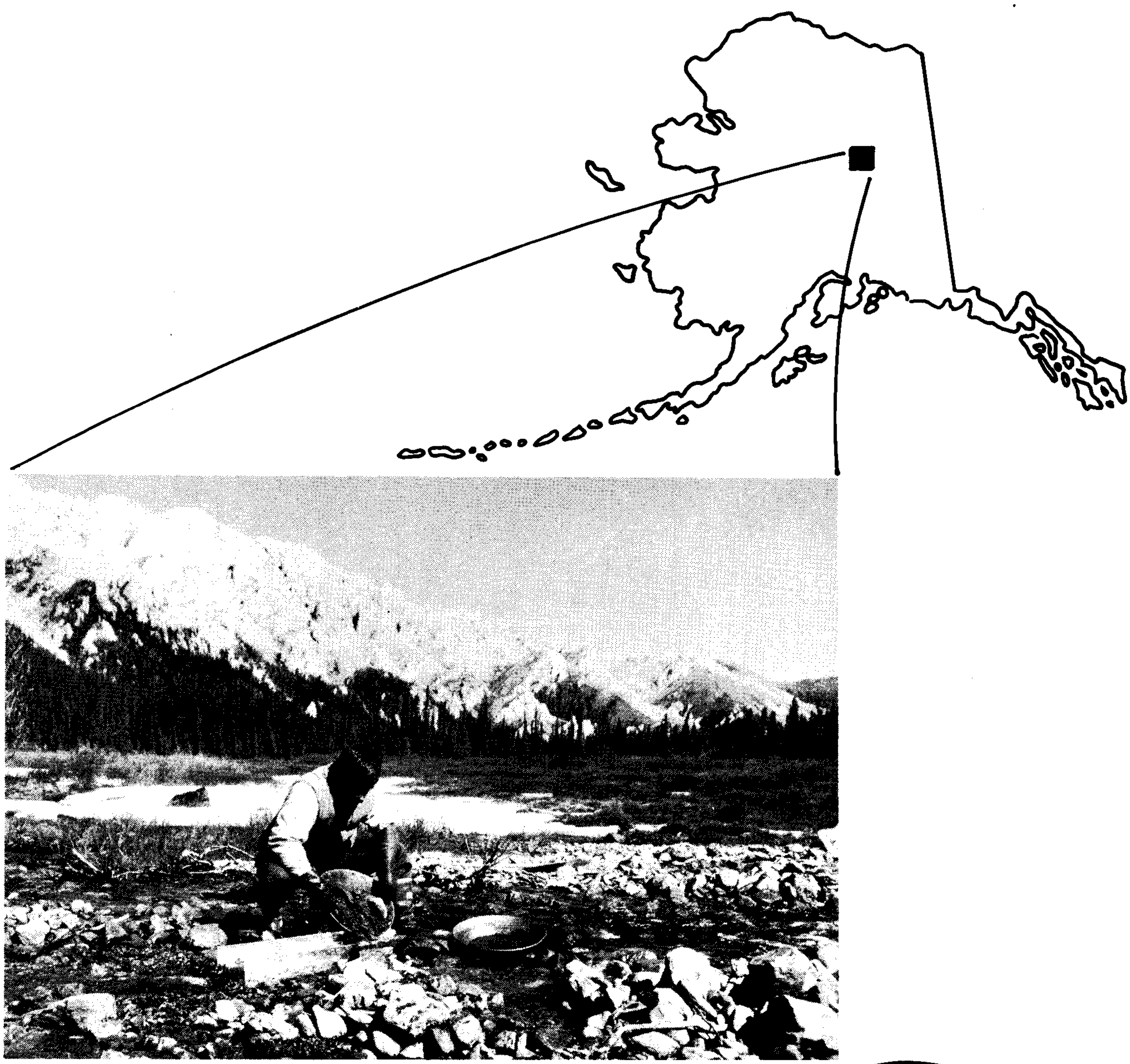
Feasibility Study of Placer Gold Mining in the White Mountains Area, Circle and Tolovana Mining Districts, Alaska

By Micheal D. Balen



UNITED STATES DEPARTMENT OF THE INTERIOR
Donald P. Hodel, Secretary

BUREAU OF MINES
T S Ary, Director

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No patentable features are contained in this report.

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

BCY	bank cubic yard
BCYD	bank cubic yard per day
ft	foot
LCY	loose cubic yard
oz	troy ounce
RGV	recoverable gold value
yd^3	cubic yard
yr	year
%	percent
$	U.S. dollars
°F	degrees Fahrenheit

FEASIBILITY STUDY OF PLACER GOLD MINING IN THE WHITE MOUNTAINS AREA, CIRCLE AND TOLOVANA MINING DISTRICTS, ALASKA

By Michael D. Balen[1/]

ABSTRACT

The Bureau of Mines performed a placer mineral resource assessment and mining feasibility study for the White Mountains Area north of Fairbanks, Alaska, in 1987. The mining feasibility study involved a cost analysis and cash flow determination for three types of placer mine models. The basic mine model design incorporated the use of dozers and loaders for material handling, vibrating screens and sluicing systems for ore processing, and gold saver type equipment for concentrate cleanup. Settling ponds were used in the mine design for effluent treatment.

Data is presented graphically and in the form of third degree polynomial equations which can be used to estimate costs and cash flow for various configurations of ore reserves, mine design, and mining rate.

The C-Type mine, which incorporates the use of mining equipment which is owned outright by the mine operator has the greatest economic viability. The C-Type mine model which is designed to operate at 1000 BCYD (bank cubic yards per day) for 6 years had the lowest breakeven RGV (recoverable gold value) threshold of $\$3.84/yd^3$.

INTRODUCTION

The Bureau of Mines (Bureau) conducted a placer mineral resource assessment of the White Mountains Area in 1986-87. The study was needed to update the Bureau of Land Management's (BLM) "Resource Management Plan/Final Environmental Impact Statement for the White Mountains National Recreation Area and the Steese National Conservation Area (1-2)[2/]. The Bureau's work supplemented the resource assessment of the area conducted jointly by the Alaska Division of Geological and Geophysical Surveys and the U.S. Geological Survey. The Bureau's work consisted of a literature search, a reconnaissance and site specific sampling program, and a mining feasibility study. The results of the literature search and sampling program are presented in a separate report (3). This report presents the results of the mining feasibility study.

The mining feasibility information presented here is preliminary in nature. An order-of-magnitude economic investigation of the feasibility of developing placer deposits in the White Mountains Area can be conducted through the use of this report.

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2/Underlined numbers in parentheses refer to items listed in the references preceding the appendices.

WHITE MOUNTAINS AREA DESCRIPTION

The White Mountains Area is located in central Alaska approximately 35 miles north of Fairbanks (fig. 1). The area is roughly one million acres in size and is comprised of the White Mountains National Recreation Area and the western portion of the Steese National Conservation Area. A drainage divide between Beaver Creek and Preacher Creek runs longitudinally through the eastern region of the area, and serves as the boundary between the Tolovana mining district to the west and the Circle mining district to the east. Approximately 90% of the study area is in the Beaver Creek drainage basin.

The topography of the White Mountains Area ranges from broad rolling hills with 1000 to 1500 feet of relief in the southern portion, to rugged mountains with over 2000 feet of relief in the northern and eastern portions. The higher mountains have been moderately glaciated.

The area has a continental climate with relatively dry, cool summers and dry, cold winters. The frost season lasts for up to 7 months with below freezing temperatures possible from mid August through the end of May. Temperature extremes range from -65 °F in the winter, to +100 °F in the summer. The short frost-free period during the year limits mining activity, hence the mining season used in this feasibility study has been estimated at 100 operating (mining) days per year.

Access to the White Mountains Area is provided by a system of roads, trails, and waterways. The Steese Highway and the Elliot Highway bound the area on the south and west, respectively. At mile 53 Steese Highway, the U.S. Creek Road provides a route into the White Mountains Area. This road terminates at Nome Creek, which is a major tributary to Beaver Creek. Beaver Creek flows throughout most of the area, and provides nonmotorized shallow draft boat access to most tributary drainages. There are numerous winter use trails in the area, and several year round use trails. The most popular trail starts at the Elliot Highway near Wickersham Dome and extends east following the divide between the Chatanika River and Beaver Creek. There are several spurs off this trail that provide overland access to the interior of the area.

MINING FEASIBILITY DATA ANALYSIS

Cost data was generated in the mining feasibility study using the Bureau's "Cost Estimation Handbook for Small Placer Mines" (CEH) (4) computer program. The Bureau's MINSIM mining simulation computer program generated cash flow data from the CEH data.

CEH ANALYSIS

The CEH was used to estimate capital and operating costs for specific types of mining operations. The costs obtained from the CEH analysis are estimates derived from cost estimation equations which were developed for the CEH program. The cost estimation equations are derived from averages of all available data from several sources. The sources are: 1) placer mine operators; 2) mine equipment suppliers; and 3) published cost information services. To account for the added expense of operation due to the remote location of the White Mountains Area, the program escalates the estimated costs with a regional escalation factor (5). The magnitude of the factor is variable and is dependent upon the cost attribute of the

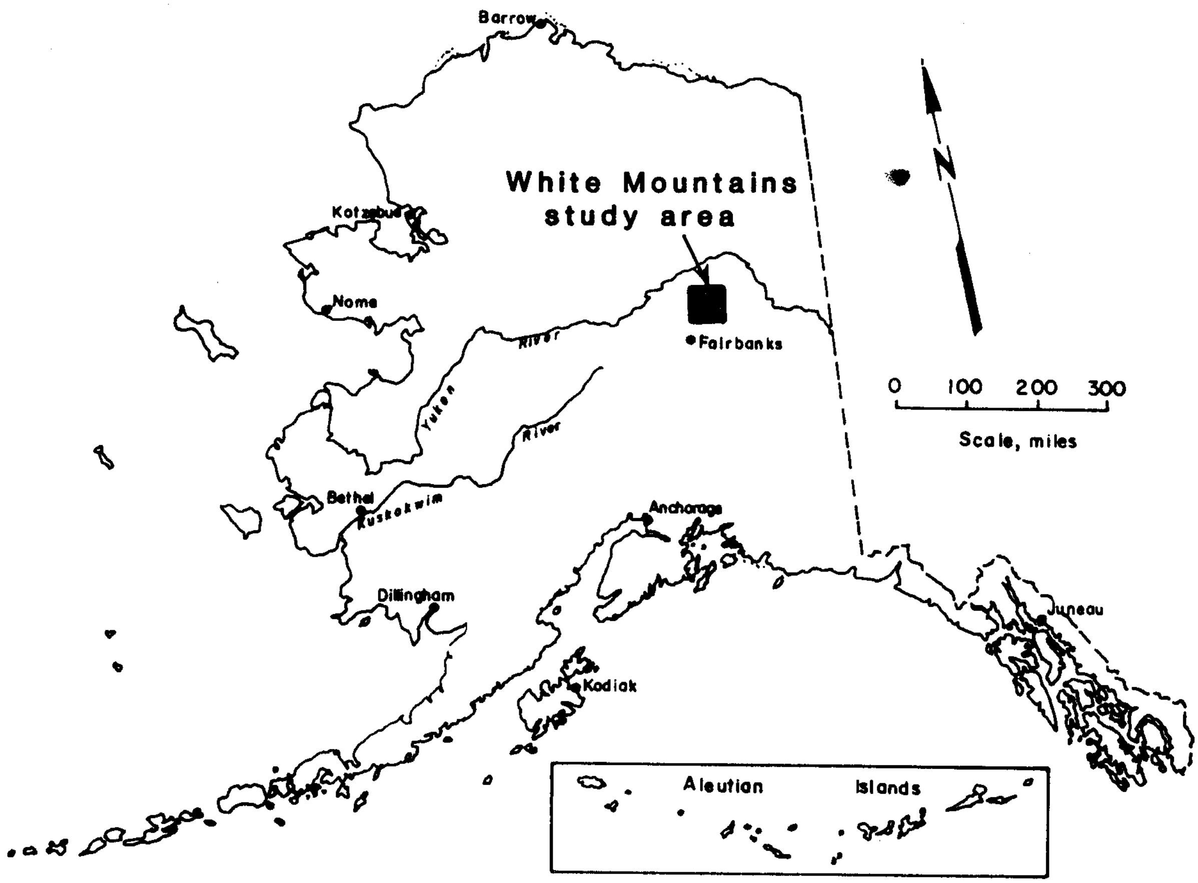


FIGURE 1 -- Location map for the White Mountains Study Area.

mining operation to which it is being applied. All costs used in this report are based on January 1985 U.S. dollars.

