90,322	$-102,104	$-113,885	$125,666	$137,447	$149,229	$164,936	$-------	$-------	$-------

SCENARIO - 3

NET CASH FLOW	$-849,600	$151,439	$173,743	$197,306	$ 220,868	$ 244,430	$267,993	$291,555	$315,118	$346,535	$-------	$-------	$-------

SCENARIO - 3a

NET CASH FLOW	$-849,600	$151,439	$173,743	$189,452	$ 205,160	$ 220,868	$236,576	$252,285	$267,993	$283,701	$299,410	$315,118	$330,826

SCENARIO - 3b

NET CASH FLOW	$-849,600	$151,439	$173,743	$189,452	$ 205,160	$ 220,868	$236,576	$252,285	$267,993	$283,701	$-------	$-------	$-------

SCENARIO - 4

NET CASH FLOW	$-911,756	$109,182	$131,054	$154,616	$ 178,179	$ 201,203	$224,764	$248,326	$271,889	$303,305	$-------	$-------	$-------

SCENARIO - 5

NET CASH FLOW	$-849,600	$151,439	$173,743	$189,452	$ 189,452	$ 189,452	$189,452	$189,452	$189,452	$189,452	$-------	$-------	$-------

SCENARIO - 6

NET CASH FLOW	$-849,600	$130,362	$144,811	$163,661	$ 182,511	$ 201,356	$220,211	$239,060	$257,910	$283,044	$-------	$-------	$-------

SAMPLE CALCULATIONS

$(P/F_{i,n})$ is the notation used in these calculations. It comes from Economic Evaluation and Investment Decision Methods by F. J. Stermole (10). The first letter designates what we are calculating, the second letter designates what we are calculating it form, i denotes the period interest rate, and n denotes the number of interest compounding periods (10).

In these calculations, we are calculating a present single sum of money, P from a future single sum of money, F, with a compound interest rate, i, brought back over n periods of time. The actual numbers for these factors can be found in almost any economic evaluation book. The ones in these calculations were taken from Stermole's book (10).

Scenario 2 - Present Worth Calculation @ 15%

$$\begin{aligned} PW &= -58{,}906(P/F_{15,1}) - 78{,}540(P/F_{15,2}) - 90{,}322(P/F_{15,3}) \\ &\quad -102{,}104(P/F_{15,4}) -113{,}885(P/F_{15,5}) -125{,}666(P/F_{15,6}) \\ &\quad -137{,}447(P/F_{15,7}) -149{,}229(P/F_{15,8}) -164{,}936(P/F_{15,9}) \\ &= -58{,}906(.8696) - 78{,}540(.7561) - 90{,}322(.6575) \\ &\quad -102{,}104(.5718) -113{,}885(.4972) -125{,}666(.4323) \\ &\quad -137{,}447(.3759) -149{,}229(.3269) -164{,}936(.2843) \end{aligned}$$

$$PW = -\$486{,}668$$

<u>Scenario 3 - Net Present Value Calculation @ 15%</u>

$$NPV = -849{,}600 + 151{,}439(P/F_{15,1}) + 173{,}743(P/F_{15,2})$$
$$+197{,}306(P/F_{15,3}) + 220{,}868(P/F_{15,4}) + 244{,}430(P/F_{15,5})$$
$$+267{,}993(P/F_{15,6}) + 291{,}555(P/F_{15,7}) + 315{,}118(P/F_{15,8})$$
$$+346{,}535(P/F_{15,9})$$
$$= -849{,}600 + 151{,}439(.8696) + 173{,}743(.7561)$$
$$+197{,}306(.6575) + 220{,}868(.5718) + 244{,}430(.4972)$$
$$+267{,}993(.4323) + 291{,}555(.3759) + 315{,}118(.3269)$$
$$+346{,}535(.2843)$$
$$NPV = \$217{,}986$$

<u>Scenario 3 - DCFROR Calculations</u>

$$\text{PW eq:}\quad 849{,}600 = 151{,}439(P/F_{i,1}) + 173{,}743(P/F_{i,2})$$
$$+197{,}306(P/F_{i,3}) + 220{,}868(P/F_{i,4})$$
$$+244{,}430(P/F_{i,5}) + 267{,}993(P/F_{i,6})$$
$$+291{,}555(p/F_{i,7}) + 315{,}118(P/F_{i,8})$$
$$+346{,}535(P/F_{i,9})$$
$$i = 20.77\%$$

