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The measurement of the viability of PGM-mining projects in a competitive market

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THE MEASUREMENT OF THE VIABILITY OF PGM-MINING PROJECTS IN A COMPETITIVE MARKET

by PAUL LOUIS BROGAN

submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in the Faculty of

ENGINEERING

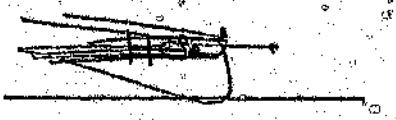
in the University of the Witwatersrand, Johannesburg

August 1991

PROMOTER : DR I. CLARK

DECLARATION

I declare that this project is my own, unaided work. It is being submitted in partial fulfilment of the degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.



(Paul Louis Brogan)

FOURTH day of SEPTEMBER 1992

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- The management of Impala Platinum Holdings Limited for permission to embark on this study, their constant encouragement and their willingness to peruse my work and to provide the facilities necessary to complete this research.

- My promoter, Doctor Isobel Clark, for her interest in getting me started on this project and for her subsequent nagging to ensure that it was finished within our agreed time constraint.

- My friends, for understanding that there were times when my study called more loudly than the next round.

- My lady friends, for understanding .....

Tout nouveau, tout beau.

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THE MEASUREMENT OF THE VIABILITY OF PGM-MINING PROJECTS IN A COMPETITIVE MARKET

1. SYNOPSIS

The careful management and design of PGM (Platinum Group Metal) mining projects has recently assumed importance with projected increases in demand for PGMs and the subsequent establishment of new PGM-mining ventures. The following points merit particular attention with regard to the overall confidence in the robustness of these projects :-

(i) cost - competitive position;
(ii) ability to sustain downturns, and
(iii) operational flexibility.

This research concentrates on what measurement criteria should be used to test the ability of proposed new PGM mines to maintain profitability during times of demand reductions and increased vulnerability to competition.

For ease of reference, the following abbreviations and terms apply throughout this document :-

PGM	:	Platinum Group Metal
Pt	:	Platinum
Pd	:	Palladium
Au	:	Gold
Rh	:	Rhodium
Ru	:	Ruthinium
Ir	:	Iridium
Ni	:	Nickel

Cu	:	Copper
Oz	:	Troye ounce
Capex	:	Capital Expenditure
IRR	:	Internal Rate of Return
NPV	:	Net Present Value
R	:	Rand
t	:	metric ton
g	:	gram
UG2	:	Upper Group 2, Bushveld Igneous Complex, South Africa
Merensky	:	Merensky Reef, Bushveld Igneous Complex, South Africa
NCR	:	Nickel / Copper Refinery
PMR	:	Precious Metals Refinery
SACPI	:	South African Consumer Price Index
USCPI	:	United States Consumer Price Index
US$	:	United States Dollar
£	:	British Pound Sterling
pa	:	Per Annum
Upside	:	Increase in parameter value (not necessarily favourable)
Downside	:	Decrease in parameter value (not necessarily unfavourable)

2. INTRODUCTION

The importance of evaluating and measuring the robustness of proposed new PGM mining projects has recently been highlighted by :-

(i) the increase in demand for PGMs, especially platinum, palladium and rhodium, in the last decade and the forecast continuance of this upward trend to the end of this century[1].

(ii) the subsequent announcement of new PGM-mining ventures such as the Kennedy's Vale, Crocodile River, Northam, Potgietersrus Platinum, Karee, Messina, Maandagshoek, Hartley and Stillwater mines.

(iii) announced expansions at established operations such as Impala, Rustenburg, Atok, Western Platinum and Eastern Platinum mines.

(iv) the volatility of PGM prices and their sensitivity to general business confidence, as witnessed by recent wide fluctuations in the prices of rhodium and platinum.

(v) the recent mothballing of Messina, Kennedy's Vale and Crocodile River Mines.

(vi) the deferment of expansion plans at Atok, Stillwater and Impala Mines.

As a result of these recent developments in the PGM market (both on the supply and on the demand sides), it has become imperative that PGM producers analyse the risks and uncertainties involved with establishing new mining projects and expansions with an increased perspicacity. This includes quantifying the potential ranges of a project's input parameters used in its evaluation via sensitivity and risk analysis. However, perhaps of greater importance is the question of a project's robustness.

In general, and under a normal free-market system with little or no opportunities for government assistance to unprofitable mining operations (which is a basic assumption of this research), a mine will continue to produce as long as it is breaking even on its working costs, interest payments and other such obligations, although its capex plans can be curtailed during periods of lower-than-normal profits, albeit thus limiting the mine's long-term potential to survive. If this kind of situation were to continue, the mine would have to close down because of the lack of capital investment in future replacement production sources and because of the refusal of shareholders to continue their investment without a return.

This process would be accelerated if the operation were to make a working loss for an extended period. In some cases, a third party may be able to salvage the operation. This, however, represents a loss of control by the initiator of the project.

The following points apply to the question of premature project failure :-

(i) Different project managers use different forecasts of economic input parameters in their project evaluations. The only certainty here is that all of these forecasts will be wrong. The best that one can hope for is to be as close to the parameters actually achieved as possible.

(ii) Basic assumptions, both technical and conceptual, may be wrong, either because of unforeseen eventualities or simply by mistake.

(iii) Substantial longer-term drops in metal prices, occurring because of an oversupply of or a reduction in demand for these metals, reduce profit levels.

(iv) Higher-than-planned escalations in capex and working costs also reduce profit levels.

(v) Changes in lease, royalty and tax rates may also reduce a project's return.

Apart from the possibilities of technical or conceptual errors (which have been ignored in this study), the above factors are common to all new projects. Sensitivity and risk analyses help to quantify the potential negative effects of these factors and thus one should assume that investors are aware of the size of any risk to which their funds are exposed.

This research concentrates on the ability of PGM-mining projects to weather out reductions in working profit, or even short-term working losses, which result from the above unexpected eventualities. It is assumed that, as profits are reduced, operations would be forced into closure one-by-one until supply has been cut back sufficiently to encourage a price balance at a level that will sustain the other operations at a normal working profit. Thus, the least favourably-placed operation would close first and the most favourably-placed operation would close last. The more profitable that a mine is, the more robust it would be.

The focal question of this research is thus :-

- **How does one measure this robustness meaningfully and thus position any particular primary PGM operation on a scale of competitiveness?**

In determining whether to proceed with a new PGM-mining venture, the following factors are normally taken into account, amongst others :-

(i) Real IRR of the project (%)
(ii) Real IRR to the investors (%)
(iii) NPV, at a hurdle discount rate, of the project (R million, base date)
(iv) Payback period (years from first project expenditure)
(v) Maximum cash exposure (R million)
(vi) Corporate financial and marketing strategy

In determining the profitability of a project (current or projected), criteria such as the following are used :-

(i) Working cost per ton milled net of by-product revenue (R/t)

(ii) Working cost per ounce of platinum produced net of by-product revenue (R/oz Pt)

(iii) Profit per ton milled (R/t)

(iv) Profit per ounce of platinum produced (R/oz Pt)

(v) Cut-off head grade (g PGM/t)

(vi) Cash margin or Profit/Revenue ratio (%)

The relationship between the above profitability or robustness criteria and project decision-making factors is important, because the more consistent this relationship is over the project-evaluation period, the better that criterion will be in predicting the likelihood that the project survives in the long term.

The approach is thus as follows :-

(i) Divide Real IRR and NPV @ 0% discount by the 6 profitability criteria listed above to create a number for each of the project years. This number has meaningless units and so is considered to be unitless in this study. It is used merely to examine the relationship between project factors and robustness criteria.

(ii) Determine the variability of each of these numbers.

(iii) Conclude which criterion is most suited to measuring robustness by choosing the one which is least variable.

Two projects will be used for the analysis : Hartley Platinum Mine and a fictitious South African Mine, XYZ.

Hartley Platinum Mine in Zimbabwe has not yet started full-scale operations, but has nevertheless announced some evaluation results. It is located on the Great Dyke in Zimbabwe and is planned to mine one of the PGM-bearing sulphide zones in this geological complex.

XYZ will add focus to the conclusions from the Hartley evaluation. It will mine a different reef type, have different grades and will be subject to different tax, lease and royalty rates. It will also be located in a country with political and economic and uncertainties different from those in Zimbabwe. A different reef type is evaluated in an attempt to examine the effect of the composition of a reef on the results of this study. For example, the UG2 Reef contains lower proportions of platinum and higher proportions of rhodium than either the Merensky Reef or this Great Dyke sulphide zone.

It should be noted that no allowance has been made for managment response to low or negative profitability. Not only is it difficult to predict the form and the extent of such a response, but it can also vary widely between mines and mining houses. In effect, therefore, it is assumed that management responses for each competitor would be equivalent to the extent that their positions in a profitability or competitiveness ranking would not change.

This is not to say, however, that management response cannot be modelled. If one were to apply the techniques of this study to a particular mine or mining group, and assuming that management response could be reasonably predicted, then a project could be analysed that much more thoroughly.

3. THE MODEL

3.1 GENERAL

Refer to appendix 1 for a copy of the model and to page 10 for a diagrammatic representation of the model's layout.

The model is written in Lotus 1-2-3, release 2.2 software[2] and is approximately 430 kbytes in size.

It is important to note that as much realism as possible has been applied to the numbers used in the evaluations of this study. However, the conclusions centre on general project behaviour rather than on the specific projects chosen for this research.

Referring to appendix 1 and to page 10, the following descriptions apply :-

Instantaneous Project Profitability Sheet :-

This sheet, also entitled "Intramarginal Analysis of Platinum Producers", works from in situ grades and splits, to head grades, then to recoveries at the Concentrator, Smelter, NCR and PMR and thus to yield, in g PGM/t, for Merensky and UG2 reefs separately, for each metal (Pt, Pd, Au, Rh, Ru, Ir plus the base metals Ni and Cu).

These yields are averaged for the percentage of UG2 milled and multiplied by the sales prices (free-market prices adjusted for sales discounts) for each metal, to produce a figure for revenue per ton milled. It is an instantaneous picture at a base date (July 1991 for all calculations in this document) using prices at that date.

In addition, working costs (including ongoing capex and average royalty and lease paid) are calculated in base date terms. The results produced are profitability figures for July 1991, namely, total costs net of by-product credits per ton milled (R/t) and per ounce of platinum produced (R/oz Pt), profit per ton milled (R/t) and per ounce

of platinum produced (R/oz Pt), cash margin (profit divided by revenue expressed as a percentage) and cut-off head grades for Merensky Reef, UG2 Reef and the combined production of both for the operation being examined, in g PGM/t.

Screen :-

This area is used to assist the operator, via menu systems and associated macros, by showing messages and instructions.

Input Parameters :-

Included in this area are basic parameters used elsewhere in the worksheet, such as metal pipelines (for yearly metal production calculations), lease formula, royalty percentages, tax rates, whether there is a tax shield for the project or not, base date calculations, sales contract percentages, sensitivity and risk analysis parameters and starting-point data for the previous financial year, July 1990 to June 1991.

Sensitivities Output Area :-

Sensitivities are calculated and placed in this area for printing.