In the CEH analysis, capital and operating costs were calculated for three mine type models for the following mining production rates: 100 bank cubic yards per day (BCYD), 300 BCYD, 500 BCYD, and 1000 BCYD. These rates refer to the average amount of ore material fed through the recovery plant each operating day of the operating season. This analysis produced 12 mine type/rate models from the three mine type models. A summary of the data calculated by the CEH for each mine type/rate is listed in appendix A.

MINSIM ANALYSIS

MINSIM is an acronym for mining simulation and is used to evaluate the cash flow and rate of return on investment for a mining model. The MINSIM analysis generated cash flow data for each mine type/rate model for four different production periods. The production periods used are 2, 4, 6, and 10 years of mine life. The production period implies a certain reserve base for each model (which can be determined by multiplying the production rate by the operating days per year by the production period). This analysis produced a total of 48 unique mine type/rate/life models.

The MINSIM program was executed 6 times for each of the 48 mine type/rate/life models, each time incrementing by 5%, a parameter defined as the target discounted cash flow rate of return on investment (DCFROI). Each MINSIM program run calculated a value referred to as the recoverable gold value (RGV). The RGV is calculated through an iterative process by the MINSIM program and is the value that causes the mining simulation to realize the target DCFROI. RGV's were calculated for target DCFROI's of 0, 5, 10, 15, 20, and 25 percent for each of the 48 mine type/rate/life models.

The RGV is defined as the value (U.S. dollars) of placer gold recovered by the mining operation per unit mined ($/LCY). For an operating mine, the RGV can be calculated from the following equation

$$RGV = A \times B \times C \qquad (1)$$

where A = $/unit of commodity
B = ore grade in units of commodity per unit mined (LCY)
C = recovery efficiency of the milling system

For example, if A = $450/oz for gold, B = .9 oz/LCY, and the mill recovery is 80%, then the RGV is calculated as

$$RGV = (\$450/oz) \times (0.9\ oz/yd^3) \times (0.8) = \$324/LCY \qquad (2)$$

Because the MINSIM program calculates the RGV as a function of the target DCFROI, the RGV as defined above and the entire cash flow analysis are insulated from: 1) the changing effects of current selling price of the commodity; 2) in-situ grade of the commodity; and 3) milling efficiency.

When RGV is plotted against the DCFROI, curves can be generated which illustrate the RGV necessary to achieve a specific DCFROI for the mine model in question. From this relationship, data can be derived which explain the relationship of RGV to mining reserves at specific DCFROI rates. RGV versus mining reserve curves are presented in appendix B.

MINE MODEL DESIGN

The three general mine type models which were used with the CEH to generate a data base are referred to as A-Type, B-Type, and C-Type mines. The main varying criteria which differentiate the three types of mines are: 1) distribution of pay within the deposit; and 2) type of mine and mill capital costs necessary to initiate a mining operation. A mine model identified as an A-Type mine requires complete preproduction purchases of all mining and milling equipment, and assumes the ore gravel to exist in the lower third of the host gravel deposit. The B-Type mine is similar to the A-Type mine in that all mine and mill equipment must be purchased prior to initiating a mining operation, but the B-Type mine assumes an ore gravel distribution such that the entire host gravel deposit is considered ore, therefore, no overburden stripping is required. Both the A-Type and the B-Type mine models purchase used equipment in the costing analysis. The C-Type mine is similar to the A-Type mine in ore gravel distribution, but differs from both the A and B-Type mines in that all the mining equipment for the C-Type mine is assumed to be owned by the mine operator. Table 1 lists a summary of the mine types and the variations of mine type attributes associated with each mine.

TABLE 1. - Comparison of mine type and mine type attributes

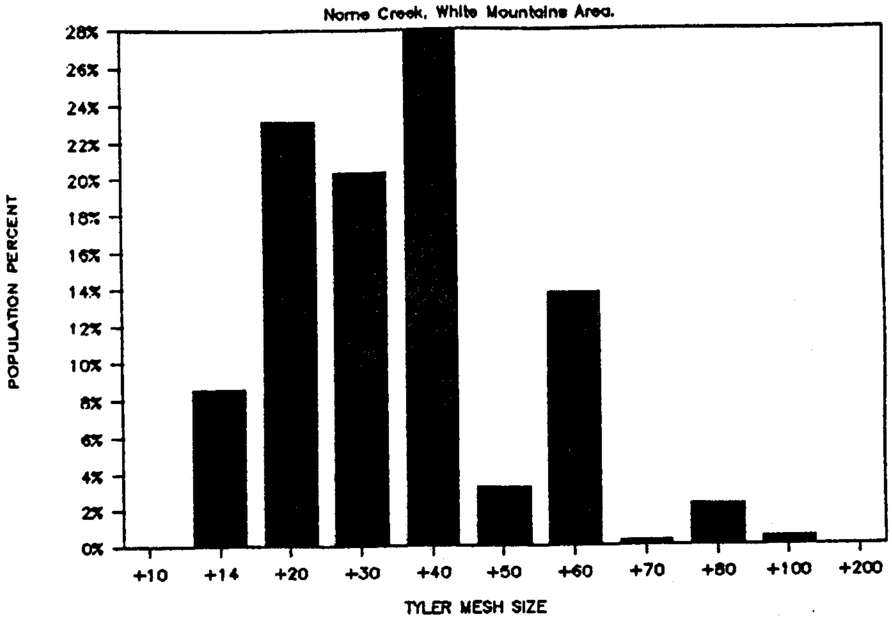
Mine type	Pay gravel distribution	Require capital acquisitions
A..........	In lower third of host gravel deposit.	yes
B..........	Entire gravel deposit thickness.	yes
C..........	In lower third of host gravel deposit.	no

Each mine type/rate design incorporates the use of various sizes of standard pieces of equipment. All mine models have the same basic type of mill equipment. Mill equipment consists of an appropriate sized sluice box, vibrating screens for classification of feed, all the necessary pumps, hoses and plumbing, and a gold saver for sluice concentrates cleanup. The mining equipment used in each model is scaled to the mining rate and specifics of the tenor of a hypothetical deposit. In general, each mine is equipped with a loader for handling feed and/or tailings, and one to two dozers for overburden stripping, pay gravel excavation, and/or tailings disposal. Also considered as mine equipment are diesel-powered generators, housing facilities (including board), and repair and maintenance facilities. Employee salaries and fuel and maintenance costs for equipment and camp operation are included as operating costs. All mines have associated exploration, clearing, and settling pond construction costs. A series of partial recycle settling ponds were incorporated into each mine model to handle mine effluent. The quantity of settling ponds per mine model is dependent upon the mining rate of the model.

For purposes of material volume calculations, a swell factor of 1.3 (30%) was applied to convert bank cubic yards to loose cubic yards.

FIGURE 2. — Gold Size Distribution

Nome Creek, White Mountains Area.



Considering the size distribution of the gold recovered from Nome Creek during the Bureau's sampling program (fig. 2), the mill plant gold recovery rate for all models was estimated at 80% for the feasibility analysis.

PREPRODUCTION ACQUISITION

All mine models except the C-Type mines have associated preproduction acquisition of mining and milling equipment. The acquisition of this equipment occurs in the first year preceding production. There are no land acquisition costs considered by this report due to the preliminary nature of this study, and to the extremely variable legal, logistical, and monetary aspects of acquiring mineable placer ground. Appendix A lists preproduction acquisition costs for each of the twelve mining type/rate models.

PRODUCTION DEVELOPMENT

It has been assumed that all mine development activities will occur during the production period. Additionally, all production development costs will be covered as an operation cost. Production development costs are: 1) costs for exploration (includes sample analysis, exploration equipment lease and operation, camp, man-power, fuel, and maintenance costs; for itemized exploration costs, see appendix C); and 2) production clearing. The production development costs for each mine model are listed in table 2.

MINING EQUIPMENT

The type of mining equipment used in the mine models is dependent upon the size of the mining operation. Generally, all mine models incorporate the use of dozers and loaders for material handling. Material handling equipment was selected for specific tasks at the mine depending on the size, cost, and operating efficiency of the equipment and the material handling requirements of the operation for the particular task in question. In all cases where mining equipment acquisition is required by

TABLE 2. -- Production development costs for placer mines in the White Mountains Area

Mine type	Mine size (BCYD)	Exploration (U.S. $/Yr)	Clearing (U.S. $/Yr)
A.........	100	4,015	10,050
B.........	100	1,704	10,050
C.........	100	4,015	10,050
A.........	300	10,128	24,824
B.........	300	3,725	13,184
C.........	300	10,128	24,824
A.........	500	16,117	40,607
B.........	500	5,746	14,893
C.........	500	16,117	40,607
A.........	1,000	30,641	70,621
B.........	1,000	10,306	31,227
C.........	1,000	30,641	70,621

the mine model, the equipment acquisition cost was minimized in the CEH analysis. All mine models requiring equipment acquisition bought used equipment, and of those mine models, all but one required acquisition of one loader and one dozer. The exception is the model for a 1000 BCYD, A-Type mine, which requires two dozers and one loader. By design, C-Type mine models have no associated equipment acquisition costs. All other costs associated with the various mine models requiring equipment acquisition are similar in nature, and are scaled to the requirements of the mine model in magnitude.

MILLING EQUIPMENT

Ore material from the mining operation is fed through a set of vibrating screens prior to delivery to the sluice box. The screens are fed by an appropriately sized loader. Once classified, the ore is fed to a sluice box designed for the operation. The sluice box was designed with a length to width ratio of 15:1. Tailings from the milling operation are handled either by the loader or the dozer.

SETTLING PONDS

Settling ponds were designed into the mining model to handle mine effluent. The settling pond system is composed of a variable number of ponds, depending on the size of the operation. The size of the ponds was integrated with the quantity of ponds so as to provide sufficient capacity for the life of the operation. The mine design plan calls for occasional cleaning of the settling ponds.

DISCUSSION

The CEH analysis generated capital and operating cost data for the three basic mine type designs. The distribution of this data was modeled with third degree polynomials, and was plotted using non-linear regression techniques. The capital cost data and the regression curves for the A- and B-Type mine models is presented in figure 3. The curves show that the