<u>Scenario 3 - Payback Period Calculations</u>

$$Y = -849{,}600 + (1)151{,}439 + (1)173{,}743 + (1)197{,}306$$
$$+(1)220{,}868 + (.43)224{,}430$$
$$Y = 4.43 \text{ years}$$

APPENDIX C

Computer Printouts from DCF1

SCENARIO 3-RUN 1-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-849600.	1	151439.	2	173743.	3	197306.
4	220868.	5	244430.	6	267993.	7	291555.
8	315118.	9	346535.	10	0.	11	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 20.77 *** PERCENT.

THE NET PRESENT VALUE IS $ 363513.610
(USING A MINIMUM ROR OF 12.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 4.43 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	1359387.	40	-376563.
2	1127929.	45	-430879.
4	928837.	50	-475243.
6	756808.	55	-511950.
8	607508.	60	-542695.
10	477386.	65	-568698.
12	363514.	70	-590932.
14	263468.	75	-610110.
16	175233.	80	-626788.
18	97129.	85	-641401.
20	27746.	90	-654294.
25	-114895.	95	-665742.
30	-224037.	100	-675966.
35	-309112.	110	-693429.

SCENARIO 3-RUN 2-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-849600.	1	151439.	2	173743.	3	197306.
4	220868.	5	244430.	6	267992.	7	291555.
8	315118.	9	346535.	10	0.	11	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 20.77 *** PERCENT.

THE NET PRESENT VALUE IS $ 217985.670
(USING A MINIMUM ROR OF 15.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 4.43 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	1359386.	40	-376563.
2	1127928.	45	-430879.
4	928637.	50	-475243.
6	756807.	55	-511951.
8	607507.	60	-542685.
10	477385.	65	-568698.
12	363513.	70	-590932.
14	263467.	75	-610110.
16	175233.	80	-626788.
18	97129.	85	-641401.
20	27746.	90	-654294.
25	-114895.	95	-665742.
30	-224037.	100	-675965.
35	-309112.	110	-693429.

SCENARIO 3-RUN 3-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-849600.	1	151439.	2	173743.	3	197306.
4	220863.	5	244430.	6	267993.	7	291555.
8	315118.	9	346535.	10	0.	11	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN FOR THIS PROJECT IS *** 20.77 *** PERCENT.

THE NET PRESENT VALUE IS $ 27746.052 (USING A MINIMUM ROR OF 20.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 4.43 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	1359387.	40	-376563.
2	1127929.	45	-430879.
4	928837.	50	-475243.
6	756808.	55	-511950.
8	607508.	60	-542685.
10	477386.	65	-568698.
12	363514.	70	-590932.
14	263468.	75	-610110.
16	175233.	80	-626788.
18	97129.	85	-641401.
20	27746.	90	-654294.
25	-114895.	95	-665742.
30	-224037.	100	-675966.
35	-309112.	110	-693429.

SCENARIO 3a-RUN 1-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-849600.	1	151439.	2	173743.	3	189452.
4	205160.	5	220868.	6	236576.	7	252285.
8	267993.	9	285701.	10	299410.	11	315118.
12	330826.	13	0.	14	0.	15	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 22.25 *** PERCENT.

THE NET PRESENT VALUE IS $ 531825.590
(USING A MINIMUM ROR OF 12.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 4.59 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	2078971.	40	-377963.
2	1691379.	45	-435131.
4	1370814.	50	-480868.
6	1103925.	55	-518099.
8	880297.	60	-548875.
10	691751.	65	-574665.
12	531826.	70	-596546.
14	395387.	75	-615311.
16	278330.	80	-631562.
18	177356.	85	-645760.
20	89798.	90	-658261.
25	-83662.	95	-669346.
30	-210237.	100	-679239.
35	-305111.	110	-696133.

SCENARIO 3a-RUN 2-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-849600.	1	151439.	2	173743.	3	189452.
4	205160.	5	220868.	6	236576.	7	252285.
8	267993.	9	285701.	10	299410.	11	315116.
12	330826.	13	0.	14	0.	15	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 22.25 *** PERCENT.