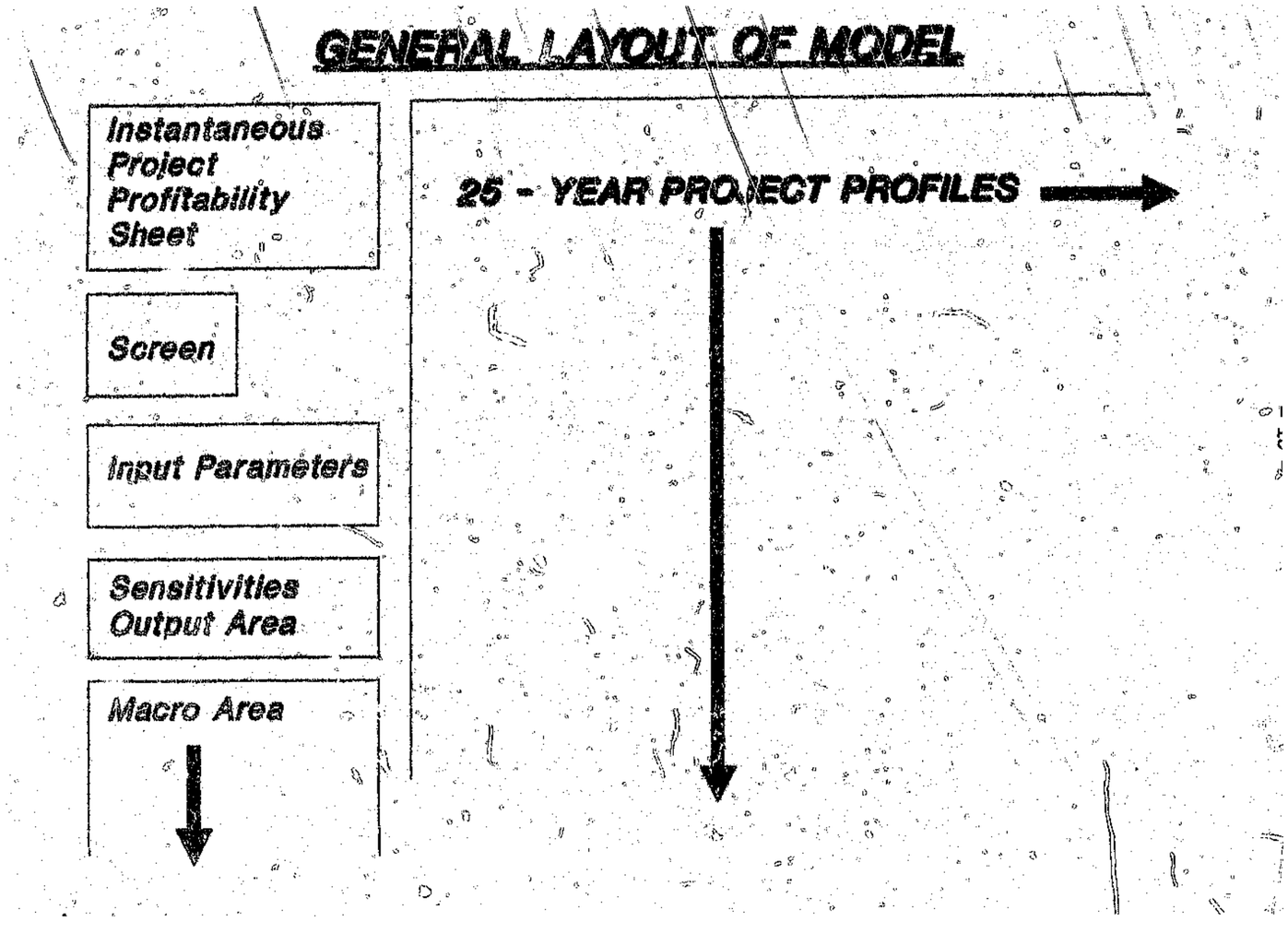
Macro Area :-

Macros are included here for inputting data, calculating, saving, sensitivity/risk analysis, printing, viewing results graphically, editing the worksheet, returning to the main directory menu and quitting from Lotus 1-2-3.

25 - Year Project Profiles :-

The input in this area, for 25 financial years (July to June) starting in 1991/92, include the SA and USCPI's, head grades, tons milled, free market prices, exchange rates, tax surcharge rates and capex. Figures from elsewhere in the worksheet are used to calculate metal production, costs and other financial data and, finally, 25 - year profiles of cashflows, NPV's, Real IRR's and the robustness parameters mentioned previously are produced.

GENERAL LAYOUT OF MODEL



3.2 CONVENTIONAL SENSITIVITY ANALYSIS

The forecast economic parameters used in this study until the financial year 1999/2000 are detailed on page 13. These figures represent one of many views of the possible economic scenario for the next ten years but have a basis in the predictions of PGM experts[1]. They are considered sufficient for this exercise's purposes. It has been said that economic forecasts tend to be even less reliable than weather forecasts but that, in fact, the average annualised error of long-term forecasts is often smaller than that of short-term ones[3]. After FY1999/2000, purchasing-power-parity is assumed[4]. That is, metal prices are escalated at the USCPI and the R/US$ exchange rate is escalated by SACPI/USCPI in order to maintain constant real metal prices in Rand terms. A straight-line price forecast is thus assumed.

The conventional results are straightforward calculations of cashflows based on the input parameters assumed and thus only one set of results in year 25 is produced. The accounting of inflation is important from a taxation point of view. Constant money terms are arrived at after discounting both negative and positive cash flows by the cumulative SACPI for each applicable year.

For sensitivity analysis, the following parameters are allowed to vary :-

(i) Individual Metal Prices (US$/oz for PGMs, US$/t for Ni and £/t for Cu)
(ii) Working Costs (R)
(iii) Capex (R)
(iv) Recovered Grades (g PGM/t)
(v) Milled Tons (t)
(vi) SACPI (% pa)
(vii) USCPI (% pa)
(viii) R/US$ Exchange Rate
(ix) R/£ Exchange Rate
(x) Lease Payments (R)

(xi) Royalty Payments (R)

(xii) Tax Rate (% applicable to taxable profit)

(xiii) Timing of Initial Production (important in build-up and expansion phases)

The worksheet menu allows for input of required sensitivity ranges for instantaneous results of net working costs per ton milled, net working costs per ounce of platinum produced and cash margin. In all cases in this study, these instantaneous figures were calculated for $\pm$ 5% on the above sensitivity parameters.

In addition, the long-term results for 25-year NPV @ 0% discount (R million, base date), 25-year Real IRR (%) and escalated maximum cash exposure (R million escalated) were calculated for $\pm$ 20% on the above sensitivity parameters.

Finally, best and worst cases for all the above were calculated using the $\pm$ 5% or $\pm$ 20% sensitivity, as the case may be. 5% and 20% were chosen to illustrate the sensitivity analysis technique, although different percentages could be chosen, depending on the preference of the operator.

FORECAST ECONOMIC PARAMETERS

Financial Parameters

Financial Year	'92	'93	'94	'95	'96	'97	'98	'99	'00
USCPI %	5,00	4,75	4,50	4,50	4,50	4,50	4,50	4,50	4,50
SACPI %	12,75	12,00	11,25	10,75	10,25	10,00	10,00	10,00	10,00
Exch.Rate R/US$	2,88	3,03	3,08	3,13	3,24	3,42	3,60	3,80	4,00
Exch.Rate US$/£	1,69	1,88	1,86	1,92	1,95	1,90	1,88	1,88	1,88

Projected Metal Prices (Free Market)

Financial Year	'92	'93	'94	'95	'96	'97	'98	'99	'00
Pt US$/oz	387	455	513	575	613	638	665	698	729
Pd US$/oz	98	113	133	148	175	175	185	198	210
Rh US$/oz	3 375	3 620	4 065	4 372	4 875	4 875	5 250	4 850	5 250
Ru US$/oz	58	58	61	64	69	69	73	77	81
Ir US$/oz	298	305	320	320	352	352	369	388	407
Au US$/oz	374	420	470	490	530	530	555	652	685
Ni US$/t	8 133	8 402	8 800	9 300	10 100	10 100	10 650	11 200	11 750
Cu US$/t	1 294	1 392	1 525	1 625	1 675	1 725	1 725	1 775	1 825

3.3 RISK ANALYSIS

@Risk, produced by Palisade Corporation, is a true "add-in" to Lotus 1-2-3, using Lotus-style menus and @functions. It allows for uncertain cell values in 1-2-3 to be defined as probability distributions using @functions. A cell containing the distribution @function @NORMAL (10;10), for example, would return samples during a simulation drawn from a normal distribution - mean = 10; standard deviation 10). Distribution @functions are only invoked during a simulation (in normal 1-2-3 operations, they show a single cell value - just the same as 1-2-3 without @Risk). Available distribution types include :-

Beta	Erlang	Lognormal
Binomial	Exponential	Negative Binomial
Chi-Square	Gamma	Normal
Correlations	General	Pareto
Cumulative	Geometric	Poisson
Discrete	Histogram	Triangular
Discrete Uniform	Hypergeometric	Uniform
Error Functions	Logistic	Weibull

@Risk has sophisticated capabilities for specifying and executing simulations of 1-2-3 models. Both Monte Carlo and Latin Hypercube sampling techniques are supported and distributions of possible results may be generated for any cell or range of cells in the spreadsheet model.

For this research, the model was designed to allow for the following distributions of input parameters :-

INPUT PARAMETER	DOWNWARD POTENTIAL %	EXPECTED %	UPWARD POTENTIAL %
Pt Price (US$/oz)	x_1	100	y_1
Pd Price (US$/oz)	x_2	100	y_2
Au Price (US$/oz)	x_3	100	y_3
Rh Price (US$/oz)	x_4	100	y_4
Ru Price (US$/oz)	x_5	100	y_5
Ir Price (US$/oz)	x_6	100	y_6
Ni Price (US$/t)	x_7	100	y_7
Cu Price (£/t)	x_8	100	y_8
Working Costs (R)	x_9	100	y_9
Capex (R)	x_{10}	100	y_{10}
Recovered Grades (g PGM/t)	x_{11}	100	y_{11}
Milled Tons (t)	x_{12}	100	y_{12}
SACPI (% pa)	x_{13}	100	y_{13}
USCPI (% pa)	x_{14}	100	y_{14}
R/US$	x_{15}	100	y_{15}
R/£	x_{16}	100	y_{16}
Lease (R)	x_{17}	100	y_{17}
Royalty (R)	x_{18}	100	y_{18}
Tax (%)	x_{19}	100	y_{19}
Timing	x_{20}	100	y_{20}

The distribution @function used in all cases follows the form of @TNORMAL(1;@MAX(y_n-100;100-x_n)/3;x_n;y_n) for n = 1 to 20.

@TNORMAL(μ;σ;minimum;maximum) is a truncated Normal distribution, constrained by truncated minimum and maximum values as shown above. The density function is:-

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(x-\mu)/2\sigma^2} [F_n(maximum) - F_n(minimum)]^{-1}$$

where $F_n(x)$ is the distribution function for the Normal.

The Normal distribution was used to represent the fact that quantities which are the sums of other quantities tend to a Normal distribution because of the central limit theorem. The input parameters above are each the sum of many other variables and subject to a host of influences that in themselves may vary according to their own distribution functions. Hence, a Normal distribution was felt to be justified. The truncation values are used in order to reflect the operator's assessment of minima and maxima. In all cases, the Latin Hypercube sampling technique was used.

It must be kept in mind that @Risk is merely a tool used during this study and that the study itself is more than just an examination of this tool.

3.4 ROBUSTNESS CRITERIA

As mentioned previously, the Real IRR (%) and NPV @ 0% discount (R million, base date) are divided by the following criteria in each of financial years 1 to 25 :-

(i) Working cost per ton milled net of by-product revenue (R/t)

(ii) Working cost per ounce of platinum produced net of by-product revenue (R/oz Pt)

(iii) Profit per ton milled (R/t)

(iv) Profit per ounce of platinum produced (R/oz Pt)

(v) Cut-off head grade (g PGM/t)

(vi) Cash margin (or Profit/Revenue ratio) (%)

In all cases, costs include ongoing capex, royalty payments and lease payments in order to properly compare projects with different requirements for these items. Therefore, figures produced for net costs, profit and margin take account of these expenditures.

If :-

x = Project Factor (Real IRR or NPV @ 0% discount)

and y = Robustness Criterion (one of the 6 above),

then the following number is produced :-

$$z = x/y$$

During simulation, each iteration produces a number :-

$$z + \Delta z = \frac{x + \Delta x}{y + \Delta y}$$

The objective is thus to determine which of the above "y" factors follows the rise and fall of the above "x" factors most closely. That is, which produces the smaller average number for Δz. For ease, the output variable examined in the simulations is:-

$$(x/y)/((x + \Delta x)/(y + \Delta y)) - 1 = z/(z + \Delta z) - 1 = \hat{V}$$

which should average as closely as possible to zero.

In this work, 1 000 iterations were run per simulation, producing both the risk analysis results and the variability of V around zero, as well as the expected result for V.

4. HARTLEY PLATINUM MINE

4.1 GENERAL

Delta Gold NL have made several announcements in recent years on the results from exploration and feasibility studies at their Hartley PGM deposit on the Great Dyke in Zimbabwe[6].

They have declared that the project is viable at a production level of 2 million t pa, 106 000 oz Pt pa and 2 450 t Ni pa. Pages 20 to 23 shows the input parameters used, taken from Delta's evaluation. The main differences in these input parameters from those used by Delta are the assumption of South African Rand terms and the forecast economic parameters shown on page 13. For strict evaluation purposes (rather than this more comparative exercise), Hartley should be rather evaluated using Zimbabwean currency and economic factors.

The reef to be mined at Hartley is a Great Dyke sulphide zone and is more similar to the Bushveld Igneous Complex's Merensky Reef than to its UG2 Reef. This evaluation has been confined to published data on this project and any missing data was estimated. No confidential information is used or, indeed, was available.