FIGURE 3.—— Capital Cost Curves

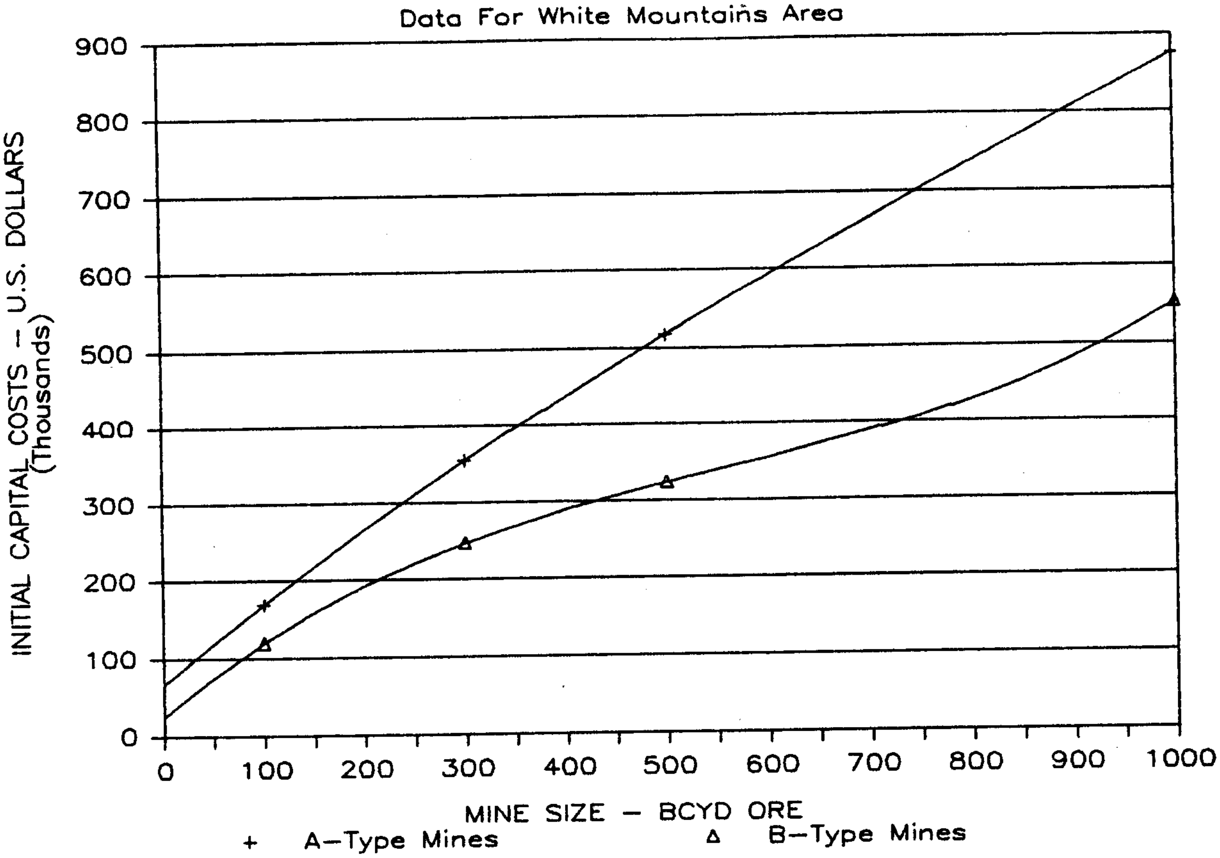
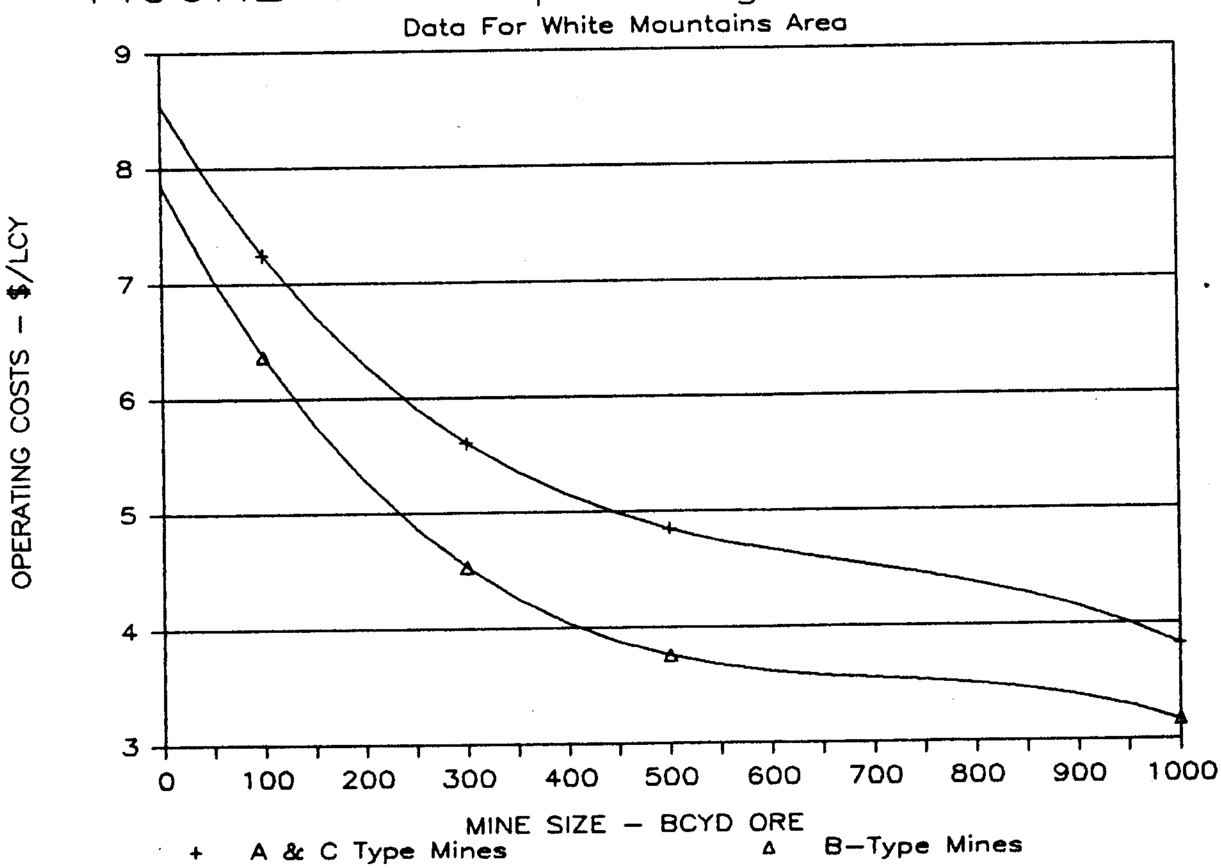


FIGURE 4.—— Operating Cost Curves



B-Type mine has lower associated capital costs than the A-Type mine. As discussed earlier, there are no capital costs for C-Type mine models. The operating cost data and associated regression curves for all mine types are presented in figure 4. These curves show that the A- and C-Type mines have higher operating costs than the B-Type mine models. The polynomial coefficients used for generating the operating and capital cost regression curves are listed in table 3. The coefficients can be used in the following equation to determine either capital or operating costs for a given size mine

$$Y = C1 + (C2 \times M) + (C3 \times M^2) + (C4 \times M^3), \tag{3}$$

where Y = either capital costs or operating costs (U.S. dollars) depending on which coefficients are in use in the equation,

M = mining rate in bank cubic yards of ore washed through the mill per day,

and C1, C2, C3, and C4 = the appropriate coefficients.

The coefficients in table 3 can be used to estimate the capital and operating costs associated with any placer mine with the same design as that presented here, and located in the same economic regime as the White Mountains Area. The curves in figures 3 and 4 represent the regression data superimposed on the base data points which were used to generate the curves.

TABLE 3. - Polynomial coefficients for calculating capital and operating costs for mines in the White Mountains Area

Mine model	Capital cost coefficients			
	C1	C2	C3	C4
A..........	66649.8095	1066.2519	-.4018	1.4531E-4
B..........	24825.6071	1081.5858	-1.3817	8.2785E-4

Mine model	Operating cost coefficients			
	C1	C2	C3	C4
A..........	8.5419	-1.4776E-2	1.9514E-5	-9.4603E-9
B..........	7.8506	-1.6993E-2	2.2936E-5	-1.0623E-8
C..........	8.5419	-1.4776E-2	1.9514E-5	-9.4603E-9

Note - "E" is used above as in, for example -9.4603E-9. This is a form of notation indicating that -9.4603E-9 is raised to the power of -9 as in -9.4603^{-9}.

To use this equation, a basic mining plan must be determined, which must be similar to either the A-, B-, or C-Type mine plan as described earlier. This provides for selection of the correct coefficients from table 3. By determining a mining rate and entering that rate into the equation in place of the "M" term, an estimate of the capital and/or operating costs for the selected mine type and mining rate can be calculated.

RGV VS RESERVES RELATIONSHIP

The MINSIM mining simulation analysis uses the CEH mining cost data to calculate a DCFROI for the mine model under evaluation. One of the most critical input parameters is the estimated value of the metal produced. By allowing the metal value to vary during a simulation, a variety of DCFROI values can be produced. By specifying a DCFROI value as a target, MINSIM attempts to achieve this target through the iterative process of varying the metal value. Determination of the metal value, which in this case is the RGV, is the ultimate product of the mining simulation.

Analysis of the distribution of the RGV data points revealed two relationships of importance. In these relationships, there are three variables which are RGV, DCFROI, and reserves. The relationship of any two variables can be examined by holding the third variable constant. By holding DCFROI constant the relationship of RGV versus reserves can be examined. This relationship is shown on the RGV vs reserves graphs in appendix B. Each graph presented shows two of the curves in the family of curves for the particular mine model. Each graph shows the RGV vs reserves relationship for the 0% and the 25% DCFROI value.

There are an infinite number of curves that could be displayed on these graphs. The 0% and 25% DCFROI values were selected to show the range of values for which a mining operation might be viable with certain levels of reserves. The range of 0% to 25% DCFROI was considered to be within an average range for which a mining venture might become interested in a deposit (0% being an extreme low and 25% not necessarily the extreme high). To facilitate in filling the gaps between the 0% and 25% DCFROI rates, a non-linear regression was performed on the data which was generated for the 48 mine models. For each mine model, an equation was generated which related RGV to reserves for DCFROI rates of 0, 5, 10, 15, 20, and 25 percent. This third degree polynomial regression equation is in the form

$$Y = C1 + (C2 \times R) + (C3 \times R^2) + (C4 \times R^3), \qquad (4)$$

where Y = Recoverable gold value (RGV) in U.S. dollars,
R = Mine reserves in bank cubic yards of ore,
and C1, C2, C3, and C4 are the appropriate coefficients.

To use the equations, select a mine type to evaluate, then select the DCFROI rate of interest. This specifies the correct coefficients for use in the equation. By substituting various values for reserves for "R" in the equation, the RGV necessary to achieve the selected DCFROI is calculated. An interested party can therefore roughly determine reserves, select a mining method, determine a desirable DCFROI, enter the value for reserves into the appropriate equation, and calculate the value of the gold that must be recoverable from the mining operation to achieve the desired DCFROI. The coefficients for the polynomials are listed in appendix D. Each polynomial equation is DCFROI and mine type specific.

It must be emphasized that this equation and this feasibility study are applicable only to the White Mountains Area and surrounding area, to the extent that all economic infrastructure considerations remain constant.

CONCLUSIONS

Of the placer mine models designed for the White Mountains Area, the C-Type mines as presented here are economically more viable than the A- and B-Type mines. The C-Type mine has greater economic viability due to the mine operators ownership of the mining equipment. The MINSIM analysis revealed that the 1000 BCYD C-Type mine model which operates for six years or more, could just break-even (zero percent DCFROI) with an RGV of $\$3.84/yd^3$. This is the lowest break-even RGV for any of the mine models. Therefore, it can be concluded that any deposit in the White Mountains Area must have at least $\$3.84/yd^3$ recoverable gold to be considered a potentially mineable deposit using the mining methods as presented in this report.

The least economically viable mine design is the A-Type mine which operates for two years at 100 BCYD. This mine is expensive because of the relatively high capital and operating costs. The minimum break-even RGV for this mine is $\$16.40/yd^3$.

The B-Type mine was in general, more viable than the A-Type mine, but less viable than the C-Type mine when comparing similarly sized mines. The B-Type mines' intermediate economic position is due to the stripping ratio considered by the mine model. Overburden stripping is not considered in the mining plan for the B-Type mine, hence the operating cost for the B-Type mine is lower than the operating cost for either the A-Type or the C-Type mine. Additionally, a reduced capital expense is realized by the B-Type mine relative to the A-Type mine because the model does not require acquisition of overburden handling equipment. This is the major factor which contributes to the intermediate economic position of the model.

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APPENDICES

APPENDIX A

DETAILED COST DATA

Type-A mine Mine size - 100 BCYD

Catagory	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$144,044.00 /yr	1988	1988
Mill equipment	$25,358.00 /yr	1988	1988
Working capital	$56,550.00 /yr	1988	1988
Mine op. cost	$5.99 /LCY	1988	All op yrs
Mill op. cost	$1.26 /LCY	1988	All op yrs

Type-B mine Mine size - 100 BCYD

Category	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$94,637.00 /yr	1988	1988
Mill equipment	$25,358.00 /yr	1988	1988
Working capital	$49,686.00 /yr	1988	1988
Mine op. cost	$5.11 /LCY	1988	All op yrs
Mill op. cost	$1.26 /LCY	1988	All op yrs

Type-C mine Mine size - 100 BCYD

Category	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$0.00 /yr		
*Mill equipment	$2,748.00 /yr	1988	1988
Working capital	$56,550.00 /yr	1988	1988
Mine op. cost	$5.99 /LCY	1988	All op yrs
Mill op. cost	$1.26 /LCY	1988	All op yrs

* This cost pertains to settling pond construction.