THE NET PRESENT VALUE IS $ 334658.610
(USING A MINIMUM ROR OF 15.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 4.59 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	2078971.	40	-377963.
2	1691379.	45	-435131.
4	1370814.	50	-480868.
6	1103925.	55	-518099.
8	880297.	60	-548875.
10	691751.	65	-574666.
12	531626.	70	-596546.
14	395387.	75	-615311.
16	278330.	80	-631562.
18	177356.	85	-645760.
20	89796.	90	-658261.
25	-83662.	95	-669346.
30	-210237.	100	-679239.
35	-305111.	110	-696133.

SCENARIO 3a-RUN 3-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-849600.	1	151439.	2	173743.	3	189452.
4	205160.	5	220868.	6	236576.	7	252285.
8	267993.	9	283701.	10	299410.	11	315118.
12	330826.	13	0.	14	0.	15	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 22.25 *** PERCENT.

THE NET PRESENT VALUE IS $ 89410.007
(USING A MINIMUM ROR OF 20.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 4.59 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	2076971.	40	-378060.
2	1689706.	45	-435201.
4	1369409.	50	-480920.
6	1102741.	55	-518137.
8	879296.	60	-548904.
10	690902.	65	-574688.
12	531104.	70	-596563.
14	394772.	75	-615324.
16	277804.	80	-631572.
18	176905.	85	-645768.
20	89410.	90	-658267.
25	-83930.	95	-669351.
30	-210425.	100	-679243.
35	-305245.	110	-696135.

SCENARIO 3b-RUN 1-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-849600.	1	151439.	2	173743.	3	189452.
4	205176.	5	220868.	6	236576.	7	252285.
8	267993.	9	283701.	10	0.	11	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 18.62 *** PERCENT.

THE NET PRESENT VALUE IS $ 259208.880
(USING A MINIMUM ROR OF 12.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 4.59 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	1131633.	40	-402024.
2	929808.	45	-451605.
4	755824.	50	-492302.
6	605154.	55	-526136.
8	474099.	60	-554591.
10	359620.	65	-578777.
12	259209.	70	-599533.
14	170789.	75	-617503.
16	92630.	80	-633186.
18	23287.	85	-646972.
20	-38454.	90	-659174.
25	-165875.	95	-670039.
30	-263921.	100	-679769.
35	-340769.	110	-696449.

SCENARIO 3b-RUN 2-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-849600.	1	151439.	2	173743.	3	189452.
4	205176.	5	220868.	6	236576.	7	252285.
8	267993.	9	283701.	10	0.	11	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 18.62 *** PERCENT.

THE NET PRESENT VALUE IS $ 130523.470
(USING A MINIMUM ROR OF 15.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 4.59 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	1131633.	40	-402024.
2	929803.	45	-451605.
4	755824.	50	-492302.
6	605154.	55	-526136.
8	474099.	60	-554591.
10	359620.	65	-578777.
12	259209.	70	-599533.
14	170789.	75	-617503.
16	92630.	80	-633186.
18	23287.	85	-646972.
20	-38454.	90	-659174.
25	-165875.	95	-670039.
30	-263921.	100	-679769.
35	-340769.	110	-696449.

SCENARIO 3b-RUN 3-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-849600.	1	151439.	2	173743.	3	189452.
4	205176.	5	220868.	6	236576.	7	252285.
8	267993.	9	283701.	10	0.	11	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 18.62 *** PERCENT.

THE NET PRESENT VALUE IS $ -38454.085
(USING A MINIMUM ROR OF 20.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 4.59 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	1131633.	40	-402024.
2	929808.	45	-451605.
4	755824.	50	-492302.
6	605154.	55	-526136.
8	474099.	60	-554591.
10	359620.	65	-578777.
12	259209.	70	-599533.
14	170789.	75	-617503.
16	92630.	80	-633186.
18	23287.	85	-646972.
20	-38454.	90	-659174.
25	-165875.	95	-670039.
30	-263921.	100	-679769.
35	-340769.	110	-696449.

SCENARIO 4-RUN 1-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-911756.	1	109182.	2	131054.	3	154616.
4	178179.	5	201203.	6	224764.	7	248326.
8	271889.	9	303305.	10	0.	11	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 13.64 *** PERCENT.