23-Jul-91 JUL 1991 TERMS — RLEY.WK1 — INTRAMARGINAL ANALYSIS OF PLATINUM PRODUCERS : — HARTLEY EVALUATION, JUNE 1991

FACF's			RESERVES (TONS) GEOLOGICAL	IN-SITU	MINEABLE	t p.a.	oz Pt p.a.	LIFE years
HEREMSKY	1.15	HEREMSKY						
USZ	1.27	USZ						

EXCHANGE RATES: JUL 1991 TERMS — R/US$ 2.935 — US$/£ 1.698

METAL PRICES : JUL 1991 TERMS

	FREE MARKET US$/oz	SALES R/oz
Pt	279.78	1 845.97
Pd	95.56	269.68
Au	384.49	1 055.11
Rh	3 275.00	9 042.38
Ru	59.59	161.52
Ir	295.83	814.58

	US$/t	R/t
Ni	8 135.00	22 460.73

	£/t	R/t
Cu	1 282.59	3 540.39

HEREMSKY	% SPLIT IN-SITU	CORRECTED IN-SITU	CORRECTED HEAD	ESTIMATED CONCENTRATOR	RECOVERIES SMELTER	NCR	PMR	YIELD g/t	% SPLIT (BASE/Pt)	REVENUE R/t
TOTALS		5,600	4,748							
Pt	44.73%	2,505	2,120	82.20%	97.52%	99.00%	99.65%	1.648	47.89%	55.49
Pd	38.25%	2,332	1,928	79.81%	97.50%	99.00%	99.00%	1.299	37.89%	11.01
Au	7.88%	0,425	0,355	72.85%	97.50%	97.00%	97.00%	0.239	6.89%	7.28
Rh	9.55%	0,201	0,179	83.18%	97.50%	95.50%	95.50%	0.124	3.55%	35.17
Ru	5.78%	0,319	0,278	72.73%	97.50%	94.00%	92.00%	0.163	4.66%	8.85
Ir	2.11%	0,116	0,108	43.63%	97.50%	94.00%	78.00%	0.028	0.80%	8.73
TOTALS	100.00%	5,600	4,748	79.19%	97.50%	97.49%	97.71%	3.501	100.00%	111.94
Ni	g/t	2 127	1803	74.62%	95.02%	95.00%		1 225	743	27.51
Cu	g/t	1 388	1176	78.25%	95.02%	95.00%		785	476	2.78

MINING EXTRACTION	UNCORRECTED IN-SITU	UNCORRECTED HEAD			
	84.64%	4,878	4,129	TOTAL REVENUE	142.24
				OVERALL RECOVERY	73.85%
				MATTE kg/t	2,691

USZ	% SPLIT IN-SITU	CORRECTED IN-SITU	CORRECTED HEAD	ESTIMATED CONCENTRATOR	RECOVERIES SMELTER	NCR	PMR	YIELD g/t	% SPLIT (BASE/Pt)	REVENUE R/t
		7,026	5,165							
Pt	45.65%	3,573	2,958	83.93%	97.50%	98.50%	99.80%	1.652	46.91%	62.33
Pd	31.51%	2,465	1,827	83.80%	97.50%	98.00%	99.80%	1.178	32.37%	18.83
Au	8.93%	0,073	0,048	83.80%	97.50%	97.00%	97.00%	0.037	8.93%	1.18
Rh	6.61%	0,593	0,452	82.80%	97.50%	94.50%	95.50%	0.257	6.51%	74.68
Ru	12.68%	0,992	0,655	83.08%	97.50%	94.00%	92.00%	0.458	11.61%	2.38
Ir	2.41%	0,189	0,224	83.08%	97.50%	94.00%	78.00%	0.066	1.68%	1.74
TOTALS	100.00%	7,826	5,165	83.80%	97.50%	97.15%	97.15%	3.947	100.00%	153.14
Ni	g/t	388	198	48.03%	95.00%	95.00%		87	47	1.95
Cu	g/t	150	59	75.00%	95.00%	95.00%		69	37	0.24

MINING EXTRACTION	UNCORRECTED IN-SITU	UNCORRECTED HEAD			
	56.26%	6,197	4,383	TOTAL REVENUE	155.33
				OVERALL RECOVERY	76.43%
				MATTE kg/t	2,282

COMBINED HEREMSKY & USZ

	YIELD g/t	% SPLIT (BASE/Pt)	REVENUE R/t
Pt	1.646	47.93%	55.49
Pd	1.259	37.95%	11.01
Au	0.238	6.92%	7.28
Rh	0.174	3.55%	35.17
Ru	0.163	4.65%	8.85
Ir	0.028	0.93%	8.73
TOTAL	3.501	100.00%	111.94
Ni	1 225	743	27.51
Cu	785	476	2.78

	TOTAL REVENUE	142.24
	OVERALL RECOVERY	73.85%
	MATTE kg/t	2,691

NOTE: IN-SITU GRADE IS QUOTED ACROSS THE THEORETICAL IDEAL STOPING WIDTH

COMBINED HEREMSKY & USZ

	g/t IN-SITU	HEAD
UNCORRECTED	4,878	4,129
CORRECTED	5,658	4,748

			HEREMSKY	USZ	COMBINED (USZ @ 0.00%)
(a) TOTAL REVENUE PER t		R/t	142.24	155.33	142.24
(b) TOTAL COSTS PER t		R/t	85.94	88.05	85.94
(c) BY-PRODUCT CREDITS PER t		R/t	86.75	92.01	86.75
(d) TOTAL REVENUE PER oz Pt		R/oz Pt	2 584	2 684	2 584
(e) TOTAL COSTS PER oz Pt		R/oz Pt	1 622	1 448	1 622
(f) BY-PRODUCT CREDITS PER oz Pt		R/oz Pt	1 637	1 562	1 637
(g) TOTAL COSTS NET OF BY-PRODUCT CREDITS	(b)-(c)	R/t	(0,80)	(5,96)	(0,81)
(h) TOTAL COSTS NET OF BY-PRODUCT CREDITS	(e)-(f)	R/oz Pt	(15)	(117)	(15)
(i) PROFIT PER TON	(a)-(b)	R/t	56,29	69,27	56,29
(j) PROFIT PER oz Pt	(d)-(e)	R/oz Pt	1 062	1 164	1 062
(k) CASH MARGIN PER TON	(i)/(a)	%/t	39,58	44,59	39,58
(l) CASH MARGIN PER oz Pt	(j)/(d)	%/oz Pt	39,58	44,59	39,58
(o) CUT-OFF HEAD GRADE	(b)/(a)*M3	g PGM/t	2,654	2,862	2,654 (CORRECTED)
(d) CUT-OFF HEAD GRADE	(b)/(a)*M3	g PGM/t	2,495	2,262	2,495 (UNCORRECTED)

WORKING COSTS : JUL 1991 TERMS

	HEREMSKY R/t	USZ R/t	TOTAL R/t
(1) MINING, R/t :	38,79	38,79	38,79
(2) MINERAL PROCESSING, R/t :	18,55	18,55	18,55
(3) ON-SITE SERVICES, R/t :	6,96	6,96	6,96
(4) OFF-SITE PROCESSING, R/t :	15,28	15,28	15,28
(5) INFRASTRUCTURE COMPANY, R/t :	5,25	5,25	5,25
SUB TOTAL	82,83	82,83	82,83
(4) MARKETING (INCL) % OF REVENUE : 0,88%			
MARKETING, R/t :	1,24	1,36	1,24
TOTAL WORKING COST	84,07	84,19	84,07
(6) ONGOING CAPEX, R/t	1,87	1,87	1,87
TOTAL COSTS	85,94	86,06	85,94
TOTAL COSTS WITH ROYALTY	85,94	86,06	85,94

SOURCES OF INPUT DATA

GEOLOGICAL/MINING DATA :	AS PER PLB, JUNE 1991
METALLURGICAL DATA :	AS PER HLM, JUNE 1991
WORKING COST DATA :	AS PER PLB, JUNE 1991
METAL PRICES :	AS PER PLB, JUNE 1991

YEARLY PRODUCTION STATISTICS :	BUDGET	ANNUALISED	% VARIANCE
'000 t MILLED, HEREMSKY	2 863	2 864	0,05%
'000 t MILLED, USZ	0	0	ERR
'000 oz Pt	105	156	0,00%
'000 " Pd	84	83	-0,44%
'000 " Au	8	8	-2,02%
	t Ni	2 150	2 150	-0,01%
	t Cu	1 538	1 570	0,51%

29-Jul-91 JUL 1991 TERMS — HARTLEY.WK4 — INTRAMARGINAL ANALYSTS OF PLATINUM PRODUCERS : — HARTLEY EVALUATION, JUNE 1991

FACT'S	
MERENSKY	1,15
UG2	1,27

RESERVES (TONS) — GEOLOGICAL / INSITU / MINEABLE; t p.a.; oz Pt p.a.; LIFE years

EXCHANGE RATES: JUL 1991 TERMS — R/US$ 2,835; US$/£ 1,698

MERENSKY	% SPLIT IN-SITU	CORRECTED IN-SITU	CORRECTED HEAD	ESTIMATED CONCENTRATOR	ESTIMATED SMELTER	RECOVERIES MCR	RECOVERIES PMR	YIELD g/t	% SPLIT (BASE/Pt)	REVENUE R/t
TOTALS		5,988	4,748							
Pt	44,73%	2,589	2,120	92,20%	97,58%	99,00%	99,66%	1,549	47,93%	55,49
Pd	36,29%	2,032	1,722	78,81%	97,59%	88,88%	98,66%	1,299	37,99%	17,81
Au	7,60%	0,425	0,356	72,65%	97,85%	97,98%	97,98%	0,239	6,98%	7,78
Rh	9,99%	0,281	0,172	83,13%	97,59%	94,56%	95,58%	0,124	3,55%	36,17
Ru	1,70%	0,319	0,270	71,73%	97,58%	94,00%	92,98%	0,163	3,86%	0,95
Ir	2,11%	0,119	0,108	43,63%	97,58%	94,88%	78,88%	0,026	0,88%	0,73
TOTALS	100,00%	5,666	4,748	78,59%	97,59%	97,46%	97,71%	3,381	100,00%	111,84
Ni	g/t	2 127	1808	74,52%	95,90%	95,90%		1 225	743	27,51
Cu	g/t	1 398	1188	78,25%	95,88%	95,90%		705	476	2,76

MINING EXTRACTION	UNCORRECTED IN-SITU	UNCORRECTED HEAD
	84,84%	4,976	4,129

TOTAL REVENUE 142,24; OVERALL RECOVERY 73,08%; MATTE kg/t 2,831

UG2	% SPLIT IN-SITU	CORRECTED IN-SITU	CORRECTED HEAD	ESTIMATED CONCENTRATOR	ESTIMATED SMELTER	RECOVERIES MCR	RECOVERIES PMR	YIELD g/t	% SPLIT (BASE/Pt)	REVENUE R/t
Pt	45,65%	7,026	5,165	83,00%	97,58%	90,00%	99,66%	1,452	45,91%	82,33
Pd	31,51%	2,466	1,627	83,00%	97,58%	90,00%	99,66%	1,778	32,37%	10,03
Au	3,93%	0,873	0,648	83,00%	97,58%	97,00%	97,00%	0,837	0,93%	1,19
Rh	8,01%	0,533	0,352	83,00%	97,58%	94,56%	95,58%	0,257	8,51%	24,68
Ru	12,66%	0,892	0,655	83,00%	97,58%	94,00%	92,98%	0,456	11,61%	2,90
Ir	2,41%	0,189	0,124	83,00%	97,58%	94,00%	78,88%	0,066	1,65%	1,74
TOTALS	100,00%	7,026	5,165	83,00%	97,58%	97,15%	97,18%	3,947	100,00%	152,14
Ni	g/t	388	198	48,00%	95,88%	95,90%		87	47	1,95
Cu	g/t	150	99	78,00%	95,88%	96,00%		80	37	0,24

MINING EXTRACTION	UNCORRECTED IN-SITU	UNCORRECTED HEAD
	66,00%	6,107	4,802

TOTAL REVENUE 155,33; OVERALL RECOVERY 76,13%; MATTE kg/t 2,262

COMBINED MERENSKY & UG2

	YIELD g/t	% SPLIT (BASE/Pt)	REVENUE R/t
Pt	1,648	47,09%	55,49
Pd	1,299	37,09%	11,81
Au	0,239	6,83%	7,78
Rh	0,124	3,55%	36,17
Ru	0,163	3,86%	0,95
Ir	0,026	0,88%	0,73
TOTAL	3,501	100,00%	111,84
Ni	1 225	743	27,51
Cu	705	476	2,76

TOTAL REVENUE 142,24; OVERALL RECOVERY 73,08%; MATTE kg/t 2,831

NOTE: IN-SITU GRADE IS QUOTED ACROSS THE THEORETICAL IDEAL CHANNEL WIDTH

COMBINED MERENSKY & UG2 — g/t IN-SITU / HEAD
UNCORRECTED 4,870 / 4,129
CORRECTED 5,590 / 4,748

			MERENSKY	UG2	COMBINED (UG2 @ 0,98%)
(a) TOTAL REVENUE PER t		R/t	142,24	155,33	142,24
(b) TOTAL COSTS PER t		R/t	56,94	106,86	56,94
(c) BY-PRODUCT CREDITS PER t		R/t	86,75	93,08	86,75
(d) TOTAL REVENUE PER oz Pt		R/oz Pt	2 934	2 809	2 804
(e) TOTAL COSTS PER oz Pt		R/oz Pt	1 622	1 446	1 622
(f) BY-PRODUCT CREDITS PER oz Pt		R/oz Pt	1 697	1 562	1 697
(g) TOTAL COSTS NET OF BY-PRODUCT CREDITS	(b)-(c)	R/t	(0,89)	(6,94)	(0,86)
(h) TOTAL COSTS NET OF BY-PRODUCT CREDITS	(e)-(f)	R/oz Pt	(15)	(117)	(15)
(i) PROFIT PER TON	(a)-(b)	R/t	56,29	69,27	56,29
(j) PROFIT PER oz Pt	(d)-(e)	R/oz Pt	1 062	1 164	1 062
(k) CASH MARGIN PER TON	(i)/(a)	%	39,58	44,59	39,59
(l) CASH MARGIN PER oz Pt	(j)/(d)	%	39,59	44,58	39,59
(m) CUT-OFF HEAD GRADE	(b)/(a)*4E6	g PGM/t	2,084	2,062	2,084 (CORRECTED)
(n) CUT-OFF HEAD GRADE	(b)/(a)*4E6	g PGM/t	2,405	2,262	2,405 (UNCORRECTED)