Type-A mine Mine size - 300 BCYD

Category	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$297,137.00 /yr	1987	1987
Mill equipment	$57,147.00 /yr	1987	1987
Working capital	$133,380.00 /yr	1988	1988
Mine op. cost	$4.47 /LCY	1988	All op yrs
Mill op. cost	$1.14 /LCY	1988	All op yrs

Type-B mine Mine size - 300 BCYD

Category	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$190,126.00 /yr	1987	1987
Mill equipment	$57,174.00 /yr	1987	1987
Working capital	$106,002.00 /yr	1988	1988
Mine op. cost	$3.39 /LCY	1988	All op yrs
Mill op. cost	$1.14 /LCY	1988	All op yrs

Type-C mine Mine size - 300 BCYD

Category	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$0.00 /yr		
*Mill equipment	$14,044.00 /yr	1988	1988
Working capital	$131,274.00 /yr	1988	1988
Mine op. cost	$4.47 /LCY	1988	All op yrs
Mill op. cost	$1.14 /LCY	1988	All op yrs

* This cost pertains to settling pond construction.

Type-A mine Mine size - 500 BCYD

Category	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$443,812.00 /yr	1987	1987
Mill equipment	$73,670.00 /yr	1987	1987
Working capital	$189,254.00 /yr	1988	1988
Mine op. cost	$3.74 /LCY	1988	All op yrs
Mill op. cost	$1.11 /LCY	1988	All op yrs

Type-B mine Mine size - 500 BCYD

Category	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$250,004.00 /yr	1987	1987
Mill equipment	$73,670.00 /yr	1987	1987
Working capital	$146,543.00 /yr	1988	1988
Mine op. cost	$2.65 /LCY	1988	All op yrs
Mill op. cost	$1.11 /LCY	1988	All op yrs

Type-C mine Mine size - 500 BCYD

Category	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$0.00 /yr		
*Mill equipment	$18,217.00 /yr	1988	1988
Working capital	$189,150.00 /yr	1988	1988
Mine op. cost	$3.74 /LCY	1988	All op yrs
Mill op. cost	$1.11 /LCY	1988	All op yrs

* This cost pertains to settling pond construction.

Type-A mine Mine size - 1000 BCYD

Category	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$770,746.00 /yr	1987	1987
Mill equipment	$105,637.00 /yr	1987	1987
Working capital	$279,960.00 /yr	1988	1988
Mine op. cost	$2.74 /LCY	1988	All op yrs
Mill op. cost	$1.08 /LCY	1988	All op yrs

Type-B mine Mine size - 1000 BCYD

Category	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$446,922.00 /yr	1987	1987
Mill equipment	$105,637.00 /yr	1987	1987
Working capital	$247,219.00 /yr	1988	1988
Mine op. cost	$2.09 /LCY	1988	All op yrs
Mill op. cost	$1.08 /LCY	1988	All op yrs

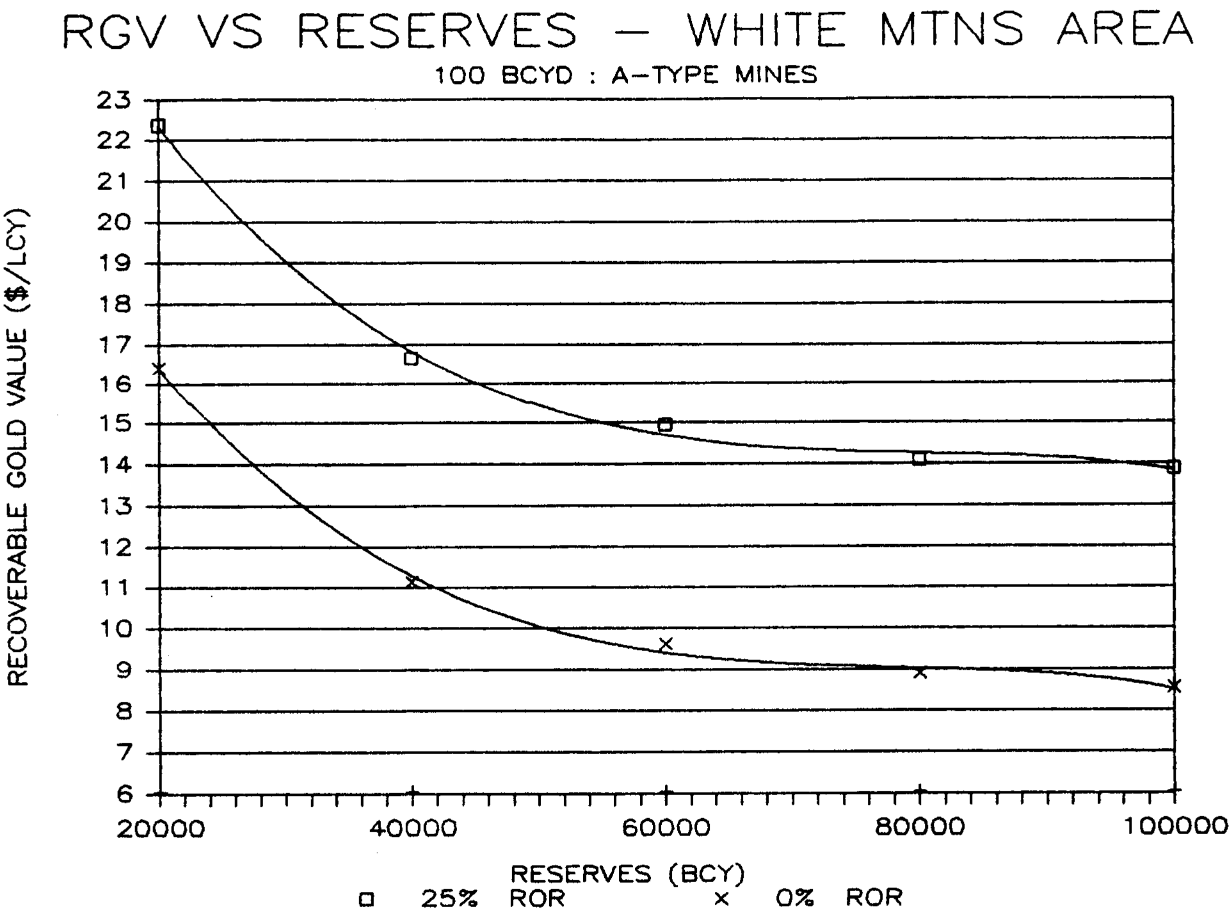
Type-C mine Mine size - 1000 BCYD

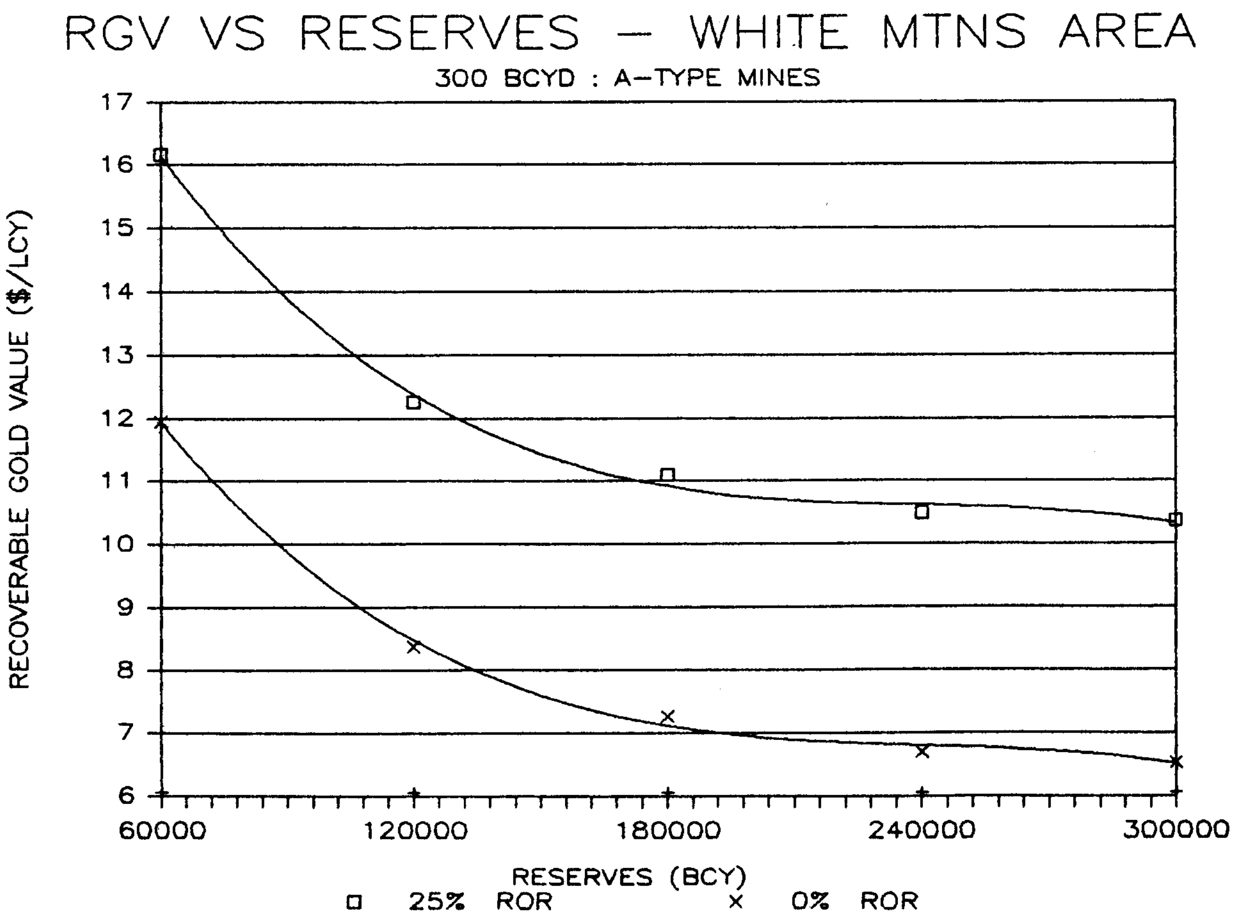
Category	Cost	Beginning Year	Ending Year
Exploration	Included as op cost		
Clearing	Included as op cost		
Mine equipment	$0.00 /yr		
*Mill equipment	$26,244.00 /yr	1988	1988
Working capital	$279,960.00 /yr	1988	1988
Mine op. cost	$2.74 /LCY	1988	All op yrs
Mill op. cost	$1.08 /LCY	1988	All op yrs