THE NET PRESENT VALUE IS $ 73048.648
(USING A MINIMUM ROR OF 12.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 5.61 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	910762.	40	-540254.
2	715407.	45	-584483.
4	547635.	50	-620453.
6	402900.	55	-650092.
8	277494.	60	-674808.
10	168378.	65	-695646.
12	73049.	70	-713390.
14	-10563.	75	-728640.
16	-84175.	80	-741857.
18	-149223.	85	-753400.
20	-206907.	90	-763552.
25	-325138.	95	-772540.
30	-415199.	100	-780544.
35	-485088.	110	-794163.

SCENARIO 4-RUN 2-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-911756.	1	109182.	2	131054.	3	154616.
4	178179.	5	201203.	6	224764.	7	248326.
8	271889.	9	303305.	10	0.	11	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN FOR THIS PROJECT IS *** 13.64 *** PERCENT.

THE NET PRESENT VALUE IS $ -48523.305
(USING A MINIMUM ROR OF 15.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 5.61 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	910762.	40	-540254.
2	715407.	45	-584483.
4	547635.	50	-620453.
6	402900.	55	-650092.
8	277494.	60	-674808.
10	168378.	65	-695646.
12	73049.	70	-713390.
14	-10563.	75	-728640.
16	-84175.	80	-741857.
18	-149223.	85	-753400.
20	-206907.	90	-763552.
25	-325138.	95	-772540.
30	-415199.	100	-780544.
35	-485038.	110	-794163.

SCENARIO 4-RUN 3-CASH FLOW SUMMARY

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-911756.	1	109182.	2	131054.	3	154616.
4	178179.	5	201203.	6	224764.	7	248326.
8	271889.	9	303305.	10	0.	11	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 13.64 *** PERCENT.

THE NET PRESENT VALUE IS $ -206906.640
(USING A MINIMUM ROR OF 20.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 5.61 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	910762.	40	-540254.
2	715407.	45	-584483.
4	547635.	50	-620453.
6	402900.	55	-650092.
8	277494.	60	-674808.
10	168378.	65	-695646.
12	73049.	70	-713390.
14	-10563.	75	-728640.
16	-84175.	80	-741857.
18	-149223.	85	-753400.
20	-206907.	90	-763552.
25	-325138.	95	-772540.
30	-415199.	100	-780544.
35	-485089.	110	-794163.

SCENARIO 5-BREAKEVEN PRODUCTION

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-849600.	1	151439.	2	173743.	3	189452.
4	189452.	5	189452.	6	189452.	7	189452.
8	189452.	9	189452.	10	0.	11	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 15.21 *** PERCENT.

THE NET PRESENT VALUE IS $ 9453.027
(USING A MINIMUM ROR OF 15.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 4.77 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	801746.	40	-434061.
2	644385.	45	-477142.
4	507964.	50	-512876.
6	389152.	55	-542875.
8	285220.	60	-568336.
10	193919.	65	-590159.
12	113384.	70	-609033.
14	42068.	75	-625489.
16	-21325.	80	-639946.
18	-77880.	85	-652731.
20	-128512.	90	-664109.
25	-233967.	95	-674291.
30	-316180.	100	-683452.
35	-381429.	110	-699251.

SCEN 6-BREAKEVEN PRICE DIFFERENTIAL

CASH FLOW SUMMARY

YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW	YEAR	CASH FLOW
0	-849600.	1	130362.	2	144811.	3	163661.
4	182511.	5	201356.	6	220211.	7	239060.
8	257910.	9	283044.	10	0.	11	0.

THE DISCOUNTED CASH FLOW RATE OF RETURN
FOR THIS PROJECT IS *** 15.87 *** PERCENT.

THE NET PRESENT VALUE IS $ 35171.472
(USING A MINIMUM ROR OF 15.0%)

(REMEMBER, THIS IS IN THOUSANDS OF DOLLARS)

THE PAYBACK PERIOD FOR THIS PROJECT IS 5.12 YEARS.

ROR/NPV SUMMARY

(UNITS SHOWN ARE THOUSANDS OF DOLLARS)

MIN ROR (%)	NPV	MIN ROR (%)	NPV
0	973326.	40	-454910.
2	783221.	45	-499814.
4	619656.	50	-536522.
6	478286.	55	-566920.
8	355560.	60	-592394.
10	248568.	65	-613972.
12	154910.	70	-632430.
14	72599.	75	-648364.
16	-16.	80	-662231.
18	-64314.	85	-674390.
20	-121451.	90	-685126.
25	-238979.	95	-694665.
30	-328980.	100	-703191.
35	-399194.	110	-717766.

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