WORKING COSTS : JUL 1991 TERMS

	MERENSKY R/t	UG2 R/t	TOTAL R/t
(1) MINING, R/t :	38,79	36,79	38,79
(2) MINERAL PROCESSING, R/t :	18,55	18,55	18,55
(3) ON-SITE SERVICES, R/t :	8,96	8,96	8,96
(4) OFF-SITE PROCESSING, R/t :	15,20	15,20	15,20
(5) INFRASTRUCTURE COMPANY, R/t :	5,25	5,25	5,25
SUB TOTAL	82,03	82,63	82,03
(4) MARKETING (UHCC)			
% OF REVENUE :	0,00%		
MARKETING, R/t :	1,24	1,36	1,24
TOTAL WORKING COST	84,07	84,18	84,07
(6) ONGOING CAPEX, R/t	1,87	1,87	1,87
TOTAL COSTS	85,94	86,06	85,94
TOTAL COSTS WITH ROYALTY	85,94	86,06	85,94

SOURCES OF INPUT DATA

GEOLOGICAL/MINING DATA :	AS PER PLB, JUNE 1991
METALLURGICAL DATA :	AS PER MAK, JUNE 1991
WORKING COST DATA :	AS PER PLB, JUNE 1991
METAL PRICES :	AS PER PLB, JUNE 1991

YEARLY PRODUCTION STATISTICS :	BUDGET	ANNUALISED	% VARIANCE
'000 t MILLED, MERENSKY	2 000	2 002	0,08%
'000 t MILLED, UG2	0	0	250
'000 oz Pt	106	106	0,00%
'000 oz Pd	64	65	0,89%
'000 oz Rh	0	0	0,00%
t Ni	2 450	2 450	0,01%
t Cu	1 578	1 578	-0,01%

Company : HARTLEY EVALUATION, JUNE 1991

METAL	1ST YR PIPELINE %
Pt	78.00%
Pd	67.00%
Au	83.00%
Rh	48.00%
Ru	48.00%
Ir	48.00%
Ni	98.00%
Cu	98.00%

INPUT FACTORS :

LEASE FORMULA : Y =			
	0.08	MINUS	0.08 /X
ROYALTY PERCENTAGE			0.00%
TAX RATE			50.00%
TAX BASE? (Y/N)	N		

BASE DATE CALCULATION ; JUL 1991 TERMS

MONTHS FROM JULY 1991 : 0

	BOTTOM	ESTIMATED LIMITS MIDDLE	
Pt PRICE :	78.00%	100.00%	138.00%
Pd PRICE :	78.00%	100.00%	120.00%
Au PRICE :	64.00%	100.00%	136.00%
Rh PRICE :	68.00%	100.00%	130.00%
Ru PRICE :	64.00%	100.00%	196.00%
Ir PRICE :	64.00%	100.00%	136.00%
Ni PRICE :	98.00%	100.00%	138.00%
Cu PRICE :	94.00%	100.00%	136.00%
WORKING COSTS :	92.00%	100.00%	102.00%
CAPEX :	95.00%	100.00%	130.00%
RECOVERED GRADE :	95.00%	100.00%	105.00%
MILLED TONNAGES :	90.00%	100.00%	110.00%
SACPI :	96.00%	100.00%	125.00%
USCPI :	98.00%	100.00%	110.00%
RUSS EXCHANGE RATE :	90.00%	100.00%	125.00%
R/E EXCHANGE RATE :	90.00%	100.00%	125.00%
LEASE PAYMENT :	0.00%	100.00%	150.00%
ROYALTY PAYMENT :	98.00%	100.00%	120.00%
TAX RATE :	96.00%	100.00%	150.00%
TIMING :	95.00%	100.00%	130.00%

SALES CONTRACTED :

Pt PRICE	97.00%
Pd PRICE	
Au PRICE	
Rh PRICE	
Ru PRICE	
Ir PRICE	
Ni PRICE	
Cu PRICE	97.00%

LEVERAGES :

Pt PRICE :	100.00%
Pd PRICE :	100.00%
Au PRICE :	100.00%
Rh PRICE :	100.00%
Ru PRICE :	100.00%
Ir PRICE :	100.00%
Ni PRICE :	100.00%
Cu PRICE :	100.00%
ALL PRICES :	100.00%
WORKING COSTS :	100.00%
CAPEX :	100.00%
RECOVERED GRADE :	100.00%
MILLED TONNAGES :	100.00%
SACPI :	100.00%
USCPI :	100.00%
RUSS EXCHANGE RATE :	100.00%
R/E EXCHANGE RATE :	100.00%
LEASE PAYMENT :	100.00%
ROYALTY PAYMENT :	100.00%
TAX RATE :	100.00%
TIMING :	100.00%

RISK ANALYSIS (Y/N) N

STARTING POINTS : 90/91

MERENSKY HEAD GRADE, g/t	3.950
UG2 HEAD GRADE, g/t	3.900
MERENSKY TONS MILLED	0
UG2 TONS MILLED	0
UNRECOVERED CAPEX, $ million	0

01-07-23

INPUT DATA

HARTLEY.WK1		FINANCIAL YEARS	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04
SACP			12,25%	12,00%	11,25%	10,75%	10,25%	10,00%	10,00%	10,00%	10,00%	10,00%	10,00%	10,00%	10,00%
SA DISCOUNT FACTOR			1,052	1,109	1,323	1,465	1,615	1,777	1,955	2,150	2,365	2,602	2,862	3,148	3,463
MERENSKY HEAD GRADE	g/t		4,740	4,740	4,740	4,740	4,740	4,740	4,740	4,740	4,740	4,740	4,740	4,740	4,740
UG2 HEAD GRADE	g/t		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
MERENSKY MILLED	t		0	0	1 748 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
UG2 MILLED	t		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL MILLED	t		0	0	1 748 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
PERCENTAGE UG2	%		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Pt PRODUCED	kg		0	0	64 454	101 539	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000
Pd PRODUCED	kg		0	0	49 972	78 917	93 500	93 500	93 500	93 500	93 500	93 500	93 500	93 500	93 500
Au PRODUCED	kg		0	0	9 206	14 564	15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000
Rh PRODUCED	kg		0	0	3 341	7 459	8 000	8 000	8 000	8 000	8 000	8 000	8 000	8 000	8 000
Ru PRODUCED	kg		0	0	4 385	9 798	18 000	18 000	18 000	18 000	18 000	18 000	18 000	18 000	18 000
Ir PRODUCED	kg		0	0	676	1 068	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Ni PRODUCED	t		0	0	1 910	2 418	2 456	2 456	2 456	2 456	2 456	2 456	2 456	2 456	2 456
Cu PRODUCED	t		0	0	1 229	1 549	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570
Pt PRICE, FREE MARKET	US$/oz		386,93	455,23	513,06	575,68	613,88	630,60	665,06	699,88	729,86	781,01	799,09	831,91	869,35
Pd PRICE, FREE MARKET	US$/oz		97,61	113,08	133,99	148,99	163,09	175,00	185,00	195,06	210,02	219,45	229,33	239,64	250,43
Au PRICE, FREE MARKET	US$/oz		379,53	420,88	478,99	498,06	518,00	542,06	555,06	652,86	665,89	715,83	740,84	781,78	816,90
Rh PRICE, FREE MARKET	US$/oz		3 375,00	3 823,49	4 804,50	4 372,00	4 625,06	4 875,00	5 250,00	4 656,66	5 256,00	5 486,25	5 733,13	5 991,12	6 260,72
Ru PRICE, FREE MARKET	US$/oz		57	50,82	61,98	64,06	66,06	68,00	73,06	77,00	81,00	84,65	88,45	92,43	96,59
Ir PRICE, FREE MARKET	US$/oz		325,13	365,22	318,00	328,00	338,00	352,70	369,00	378,00	407,00	425,32	444,45	464,45	485,36
Ni PRICE, FREE MARKET	US$/t		8 133,47	8 181,32	8 000,00	8 200,00	8 600,00	8 [illegible]6,06	10 550,00	11 [illegible]0,00	11 700,00	12 220,75	12 231,20	13 698,70	14 312,65
Cu PRICE, FREE MARKET	R/t		1 394,26	1 391,61	1 535,00	1 575,00	1 625,00	1 675,00	1 725,00	1 [illegible]5,00	1 825,00	1 900,00	1 954,99	2 023,41	2 094,23
EXCHANGE RATE	R/US$		2,80	3,03	3,86	3,13	3,24	3,42	3,66	3,00	4,06	4,21	4,48	4,67	4,91
EXCHANGE RATE	R/£		5,45	5,69	5,73	6,08	6,59	6,91	6,70	7,16	7,53	8,08	8,51	9,84	9,61

91-07-25

INPUT DATA

HARTLEY.WK1		FINANCIAL YEARS	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96
SACPI			16,00%	15,00%	16,00%	10,00%	16,00%	15,00%	10,00%	10,00%	10,00%	10,00%	15,00%	10,00%
SA DISCOUNT FACTOR			3,000	4,190	4,600	5,676	5,577	5,195	6,748	7,423	8,165	8,982	8,999	10,000
MERENSKY HEAD GRADE	g/t		4,748	4,748	4,748	4,748	4,748	4,748	4,748	4,748	4,748	4,748	4,748	4,748
UG2 HEAD GRADE	g/t		8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
MERENSKY MILLED	t		2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
UG2 MILLED	t		0	0	0	0	0	0	0	0	0	0	0	0
TOTAL MILLED	t		2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
PERCENTAGE UG2	%		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Pt PRODUCED	oz		186 000	186 000	186 000	186 000	186 000	186 000	186 000	186 000	186 000	186 000	186 000	186 000
Pd PRODUCED	oz		93 000	93 000	93 000	93 000	93 000	93 000	93 000	93 000	93 000	93 000	93 000	93 000
Au PRODUCED	oz		15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000	15 000
Rh PRODUCED	oz		8 000	8 000	8 000	8 000	8 000	8 000	8 000	8 000	8 000	8 000	8 000	8 000
Ru PRODUCED	oz		19 000	19 000	19 000	19 000	19 000	19 000	19 000	19 000	19 000	19 000	19 000	19 000
Ir PRODUCED	oz		1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
Ni PRODUCED	t		2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450
Cu PRODUCED	t		1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570
Pt PRICE, FREE MARKET	US$/oz		908,47	949,38	992,97	1 036,71	1 083,36	1 132,11	1 183,05	1 236,30	1 291,93	1 350,07	1 418,82	1 474,81
Pd PRICE, FREE MARKET	US$/oz		261,78	273,47	285,79	298,64	312,08	326,12	340,98	356,14	372,16	388,81	406,41	424,78
Au PRICE, FREE MARKET	US$/oz		853,63	892,05	932,19	974,14	1 017,99	1 063,85	1 111,85	1 161,69	1 213,05	1 268,50	1 325,97	1 385,32
Rh PRICE, FREE MARKET	US$/oz		5 542,40	6 056,87	7 144,52	7 408,63	7 682,98	8 159,83	8 519,98	8 909,38	9 304,83	9 722,71	16 168,28	16 917,44
Ru PRICE, FREE MARKET	US$/oz		108,94	105,49	110,23	115,19	120,37	125,78	131,45	137,37	143,55	150,01	156,76	163,81
Ir PRICE, FREE MARKET	US$/oz		587,20	630,02	658,07	578,79	604,74	632,00	660,58	690,22	721,28	753,74	787,66	823,10
Ni PRICE, FREE MARKET	US$/t		14 842,64	15 381,36	15 999,13	16 799,58	17 [illegible]	18 247,99	19 069,52	19 926,51	20 822,38	21 769,35	22 739,57	23 782,05
Cu PRICE, FREE MARKET	R/t		2 167,53	2 243,39	2 321,91	2 403,19	2 [illegible]	2 574,34	2 654,44	2 757,79	2 854,22	2 954,12	3 057,51	3 164,52
EXCHANGE RATE	R/US$		5,17	5,44	5,79	6,03	6,35	6,68	7,03	7,48	7,78	8,28	8,57	9,09
EXCHANGE RATE	R/£		10,21	10,05	11,53	12,28	12,63	13,05	14,72	15,54	16,52	17,57	18,78	19,95

4.2 CONVENTIONAL RESULTS

Pages 25 to 33 shows the detailed results, with graphs, of the standard project evaluation of Hartley. In summary, these are as follows :-

Real IRR, %, 25 years :	11,36
NPV, R million, 25 years, @ 0% discount :	993
@ 3% discount :	530
@ 5% discount :	333
Maximum Exposure, escalated, R million :	595
Maximum Exposure, base date, R million :	518
Payback Period, years, escalated money :	6
Payback Period, years, base date money :	9

In addition, sensitivities were run (see pages 34 to 40) showing that the project was most sensitive to variations in metal prices and recovered grades.