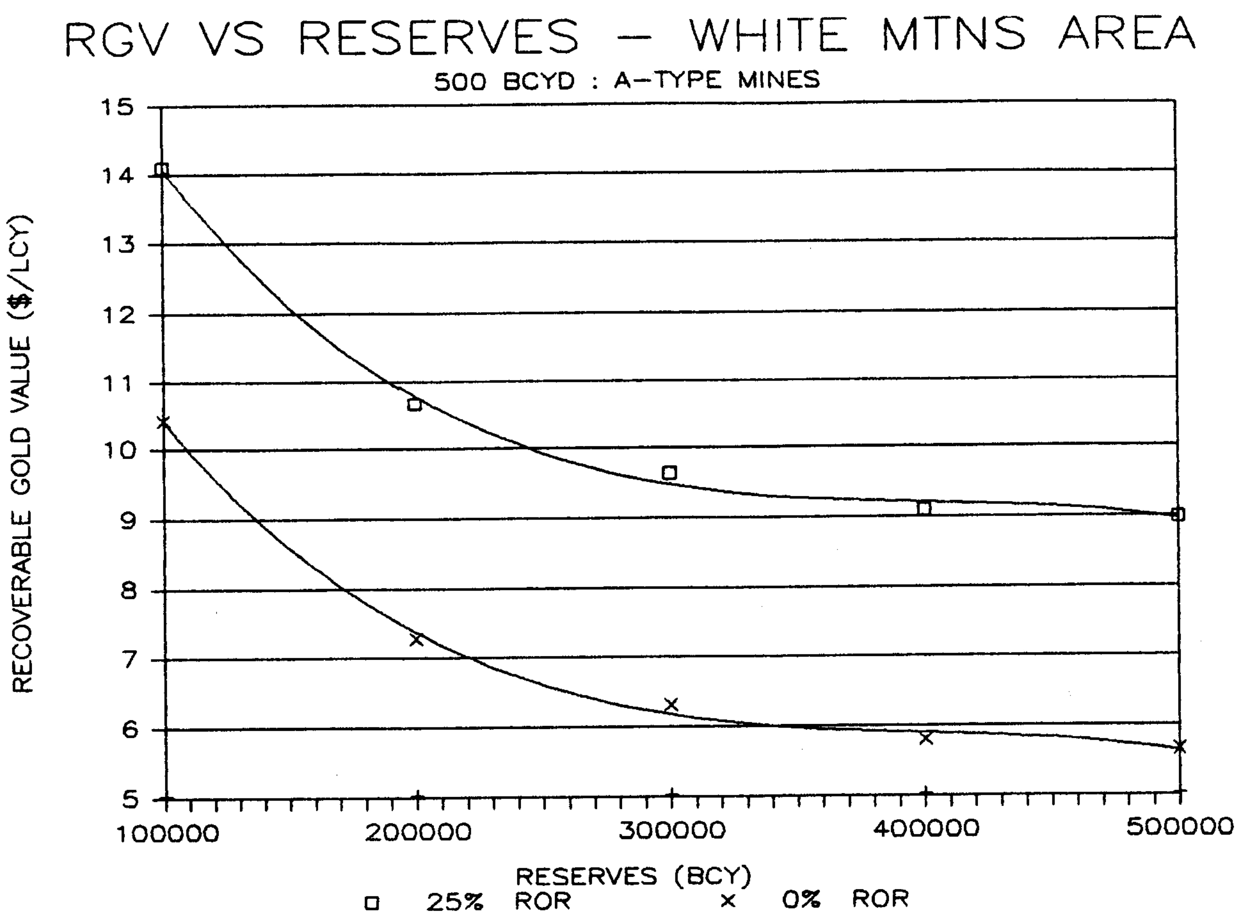
* This cost pertains to settling pond construction.

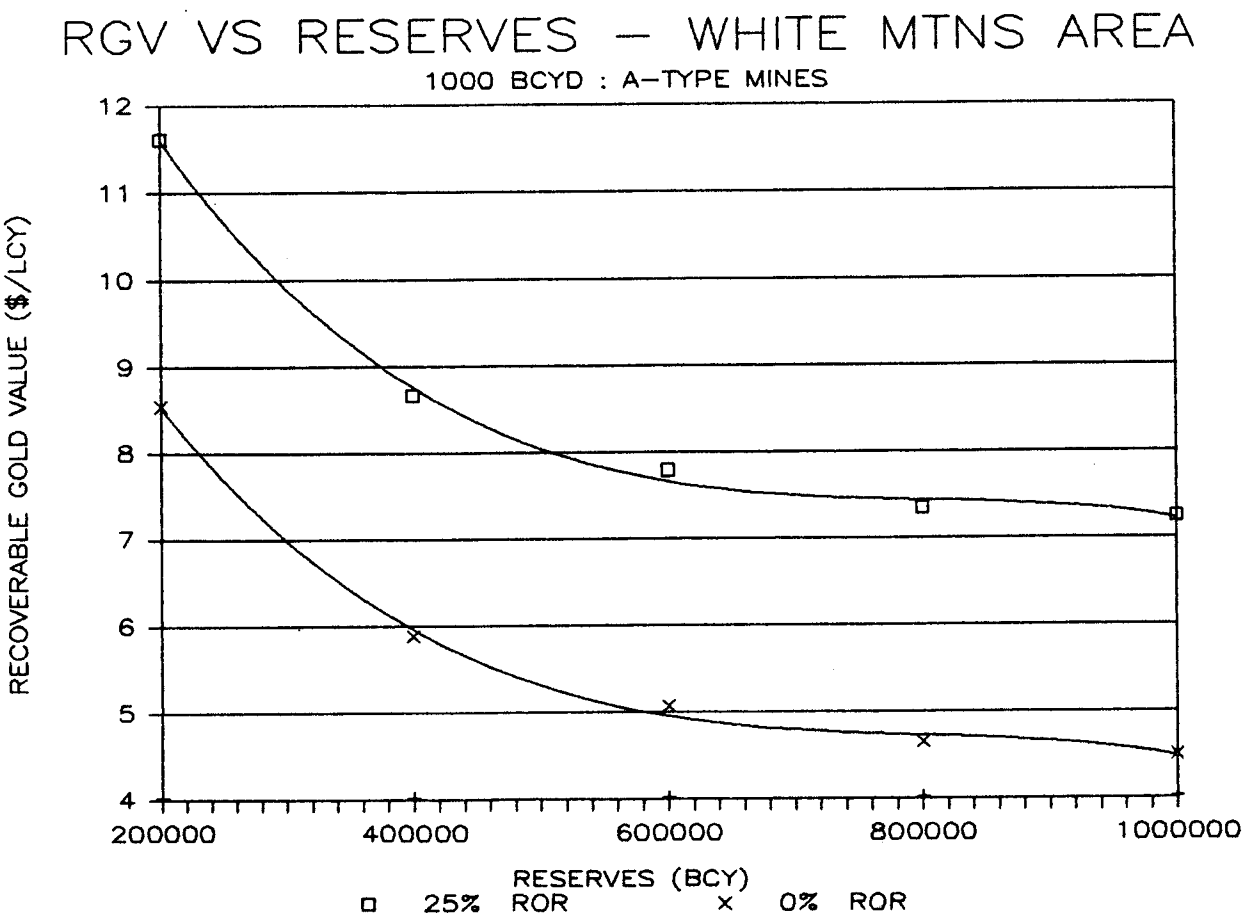
Appendix B

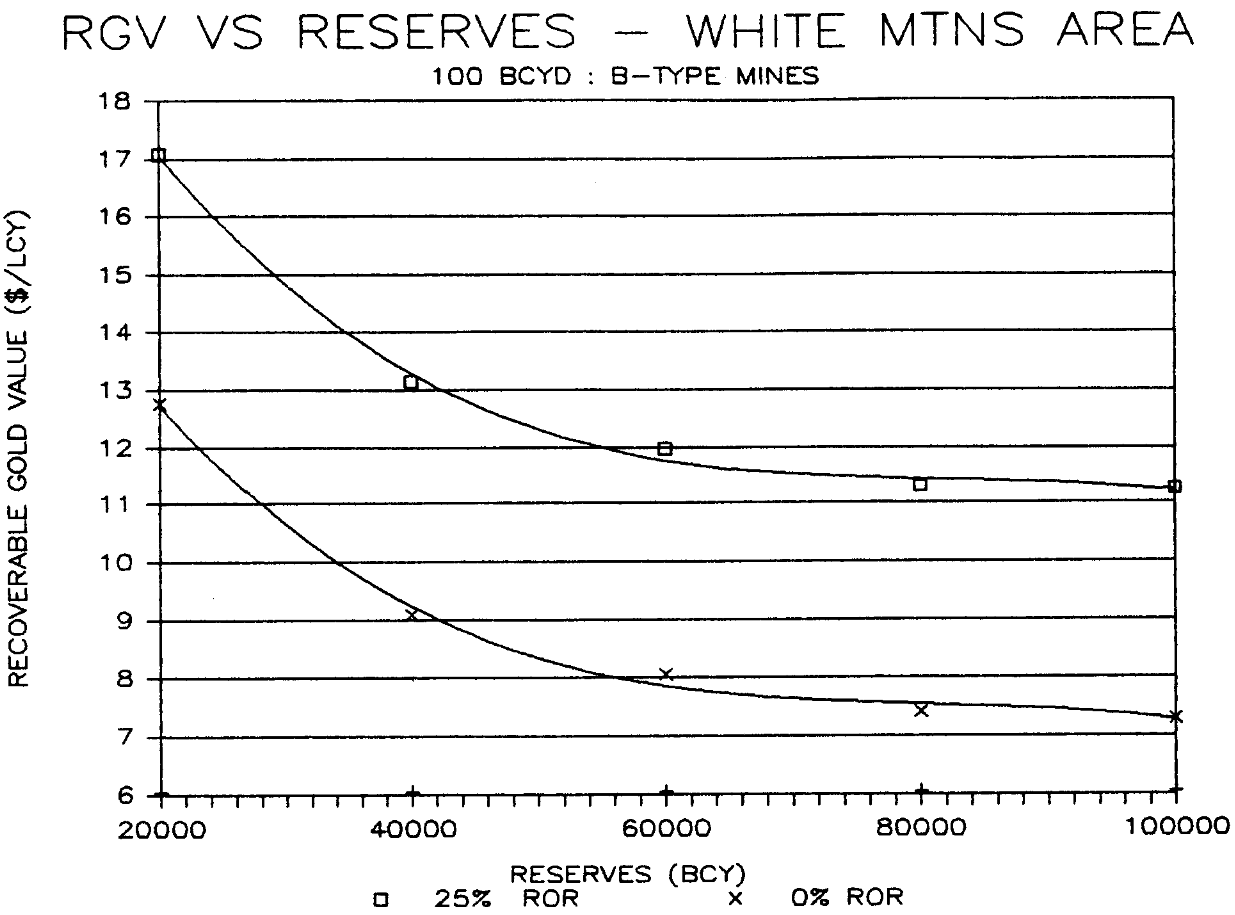
Graphs Showing RGV Vs Reserves


RGV VS RESERVES – WHITE MTNS AREA
100 BCYD : A–TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
20000
40000
60000
80000
100000
RESERVES (BCY)
25% ROR
0% ROR

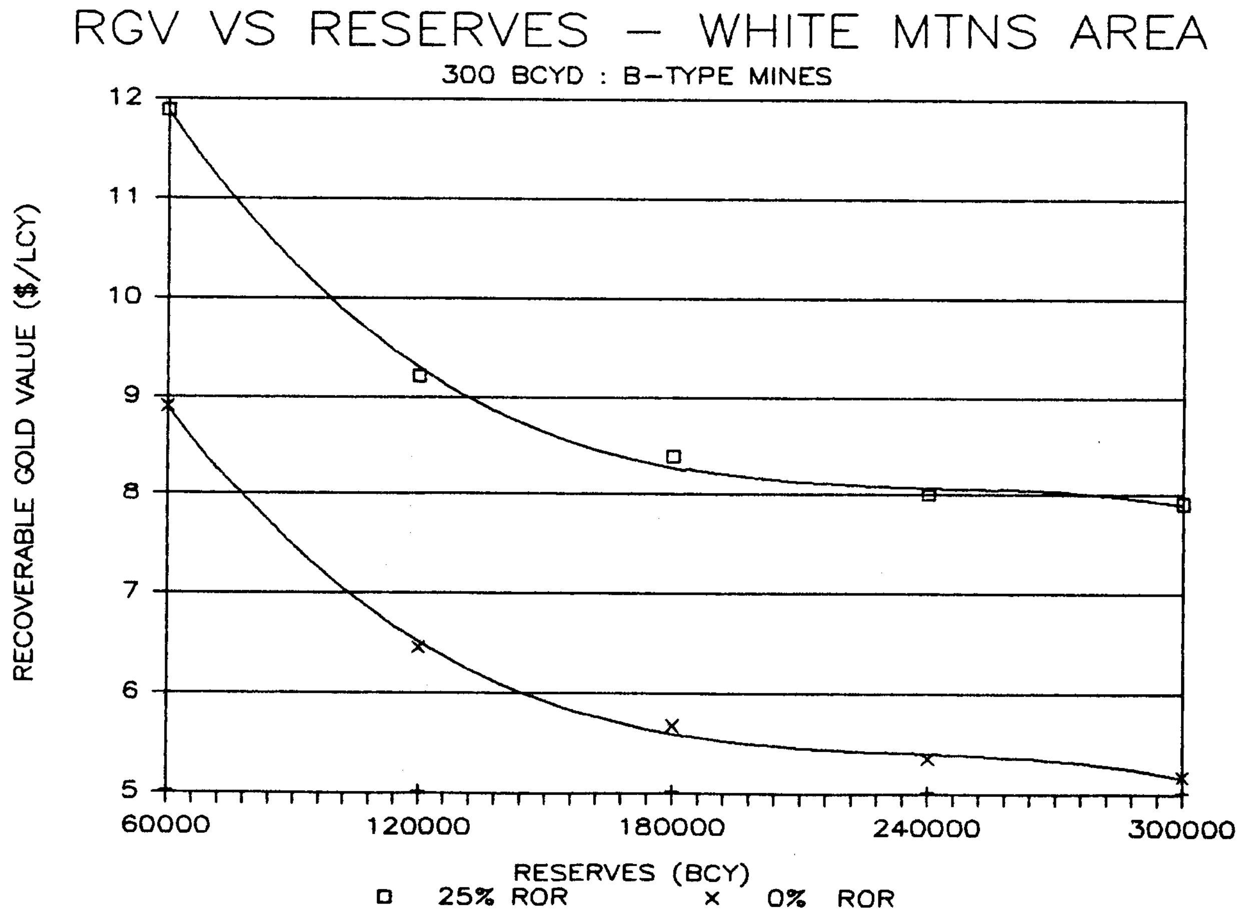

RGV VS RESERVES – WHITE MTNS AREA
300 BCYD : A–TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
17
16
15
14
13
12
11
10
9
8
7
6
60000
120000
180000
240000
300000
RESERVES (BCY)
25% ROR
0% ROR