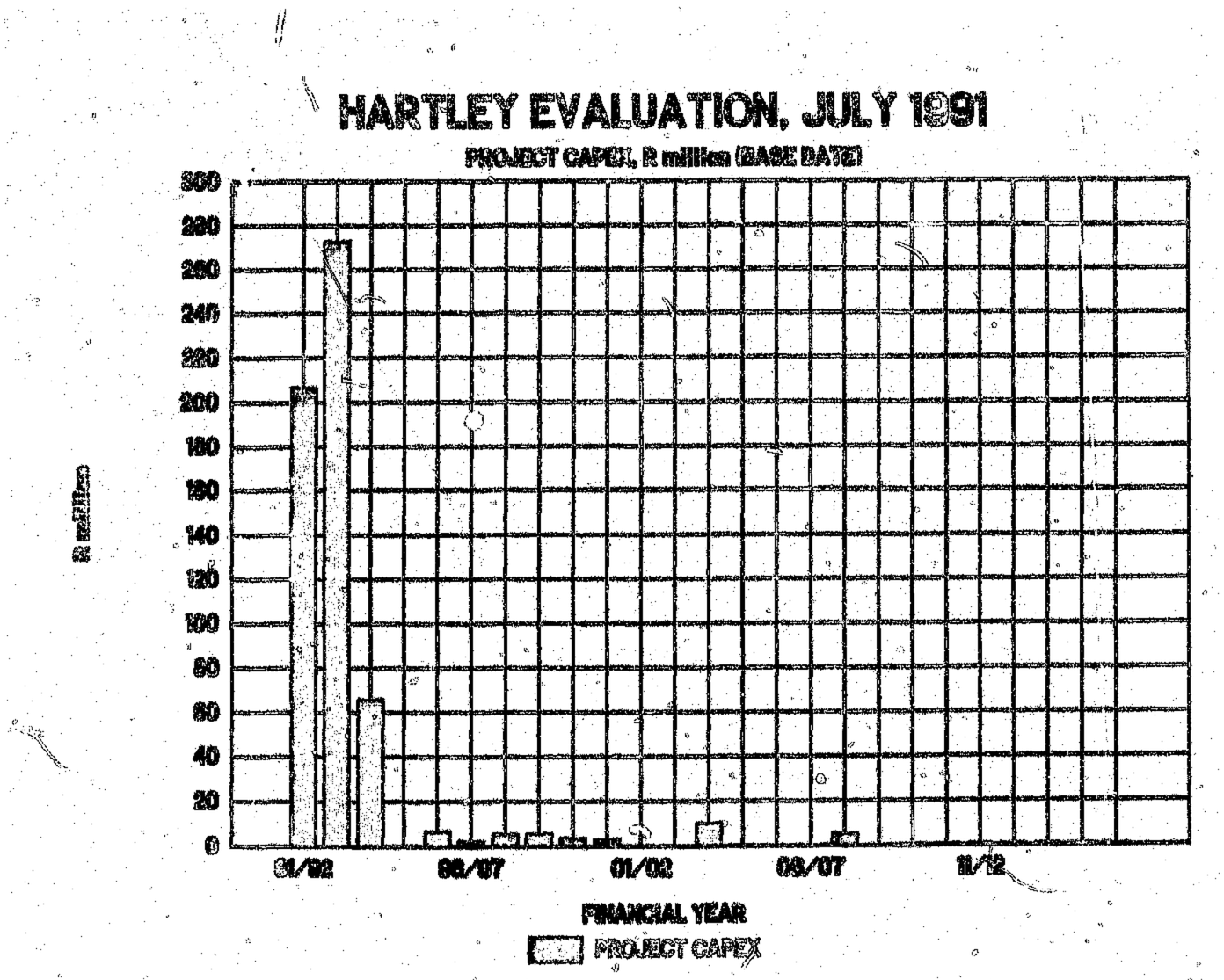
01-07-23 ANALYSIS RESULTS

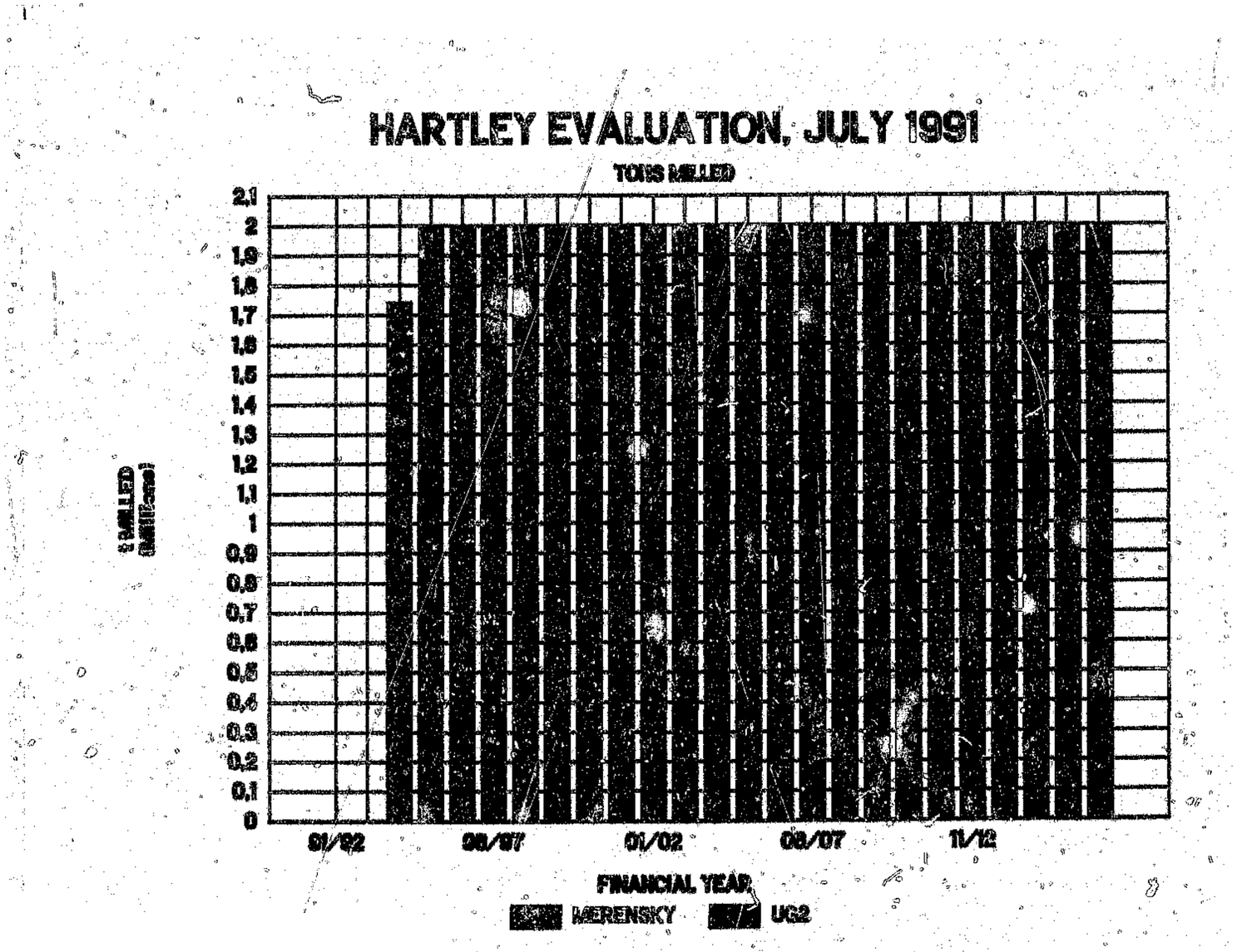
HARTLEY,MK1	FINANCIAL YEARS	01/92	02/93	03/94	04/95	05/96	06/97	07/98	23/99	09/00	00/01	01/02	02/03	03/04
ESCALATED R million														
REVENUE		0	0	232	421	493	534	593	641	713	784	869	949	1 844
TOTAL WORKING COST		0	0	184	246	272	299	328	362	398	437	481	529	592
WORKING PROFIT		0	0	48	175	212	235	264	280	315	347	382	420	762
WORKING CAPEX		0	0	0	0	0	0	0	0	0	0	0	0	0
PROJECT CAPEX		219	324	87	6	11	4	11	12	9	7	8	8	36
ONGOING CAPEX		0	0	4	5	6	7	7	8	8	10	11	12	13
TOTAL CAPEX		219	324	91	11	17	11	18	20	17	17	11	12	49
LEASE PAYMENT		0	0	0	0	0	0	0	0	0	0	0	0	0
ROYALTY PAYMENT		0	0	0	0	0	0	0	0	0	0	0	0	0
TAX PAYABLE		0	0	0	0	0	112	123	130	149	165	185	204	297
TOTAL GOVERNMENT		0	0	0	0	0	112	123	130	149	165	185	204	297
ESCALATED CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		(219)	(324)	(51)	176	195	112	123	130	149	165	185	204	297
BASE DATE CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		(206)	(273)	(36)	116	121	69	69	69	69	69	69	69	69
ESCALATED CUMULATIVE CASH FLOW	R million	(219)	(543)		(425)	(230)	(118)	6	134	283	448	633	837	1 844
BASE DATE CUMULATIVE CASH FLOW	R million	(206)	(479)		(402)	(282)	(219)	(156)	(95)	(32)	31	99	161	229
BASE DATE REVENUE PER t MILLED	R/t	0,00	0,00		148,81	148,81	150,16	151,61	149,98	150,75	150,75	150,75	150,75	150,75
BASE DATE REVENUE PER oz Pt	R/oz Pt	0	0	2 733	2 824	2 824	2 933	2 858	2 913	2 844	2 844	2 844	2 844	2 844
BASE DATE TOTAL COSTS PER t MILLED	R/t	0,00	0,00	85,94	85,94	85,94	88,84	85,94	85,94	85,94	85,94	85,94	85,94	85,94
BASE DATE TOTAL COSTS PER oz Pt	R/oz Pt	0	0	2 317	1 607	1 622	1 622	1 622	1 622	1 822	1 622	1 622	1 622	1 622
BASE DATE BY-PRODUCT CREDITS PER t MILLED	R/t	0,00	0,00	50,32	62,90	86,15	86,69	80,39	85,4	87,11	87,11	87,11	87,11	87,11
BASE DATE BY-PRODUCT CREDITS PER oz Pt	R/oz Pt	0	0	1 572	1 620	1 625	1 639	1 668	1 612	1 644	1 644	1 644	1 644	1 644
BASE DATE NETT TOTAL COSTS PER t MILLED	R/t	0,00	0,00	27,63	2,96	(0,91)	(0,93)	(2,45)	0,53	(1,16)	(1,16)	(1,16)	(1,16)	(1,16)
BASE DATE NETT TOTAL COSTS PER oz Pt	R/oz Pt	0	0	745	58	(4)	(16)	(46)	19	(22)	(22)	(22)	(22)	(22)
BASE DATE WORKING PROFIT PER t MILLED	R/t	0,00	0,00	15,45	57,07	53,67	64,22	65,66	63,14	64,80	64,80	64,80	64,80	64,80
BASE DATE WORKING PROFIT PER oz Pt	R/oz Pt	0	0	416	1 136	1 201	1 212	1 239	1 191	1 223	1 223	1 223	1 223	1 223
CASH MARGIN, PROFIT/REVENUE	%	0,00	0,00	18,24	48,24	42,55	42,77	43,31	42,35	42,89	42,99	42,99	42,99	42,99
MERENSKY CUT-OFF HEAD GRADE	g PGM/t	0,000	0,000	4,010	2,933	2,723	2,713	2,903	2,732	2,702	2,702	2,702	2,702	2,702
UG2 CUT-OFF HEAD GRADE	g PGM/t	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
TOTAL CUT-OFF HEAD GRADE	g PGM/t	0,000	0,000	4,010	2,933	2,723	2,713	2,897	2,732	2,702	2,702	2,702	2,702	2,702
NPV CASH FLOW, 0%	R million	(206)	(479)	(518)	(402)	(282)	(219)	(156)	(95)	(32)	31	99	161	228
NPV CASH FLOW, 1%	R million	(204)	(472)	(509)	(390)	(263)	(224)	(185)	(118)	(52)	5	63	121	178
NPV CASH FLOW, 2%	R million	(202)	(464)	(501)	(394)	(265)	(228)	(174)	(123)	(70)	(18)	34	85	131
NPV CASH FLOW, 3%	R million	(200)	(457)	(493)	(398)	(266)	(233)	(102)	(158)	(95)	(90)	8	53	94
NPV CASH FLOW, 4%	R million	(198)	(451)	(485)	(306)	(267)	(237)	(109)	(145)	(101)	(58)	(16)	24	68
NPV CASH FLOW, 5%	R million	(197)	(444)	(477)	(302)	(266)	(241)	(155)	(115)	(75)	(39)	(2)	(30)	38
NPV CASH FLOW, 6%	R million	(195)	(437)	(470)	(270)	(260)	(244)	(202)	(164)	(127)	(91)	(57)	(25)	3
NPV CASH FLOW, 7%	R million	(193)	(431)	(463)	(274)	(255)	(246)	(207)	(173)	(138)	(106)	(75)	(46)	(21)
NPV CASH FLOW, 8%	R million	(191)	(425)	(456)	(271)	(253)	(249)	(212)	(180)	(146)	(119)	(91)	(65)	(43)
NPV CASH FLOW, 9%	R million	(189)	(419)	(449)	(307)	(298)	(251)	(216)	(186)	(157)	(130)	(105)	(82)	(59)
NPV CASH FLOW, 10%	R million	(187)	(413)	(442)	(363)	(266)	(253)	(220)	(192)	(165)	(141)	(118)	(98)	(80)
NPV CAPEX, 0%	R million	209	479	545	545	551	554	568	565	569	572	572	572	582
IRR CASH FLOW, %		ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	(2,92)	1,22	3,31	4,93	6,11

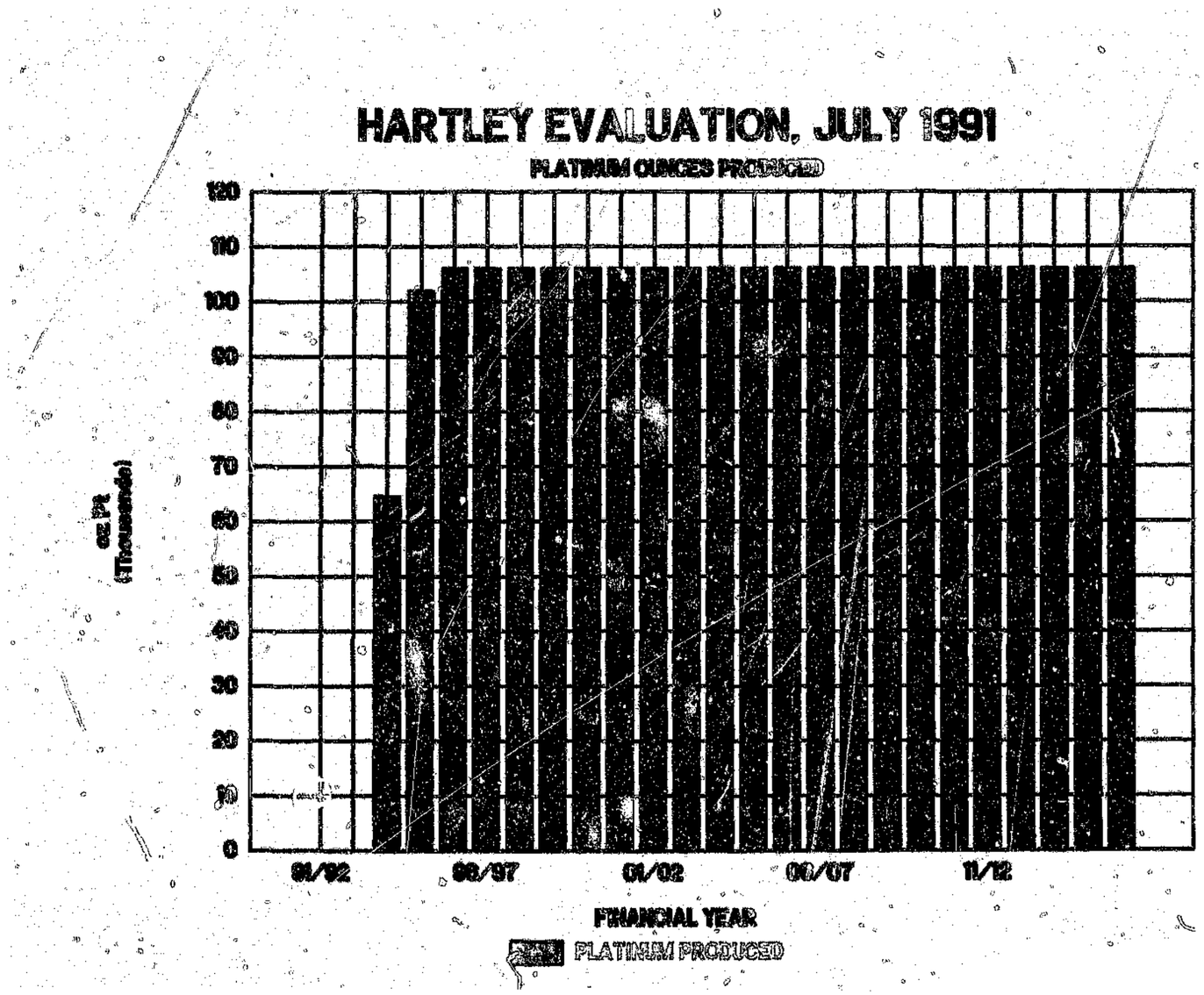
91-07-23

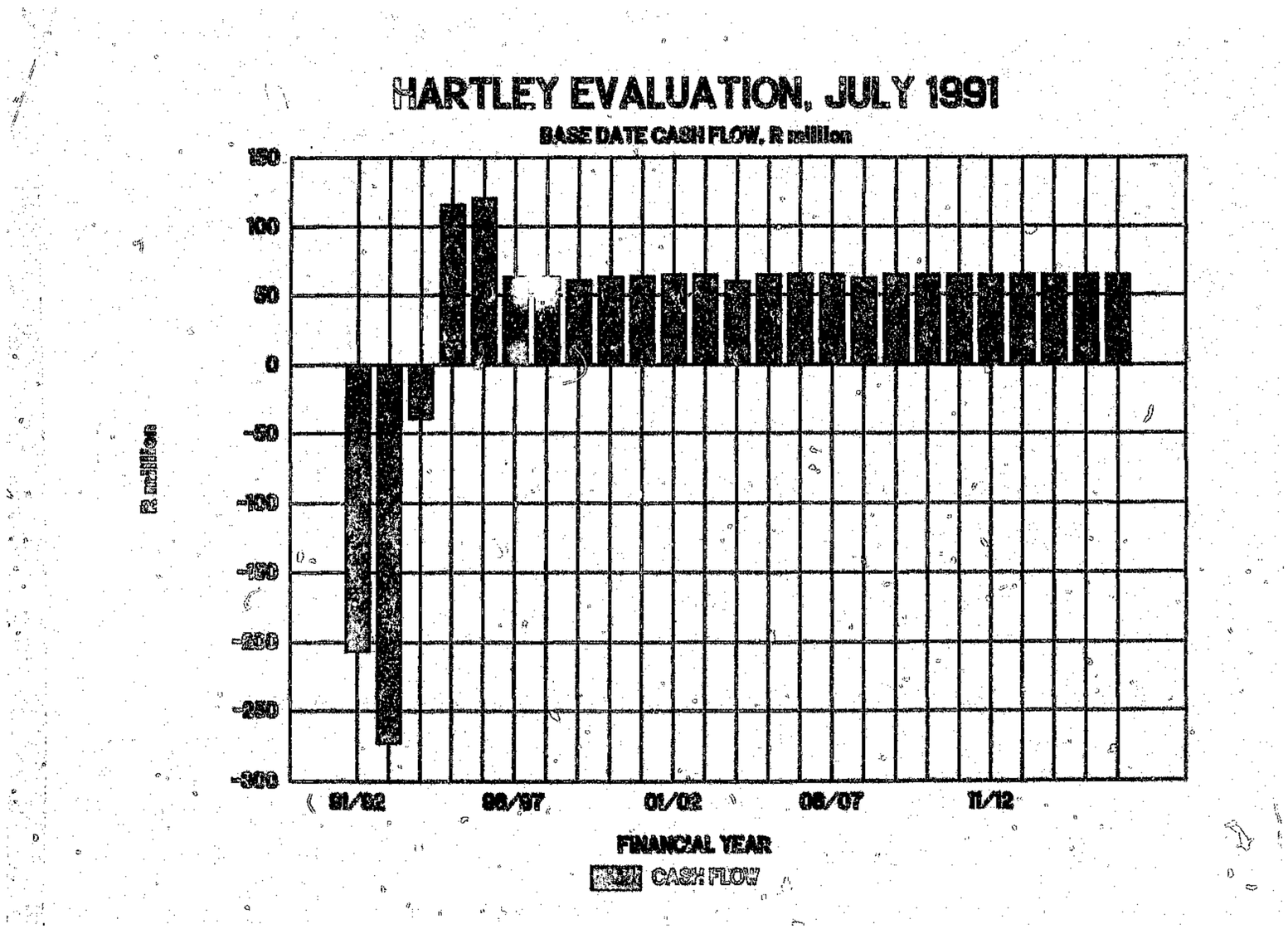
ANALYSIS RESULTS

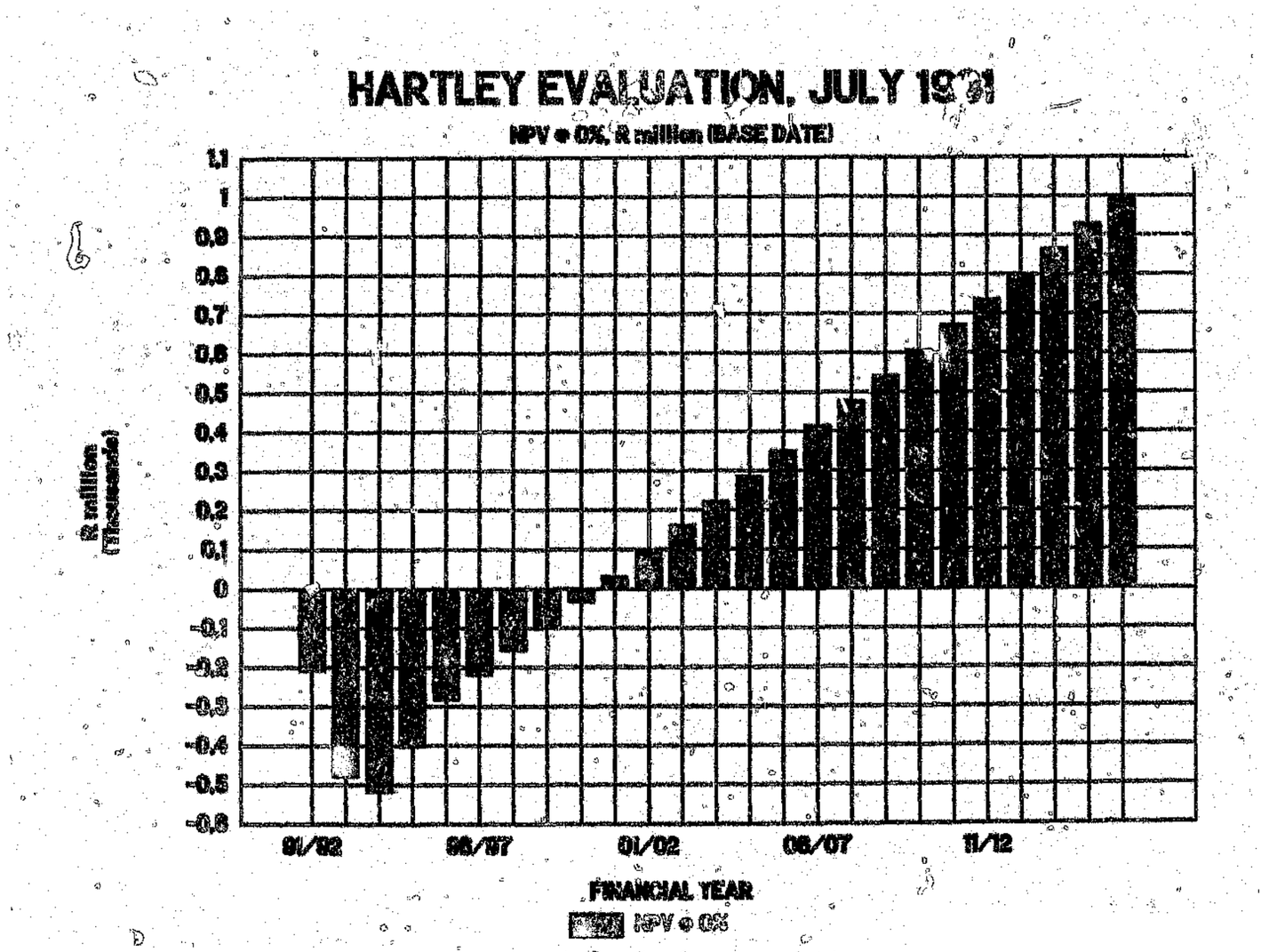
HARTLEY.WK1	FINANCIAL YEARS	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
ESCALATED R million													
REVENUE		1 148	1 263	1 398	1 529	1 681	1 859	2 035	2 238	2 462	2 708	979	3 277
TOTAL WORKING COST		641	765	775	853	938	1 032	1 135	1 240	1 373	1 518	681	1 827
WORKING PROFIT		506	559	615	676	744	818	900	998	1 089	1 190	317	1 449
WORKING CAPEX		0	0	0	0	0	0	0	0	0	0	0	0
PROJECT CAPEX		2	6	6	27	3	3	4	4	4	4	5	5
ONGOING CAPEX		14	16	17	19	21	23	25	28	31	34	37	41
TOTAL CAPEX		16	16	17	46	21	26	29	31	35	38	42	46
LEASE PAYMENT		0	0	0	0	0	0	0	0	0	0	0	0
ROYALTY PAYMENT		0	0	0	0	0	0	0	0	0	0	0	0
TAX PAYABLE		816	272	299	315	361	396	436	479	523	580	638	702
TOTAL GOVERNMENT		248	272	299	315	361	396	436	479	527	588	638	702
ESCALATED CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		348	272	299	315	361	396	436	479	527	588	638	762
BASE DATE CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		65	65	65	62	65	65	65	65	65	65	65	65
ESCALATED CUMULATIVE CASH FLOW	R million	1 208	1 561	1 860	2 175	2 536	2 932	3 368	3 847	4 374	4 954	5 592	6 294
BASE DATE CUMULATIVE CASH FLOW	R million	285	350	414	477	541	606	670	735	800	864	929	993
BASE DATE REVENUE PER t MILLED	R/t	150,75	150,75	150,75	150,75	150,75	150,75	150,75	150,75	150,75	150,75	150,75	150,75
BASE DATE REVENUE PER oz Pt	R/oz Pt	2 844	2 844	2 844	2 844	2 844	2 844	2 844	2 844	2 844	2 844	2 844	2 844
BASE DATE TOTAL COSTS PER t MILLED	R/t	85,94	85,94	85,94	85,94	85,94	85,94	85,94	85,94	85,94	85,94	85,94	85,94
BASE DATE TOTAL COSTS PER oz Pt	R/oz Pt	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622
BASE DATE BY-PRODUCT CREDITS PER t MILLED	R/t	87,11	87,11	87,11	87,11	87,11	87,11	87,11	87,11	87,11	87,11	87,11	87,11
BASE DATE BY-PRODUCT CREDITS PER oz Pt	R/oz Pt	1 644	1 644	1 644	1 644	1 644	1 644	1 644	1 644	1 644	1 644	1 644	1 644
BASE DATE NETT TOTAL COSTS PER t MILLED	R/t	(1,16)	(1,16)	(1,16)	(1,16)	(1,16)	(1,16)	(1,16)	(1,16)	(1,16)	(1,16)	(1,16)	(1,16)