RGV VS RESERVES — WHITE MTNS AREA
500 BCYD : A-TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
15
14
13
12
11
10
9
8
7
6
5
100000
200000
300000
400000
500000
RESERVES (BCY)
25% ROR
0% ROR

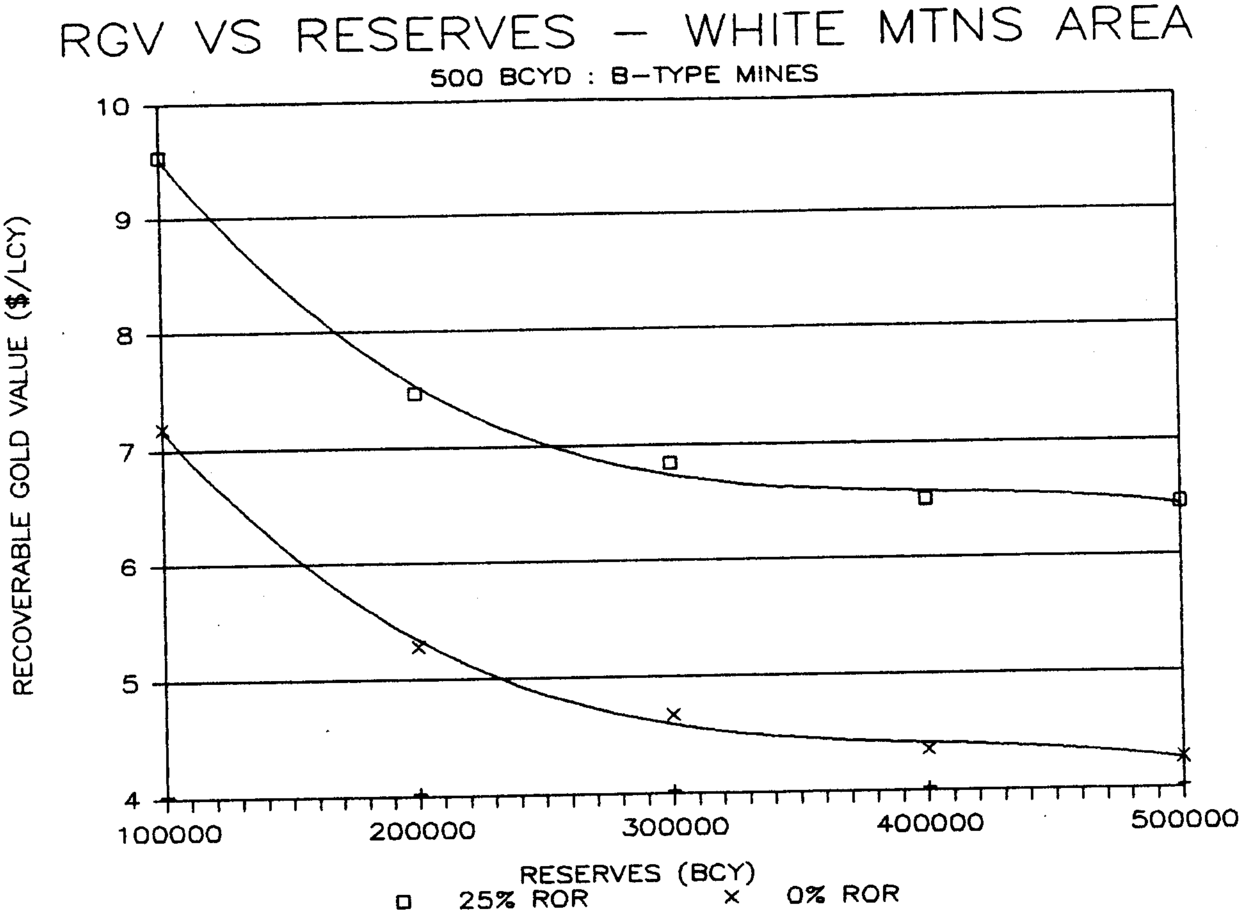

RGV VS RESERVES — WHITE MTNS AREA
1000 BCYD : A-TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
12
11
10
9
8
7
6
5
4
200000
400000
600000
800000
1000000
RESERVES (BCY)
25% ROR
0% ROR

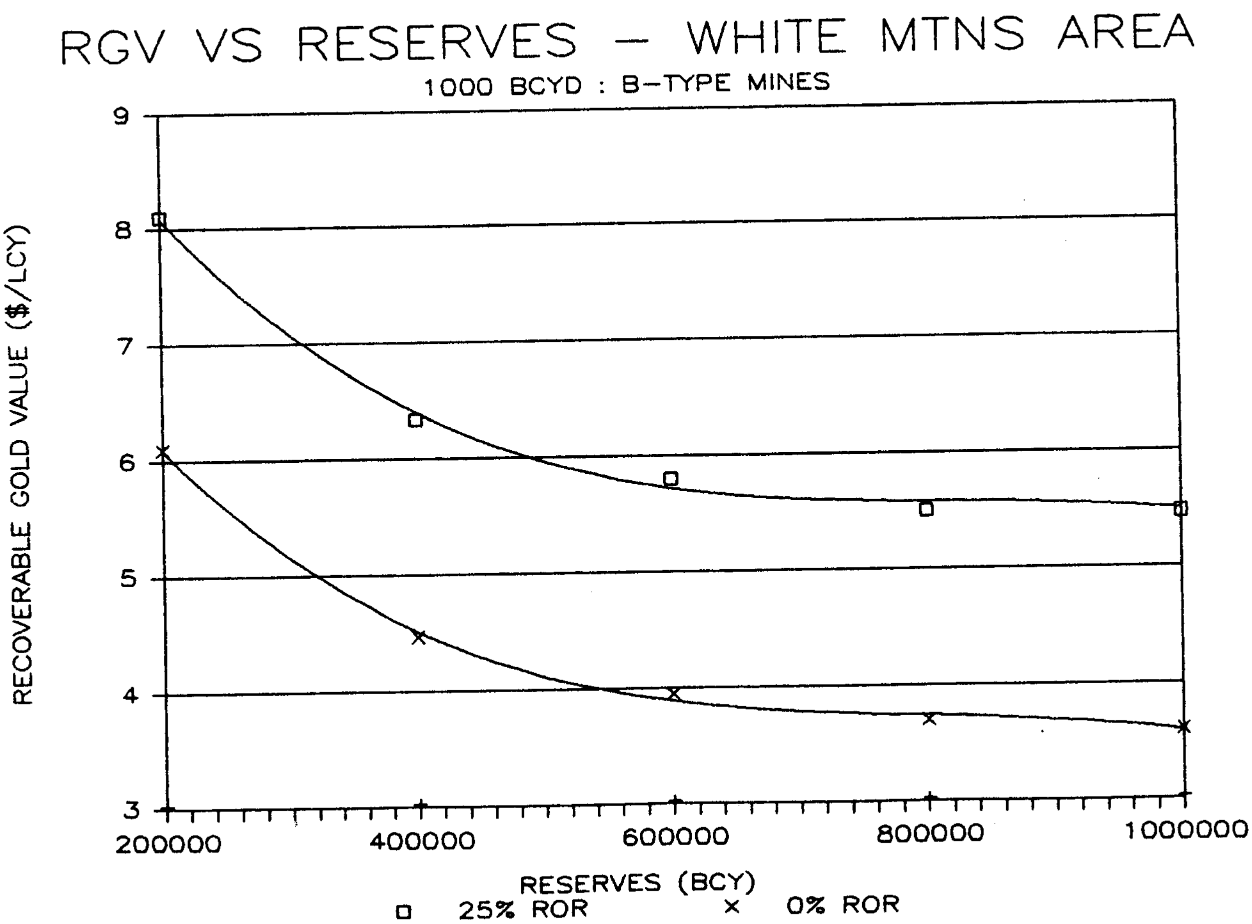


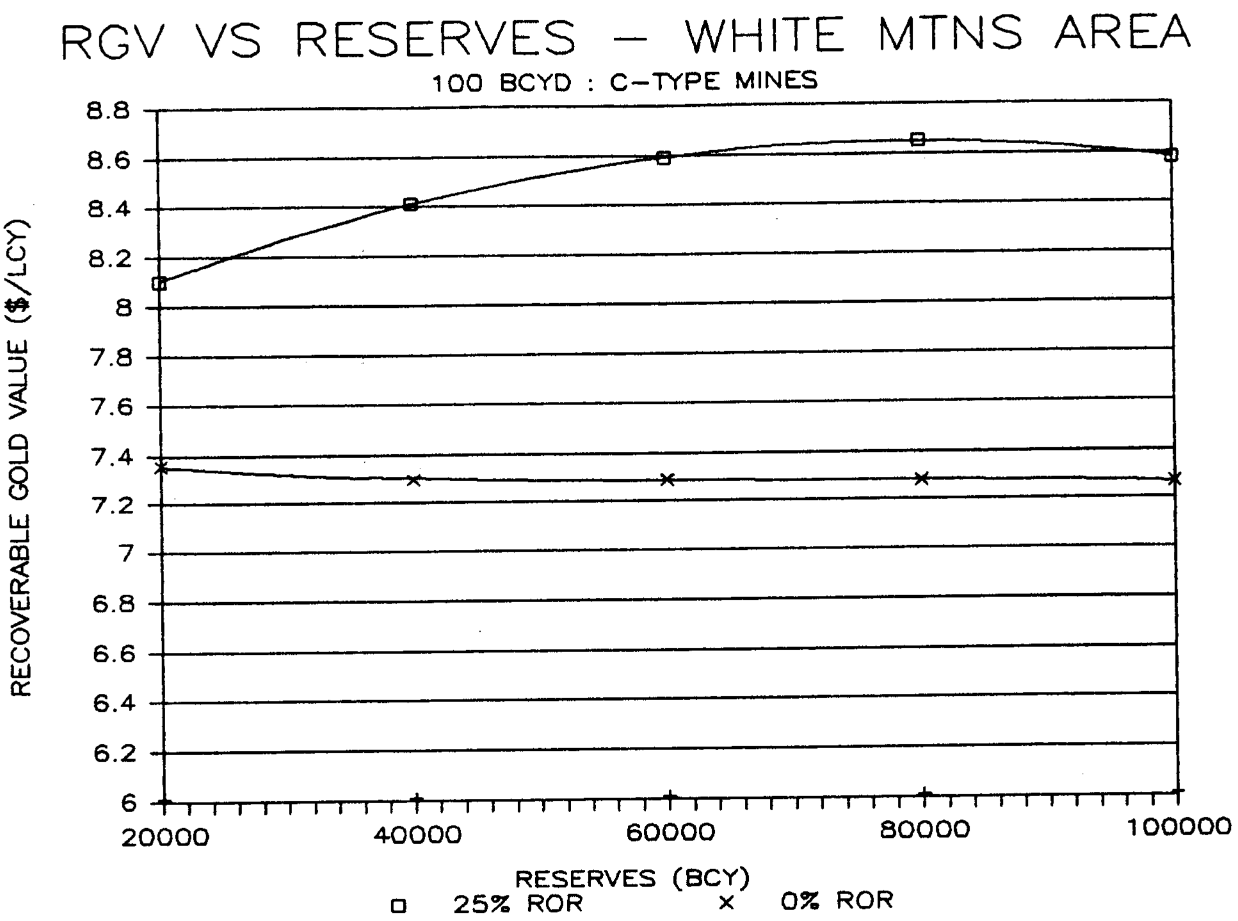
RGV VS RESERVES — WHITE MTNS AREA
100 BCYD : B-TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
18
17
16
15
14
13
12
11
10
9
8
7
6
20000
40000
60000
80000
100000
RESERVES (BCY)
□ 25% ROR
× 0% ROR

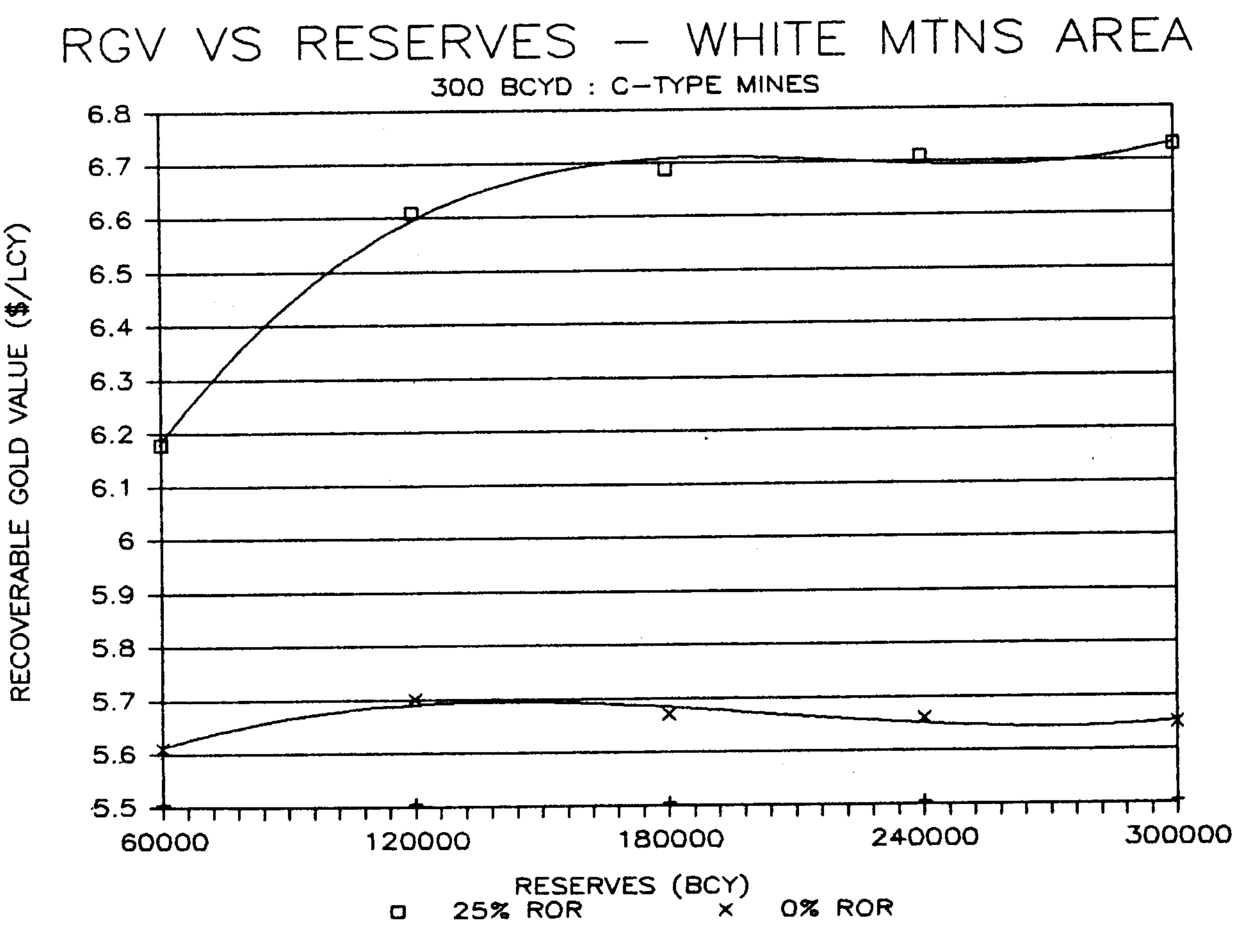


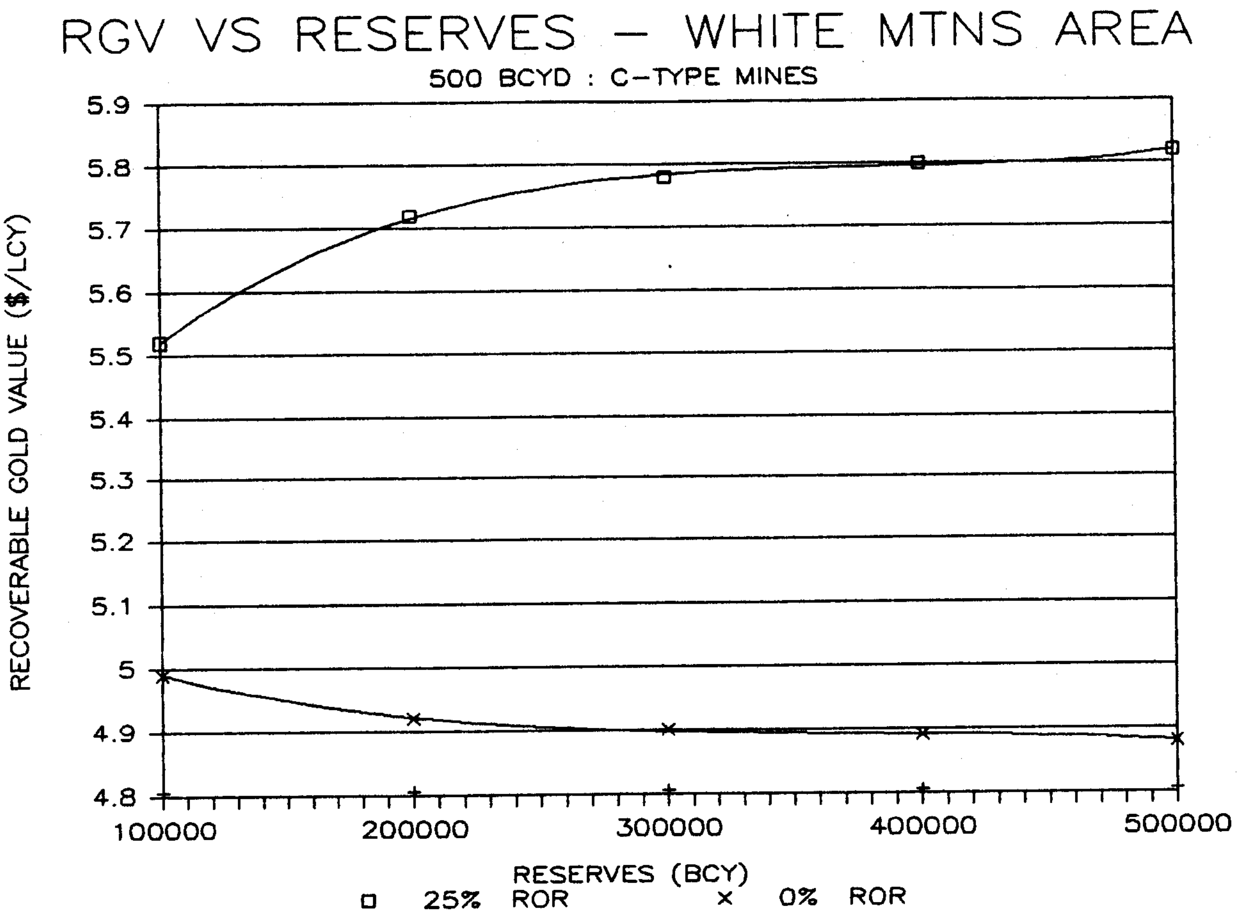
RGV VS RESERVES — WHITE MTNS AREA
300 BCYD : B-TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
12
11
10
9
8
7
6
5
60000
120000
180000
240000
300000
RESERVES (BCY)
□ 25% ROR
× 0% ROR

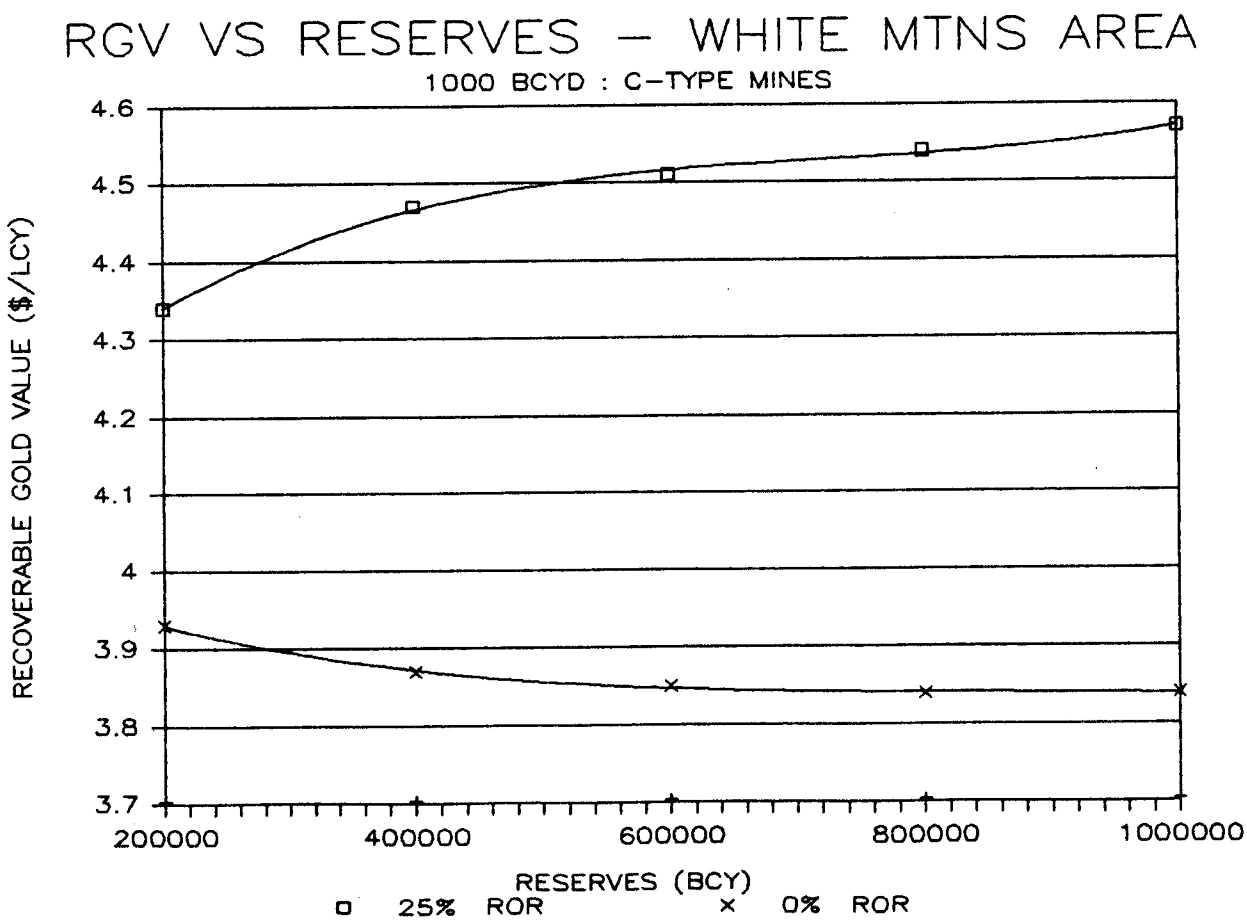

RGV VS RESERVES — WHITE MTNS AREA
500 BCYD : B-TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
10
9
8
7
6
5
4
100000
200000
300000
400000
500000
RESERVES (BCY)
25% ROR
0% ROR


RGV VS RESERVES — WHITE MTNS AREA
1000 BCYD : B-TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
9
8
7
6
5
4
3
200000
400000
600000
800000
1000000
RESERVES (BCY)
25% ROR
0% ROR


RGV VS RESERVES – WHITE MTNS AREA
100 BCYD : C-TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
8.8
8.6
8.4
8.2
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
6
20000
40000
60000
80000
100000
RESERVES (BCY)
25% ROR
0% ROR


RGV VS RESERVES – WHITE MTNS AREA
300 BCYD : C-TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
6.8
6.7
6.6
6.5
6.4
6.3
6.2
6.1
6
5.9
5.8
5.7
5.6
5.5
60000
120000
180000
240000
300000
RESERVES (BCY)
25% ROR
0% ROR


RGV VS RESERVES – WHITE MTNS AREA
500 BCYD : C–TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
5.9
5.8
5.7
5.6
5.5
5.4
5.3
5.2
5.1
5
4.9
4.8
100000
200000
300000
400000
500000
RESERVES (BCY)
25% ROR
0% ROR


RGV VS RESERVES – WHITE MTNS AREA
1000 BCYD : C–TYPE MINES
RECOVERABLE GOLD VALUE ($/LCY)
4.6
4.5
4.4
4.3
4.2
4.1
4
3.9
3.8
3.7
200000
400000
600000
800000
1000000
RESERVES (BCY)
25% ROR
0% ROR

APPENDIX C

Itemized exploration costs for mine type/rate models. All figures are U.S. dollars.