BASE DATE NETT TOTAL COSTS PER oz Pt	R/oz Pt	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)
BASE DATE WORKING PROFIT PER t MILLED	R/t	64,80	64,80	64,80	64,80	64,80	64,80	64,80	64,80	64,80	64,80	64,80	64,80
BASE DATE WORKING PROFIT PER oz Pt	R/oz Pt	1 223	1 223	1 223	1 223	1 223	1 223	1 223	1 223	1 223	1 223	1 223	1 223
CASH MARGIN, PROFIT/REVENUE		42,99	42,99	42,99	42,99	42,99	42,99	42,99	42,99	42,99	42,99	42,99	42,99
MERENSKY CUT-OFF HEAD GRADE	g PGM/t	2,702	2,702	2,702	2,702	2,702	2,702	2,702	2,702	2,702	2,702	2,702	2,702
UG2 CUT-OFF HEAD GRADE	g PGM/t	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
TOTAL CUT-OFF HEAD GRADE	g PGM/t	2,702	2,702	2,702	2,702	2,702	2,702	2,702	2,702	2,702	2,702	2,702	2,702
NPV CASH FLOW, 0%	R million	285	350	414	477	541	606	670	735	800	864	929	993
NPV CASH FLOW, 1%	R million	229	285	341	393	447	501	553	608	658	709	760	810
NPV CASH FLOW, 2%	R million	180	228	275	320	365	410	453	496	537	579	618	658
NPV CASH FLOW, 3%	R million	136	178	210	256	294	331	367	401	435	469	499	530
NPV CASH FLOW, 4%	R million	97	133	166	206	232	262	292	320	347	374	399	423
NPV CASH FLOW, 5%	R million	63	94	123	150	177	203	227	250	273	294	314	333
NPV CASH FLOW, 6%	R million	34	60	84	107	130	151	171	190	208	226	241	256
NPV CASH FLOW, 7%	R million	4	27	48	69	88	106	122	139	153	168	179	191
NPV CASH FLOW, 8%	R million	(21)	(1)	16	35	51	66	80	93	105	116	126	135
NPV CASH FLOW, 9%	R million	(44)	(26)	(9)	5	19	31	43	53	63	72	80	88
NPV CASH FLOW, 10%	R million	(63)	(48)	(34)	(22)	(10)	1	10	19	27	34	41	47
NPV CAPEX, 0%	R million	583	599	583	588	588	588	588	588	590	590	591	591
IRR CASH FLOW, %		7,14	7,77	8,64	9,19	9,64	10,02	10,34	10,62	10,85	11,04	11,21	11,36

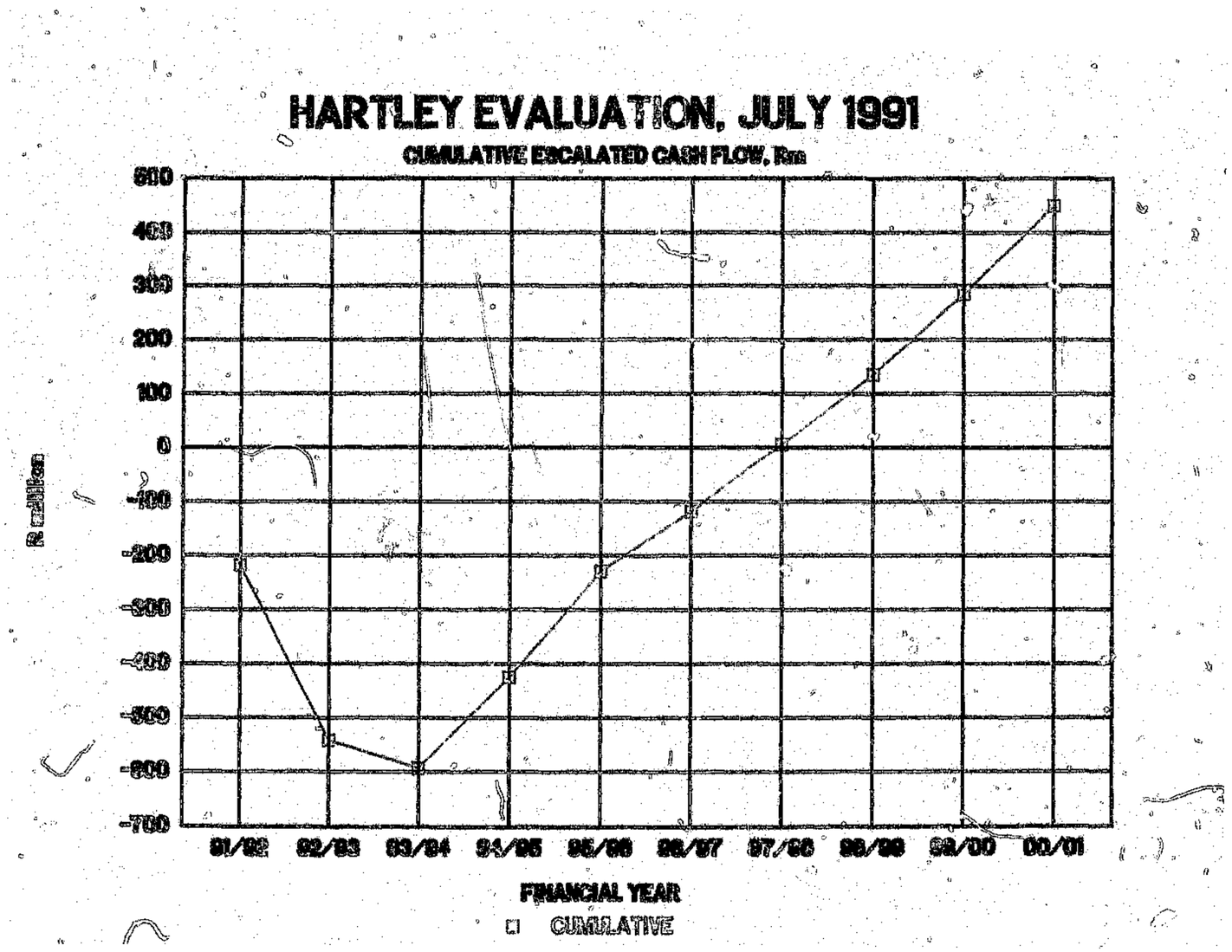

HARTLEY EVALUATION, JULY 1991
PROJECT CAPEX, R million (BASE DATE)
R million
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
01/02
06/07
01/02
03/07
11/12
FINANCIAL YEAR
PROJECT CAPEX

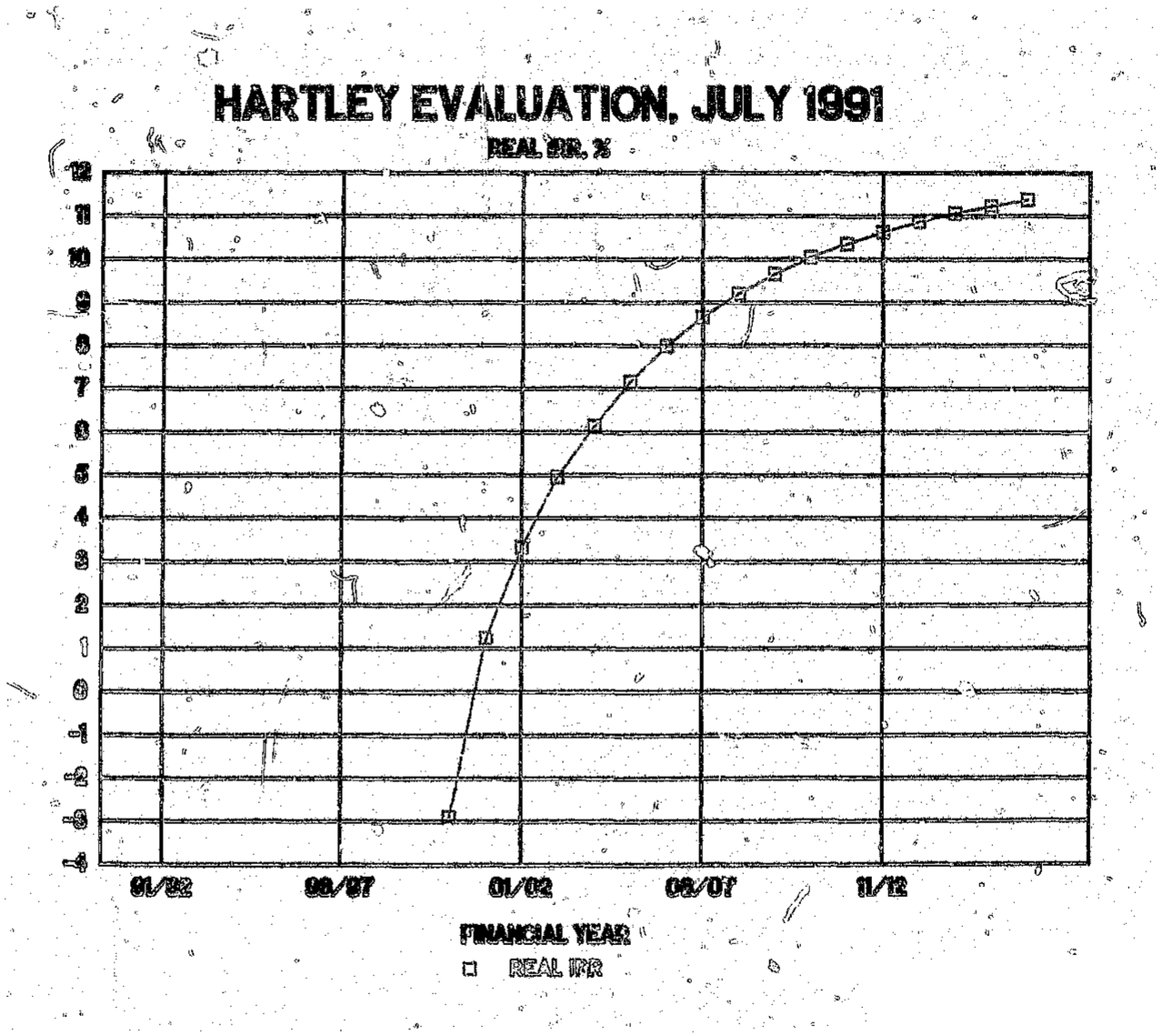

HARTLEY EVALUATION, JULY 1991
TONS MILLED
2,1
2
1,9
1,8
1,7
1,6
1,5
1,4
1,3
1,2
1,1
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
91/92
96/97
01/02
06/07
11/12
FINANCIAL YEAR
MERENSKY
UG2