Yearly costs of exploration for a 100 BCYD mine.

Mine type	Camp operation cost	Sample analysis	Equipment rental	Fuel and maint.	Total
A	772.57	1,878.19	1,259.00	115.12	4,015.88
B	160.48	754.86	750.00	38.37	1,703.71
C	772.57	1,878.19	1,259.00	115.12	4,015.88

Yearly costs of exploration for a 300 BCYD mine.

Mine type	Camp operation cost	Sample analysis	Equipment rental	Fuel and maint.	Total
A	2,317.70	5,248.16	2,216.44	345.37	10,127.67
B	481.63	1,878.19	1,250.00	115.12	3,724.74
C	2,317.70	5,248.16	2,216.44	345.37	10,127.67

Yearly costs of exploration for a 500 BCYD mine.

Mine type	Camp operation cost	Sample analysis	Equipment rental	Fuel and maint.	Total
A	3,862.83	8,618.14	3,060.73	575.62	16,117.32
B	802.38	3,001.51	1,750.00	191.87	5,745.76
C	3,862.83	8,618.14	3,060.73	575.62	16,117.32

Yearly costs of exploration for a 1000 BCYD mine.

Mine type	Camp operation cost	Sample analysis	Equipment rental	Fuel and maint.	Total
A	7,725.67	17,043.08	4,721.47	1,151.23	30,641.45
B	1,604.75	5,809.83	2,507.16	383.74	10,305.48
C	7,725.67	17,043.08	4,721.47	1,151.23	30,641.45

APPENDIX D

COEFFICIENTS FOR POLYNOMIAL EQUATIONS FOR RGV VS RESERVES RELATIONSHIPS.

Coefficients for polynomial non-linear regression equations in the form of:
$Y=C1+(C2 \times R)+(C3 \times R^2)+(C4 \times R^3)$. R=Reserves in bank cubic yards.
Note: E is used below as in, for example -6.4590E-04. This is a form of notation indicating that -6.4590E-04 is raised to the power of -4 as in -9.4603^{-04}.

Mine description	Target R.O.R.	COEFFICIENTS C1	C2	C3	C4
A-Type - 100 BCYD	! 0%	26.3080	-6.4590E-04	8.1589E-09	-3.4792E-14
A-Type - 100 BCYD	5%	27.3480	-6.4362E-04	7.9545E-09	-3.3229E-14
A-Type - 100 BCYD	10%	28.9520	-6.7917E-04	8.5625E-09	-3.6458E-14
A-Type - 100 BCYD	15%	30.6120	-7.1096E-04	9.1143E-09	-3.5417E-14
A-Type - 100 BCYD	20%	31.5600	-6.8348E-04	8.4679E-09	-3.5417E-14
A-Type - 100 BCYD	! 25%	32.9080	-6.8323E-04	8.4366E-09	-3.5104E-14
B-Type - 100 BCYD	! 0%	19.3880	-4.2960E-04	5.2598E-09	-2.1771E-14
B-Type - 100 BCYD	5%	20.2960	-4.3844E-04	5.3384E-09	-2.1979E-14
B-Type - 100 BCYD	10%	21.3000	-4.5189E-04	5.5241E-09	-2.2813E-14
B-Type - 100 BCYD	15%	22.4840	-4.7674E-04	6.0027E-09	-2.5521E-14
B-Type - 100 BCYD	20%	23.2320	-4.6232E-04	5.6652E-09	-2.3439E-14
B-Type - 100 BCYD	! 25%	24.0840	-4.5165E-04	5.4277E-09	-2.1979E-14
C-Type - 100 BCYD	! 0%	7.4800	-8.0595E-06	1.1161E-10	-5.2083E-16
C-Type - 100 BCYD	5%	7.4380	3.5000E-06	-2.5000E-11	3.2312E-27
C-Type - 100 BCYD	10%	7.5200	5.8800E-6	1.0714E-11	-4.1667E-16
C-Type - 100 BCYD	15%	7.6020	9.9643E-06	1.0714E-11	6.2500E-16
C-Type - 100 BCYD	20%	7.6160	1.8690E-05	-9.4643E-11	-2.0833E-16
C-Type - 100 BCYD	! 25%	7.6666	2.4857E-05	-1.5714E-10	
A-Type - 300 BCYD	! 0%	18.484	-1.4096E-04	5.7520E-10	-7.9475E-16
A-Type - 300 BCYD	5%	19.496	-1.4739E-04	6.0903E-10	-8.5262E-16
A-Type - 300 BCYD	10%	20.572	-1.5462E-04	6.4841E-10	-9.1821E-16
A-Type - 300 BCYD	15%	21.368	-1.5276E-04	6.2688E-10	-8.6806E-16
A-Type - 300 BCYD	20%	22.476	-1.5736E-04	6.5308E-10	-9.1435E-16
A-Type - 300 BCYD	! 25%	23.348	-1.5522E-04	6.3780E-10	-8.8349E-16
B-Type - 300 BCYD	! 0%	13.514	-9.9782E-05	4.1567E-10	-5.8642E-16
B-Type - 300 BCYD	5%	14.134	-1.0163E-04	4.2073E-10	-5.9028E-16
B-Type - 300 BCYD	10%	14.776	-1.0366E-04	4.2808E-10	-5.9799E-16
B-Type - 300 BCYD	15%	15.466	-1.0610E-04	4.3938E-10	-6.1343E-16
B-Type - 300 BCYD	20%	16.134	-1.0641E-04	4.3740E-10	-6.0571E-16
B-Type - 300 BCYD	! 25%	16.768	-1.0535E-04	4.3075E-10	-5.9414E-16
C-Type - 300 BCYD	! 0%	5.388	5.2857E-06	-2.8571E-11	4.6296E-17
C-Type - 300 BCYD	5%	5.384	7.7659E-06	-3.9087E-11	6.1728E-17
C-Type - 300 BCYD	10%	5.362	1.0881E-05	-5.2679E-11	8.1019E-17
C-Type - 300 BCYD	15%	5.350	1.3516E-05	-6.3393E-11	9.6451E-17
C-Type - 300 BCYD	20%	5.288	1.7353E-05	-8.1151E-11	7.4000E-17
C-Type - 300 BCYD	! 25%	5.294	1.9758E-05	-9.0377E-11	1.3503E-16

(! - symbol indicates equation is graphically illustrated in this report)

Coefficients for polynomial non-linear regression equations in the form of: $Y=C1+(C2 \times R)+(C3 \times R^2)+(C4 \times R^3)$. R=Reserves in bank cubic yards.
Note: E is used below as in, for example -6.4590E-04. This is a form of notation indicating that -6.4590E-04 is raised to the power of -4 as in -9.4603^{-04}.

Mine description	Target R.O.R.	COEFFICIENTS C1	C2	C3	C4
A-Type - 500 BCYD	! 0%	16.1200	-7.3914E-05	1.8086E-10	-1.5000E-16
A-Type - 500 BCYD	5%	16.9520	-7.6526E-05	1.8807E-10	-1.5667E-16
A-Type - 500 BCYD	10%	17.6600	-7.6564E-05	1.8436E-10	-1.5000E-16
A-Type - 500 BCYD	15%	18.4660	-7.7195E-05	1.8421E-10	-1.4833E-16
A-Type - 500 BCYD	20%	19.4360	-7.9774E-05	1.9343E-10	-1.5833E-16
A-Type - 500 BCYD	! 25%	20.3560	-8.1214E-05	1.9936E-10	-1.6500E-16
B-Type - 500 BCYD	! 0%	10.6500	-4.4676E-05	1.0832E-10	-8.9167E-17
B-Type - 500 BCYD	5%	11.1840	-4.6450E-05	1.1400E-10	-9.5000E-17
B-Type - 500 BCYD	10%	11.7480	-4.8171E-05	1.1929E-10	-1.0000E-17
B-Type - 500 BCYD	15%	12.4140	-5.0955E-05	1.2854E-10	-1.0917E-16
B-Type - 500 BCYD	20%	12.8000	-4.9214E-05	1.2086E-10	-1.0000E-16
B-Type - 500 BCYD	! 25%	13.2800	-4.8324E-05	1.1718E-10	-9.5833E-17
C-Type - 500 BCYD	! 0%	5.1260	-1.7905E-06	4.6786E-12	-4.1667E-18
C-Type - 500 BCYD	5%	5.0960	-1.7857E-07	2.1429E-13	3.7865E-29
C-Type - 500 BCYD	10%	5.1000	1.2167E-06	-3.5000E-12	3.7865E-29
C-Type - 500 BCYD	15%	5.1180	2.4024E-06	-6.3929E-12	5.8333E-18
C-Type - 500 BCYD	20%	5.1080	3.9690E-06	-1.0393E-11	9.1667E-18
C-Type - 500 BCYD	! 25%	5.1280	5.1476E-06	-1.3357E-11	1.1667E-17
A-Type - 1000 BCYD	! 0%	13.4700	-3.1936E-05	3.9509E-11	-1.6563E-17
A-Type - 1000 BCYD	5%	14.1700	-3.3068E-05	4.0973E-11	-1.7187E-17
A-Type - 1000 BCYD	10%	14.8400	-3.3767E-05	4.1687E-11	-1.7396E-17
A-Type - 1000 BCYD	15%	15.4840	-3.3657E-05	4.0652E-11	-1.6563E-17
A-Type - 1000 BCYD	20%	16.1520	-3.3731E-05	4.0554E-11	-1.6458E-17
A-Type - 1000 BCYD	! 25%	17.0380	-3.5156E-05	4.3366E-11	-1.8021E-17
B-Type - 1000 BCYD	! 0%	9.1040	-1.9461E-05	2.3946E-11	-1.0000E-17
B-Type - 1000 BCYD	5%	9.4540	-1.9388E-05	2.3393E-11	-9.5833E-18
B-Type - 1000 BCYD	10%	10.0080	-2.0632E-05	2.5464E-11	-1.0625E-17
B-Type - 1000 BCYD	15%	10.5440	-2.1701E-05	2.7411E-11	-1.1667E-17
B-Type - 1000 BCYD	20%	10.9320	-2.1385E-05	2.6598E-11	-1.1146E-17
B-Type - 1000 BCYD	! 25%	11.2520	-2.0320E-05	2.4420E-11	-9.8583E-18
C-Type - 1000 BCYD	! 0%	4.0360	-6.7857E-07	7.9464E-13	-3.1250E-19
C-Type - 1000 BCYD	5%	4.0480	-2.4048E-07	2.7679E-13	-1.0417E-19
C-Type - 1000 BCYD	10%	4.0550	2.2083E-07	-2.5000E-13	1.0417E-19
C-Type - 1000 BCYD	15%	4.0850	6.1607E-07	-7.3214E-13	3.1250E-19
C-Type - 1000 BCYD	20%	4.0700	1.2476E-06	-1.6161E-12	7.2917E-19
C-Type - 1000 BCYD	! 25%	4.0960	1.6000E-06	-2.0625E-12	9.3750E-19

(! - symbol indicates equation is graphically illustrated in this report)