HARTLEY EVALUATION, JULY 1991
PLATINUM OUNCES PRODUCED
120
110
100
90
80
70
60
50
40
30
20
10
0
oz Pt (Thousands)
01/92
06/97
01/02
06/07
11/12
FINANCIAL YEAR
PLATINUM PRODUCED


HARTLEY EVALUATION, JULY 1991
BASE DATE CASH FLOW, R million
150
100
50
0
-50
-100
-150
-200
-250
-300
R million
91/92
96/97
01/02
06/07
11/12
FINANCIAL YEAR
CASH FLOW


HARTLEY EVALUATION, JULY 1991
NPV @ 0%, R million (BASE DATE)
R million (Thousands)
1,1
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
-0,1
-0,2
-0,3
-0,4
-0,5
-0,6
91/92
96/97
01/02
06/07
11/12
FINANCIAL YEAR
NPV @ 0%


HARTLEY EVALUATION, JULY 1991
CUMULATIVE ESCALATED CASH FLOW, Rm
600
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
R million
91/92
92/93
93/94
94/95
95/96
96/97
97/98
98/99
99/00
00/01
FINANCIAL YEAR
CUMULATIVE


HARTLEY EVALUATION, JULY 1991
REAL RR, %
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
01/02
06/07
01/02
06/07
11/12
FINANCIAL YEAR
REAL IRR

Company : HARTLEY EVALUATION, JUNE 1991

SENSITIVITIES ON NETT TOTAL COSTS PER t, R/t

	-5%	BASE	5%
METAL PRICES	3,47	(0,00)	(5,09)
WORK COSTS	(5,01)	(0,00)	3,40
CAPEX	(0,96)	(0,00)	(0,71)
REC GRADES	3,47	(0,00)	(5,09)
MILLED TONS	(0,00)	(0,00)	(0,00)
SACP1	(0,00)	(0,00)	(0,00)
USCP1	(0,00)	(0,00)	(0,00)
R/US$	3,47	(0,00)	(5,09)
R/£	(0,00)	(0,00)	(0,00)
LEASE	(0,00)	(0,00)	(0,00)
ROYALTY	(0,00)	(0,00)	(0,00)
TAX RATE	(0,00)	(0,00)	(0,00)
WORST CASE		15,60	
BEST CASE		(10,59)	

SENSITIVITIES ON NETT TOTAL COSTS PER oz Pt, R/oz Pt

	-5%	BASE	5%
METAL PRICES	66	(15)	(96)
WORK COSTS	(94)	(15)	64
CAPEX	(17)	(15)	(13)
REC GRADES	69	(15)	(98)
MILLED TONS	(15)	(15)	(15)
SACP1	(15)	(15)	(15)
USCP1	(15)	(15)	(15)
RAUS$	68	(15)	(98)
R/£	(15)	(15)	(15)
LEASE	(15)	(15)	(15)
ROYALTY	(15)	(15)	(15)
TAX RATE	(15)	(15)	(15)
WORST CASE		311	
BEST CASE		(334)	

SENSITIVITIES ON CASH MARGIN, %

	-5%	BASE	5%
METAL PRICES	35,48	39,50	42,41
WORK COSTS	42,53	39,50	36,82
CAPEX	39,84	39,50	39,51
REC GRADES	36,46	39,50	42,41
MILLED TONS	39,50	39,50	39,50
SACP1	39,50	39,50	39,50
USCP1	39,50	39,50	39,50
RAUS$	36,44	39,50	42,41
R/£	39,50	39,50	39,50
LEASE	39,50	39,50	39,50
ROYALTY	39,50	39,50	39,50
TAX RATE	39,50	39,50	39,50
WORST CASE		26,18	
BEST CASE		50,28	

SENSITIVITIES ON NPV @ 0%, R million

	-20%	BASE	20%
METAL PRICES	287	993	1 717
WORK COSTS	1 426	993	607
CAPEX	1 107	993	908
REC GRADES	287	993	1 717
MILLED TONS	711	993	1 306
SACP1	1 176	993	780
USCP1	1 119	993	909
RAUS$	755	993	1 251
R/£	670	993	1 317
LEASE	993	993	993
ROYALTY	993	993	993
TAX RATE	1 240	993	730
TIMING	1 018	993	993
WORST CASE		(1 462)	
BEST CASE		5 531	

SENSITIVITIES ON IRR, % REAL

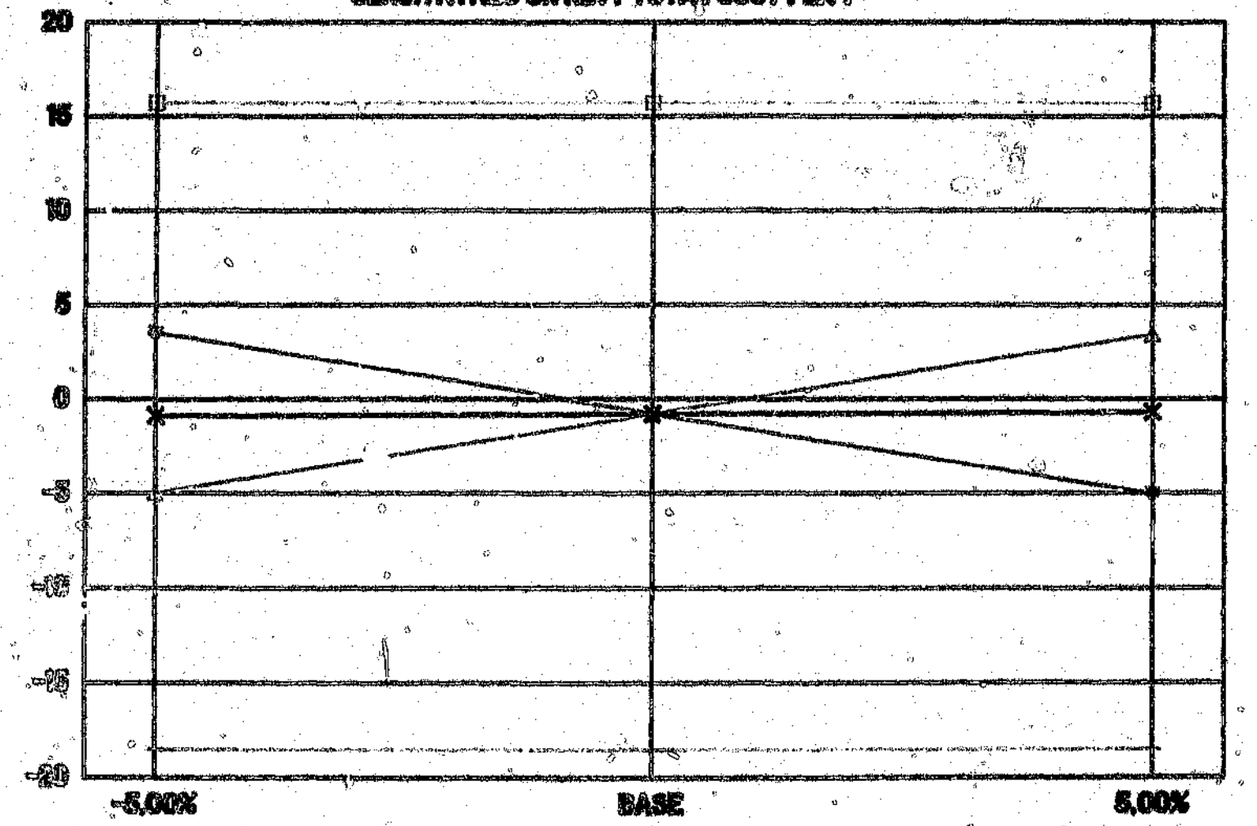
	-20%	BASE	20%
METAL PRICES	3,99	11,36	18,06
WORK COSTS	15,78	11,36	7,91
CAPEX	14,95	11,36	9,28
REC GRADES	3,99	11,36	18,06
MILLED TONS	8,77	11,36	14,25
SACP1	10,54	11,36	12,44
USCP1	11,19	11,36	11,84
RAUS$	7,04	11,36	15,94
R/£	14,11	11,36	11,60
LEASE	11,36	11,36	11,36
ROYALTY	11,36	11,36	11,36
TAX RATE	13,09	11,36	9,30
TIMING	11,96	11,36	11,00
WORST CASE		ERR	
BEST CASE		ERR	

SENSITIVITIES ON MAX EXPOSURE, R million

	-20%	BASE	20%
METAL PRICES	(841)	(995)	(940)
WORK COSTS	(550)	(995)	(938)
CAPEX	(1489)	(995)	(721)
REC GRADES	(841)	(995)	(940)
MILLED TONS	(902)	(995)	(900)
SACP1	(811)	(995)	(979)
USCP1	(884)	(995)	(967)
RAUS$	(813)	(995)	(934)
R/£	(897)	(995)	(953)
LEASE	(995)	(995)	(995)
ROYALTY	(995)	(995)	(995)
TAX RATE	(999)	(995)	(995)
TIMING	(966)	(995)	(982)
WORST CASE		ERR	
BEST CASE		(995)	

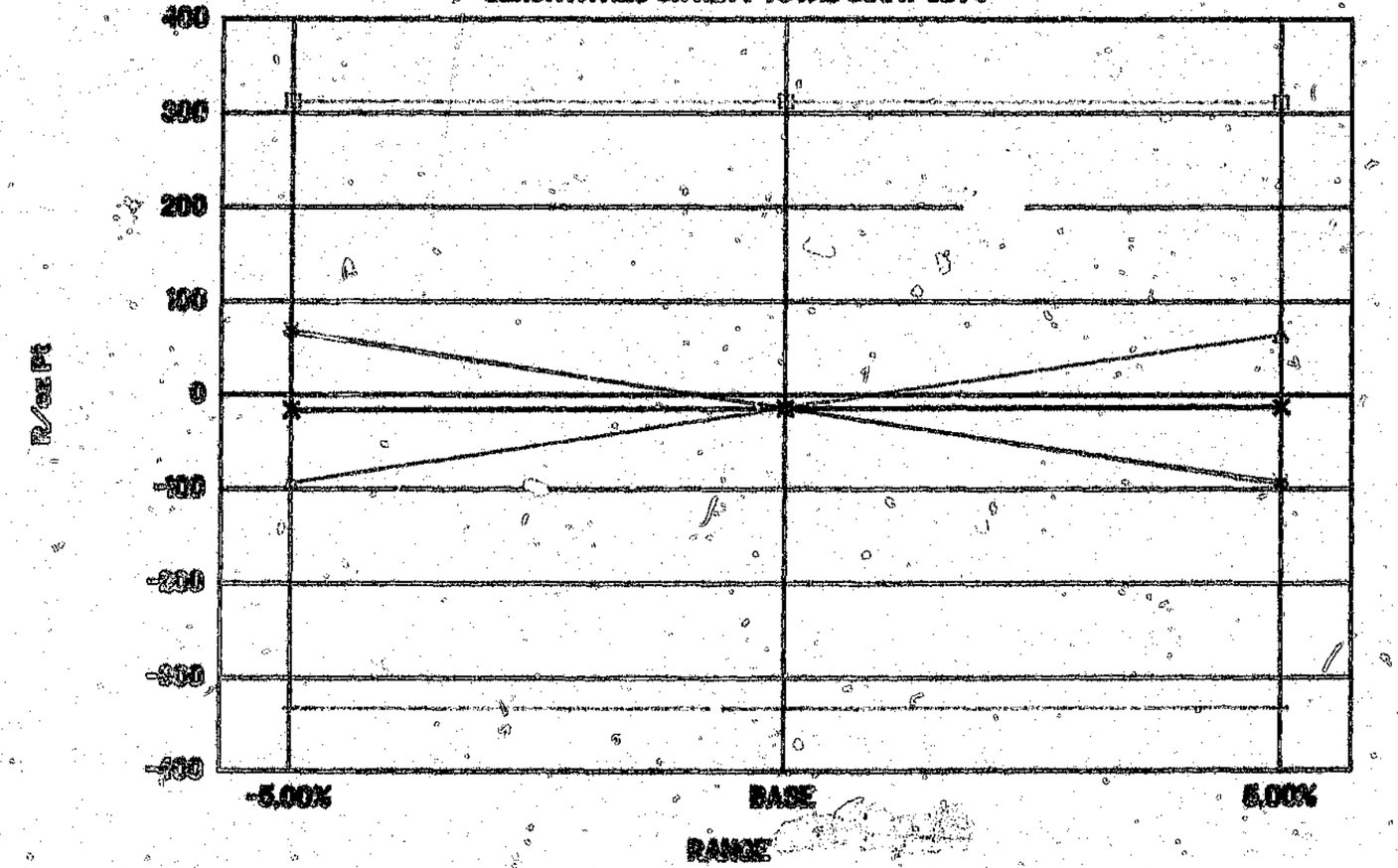
HARTLEY EVALUATION, JULY 1991

SENSITIVITIES ON NETT TOTAL COST PER t

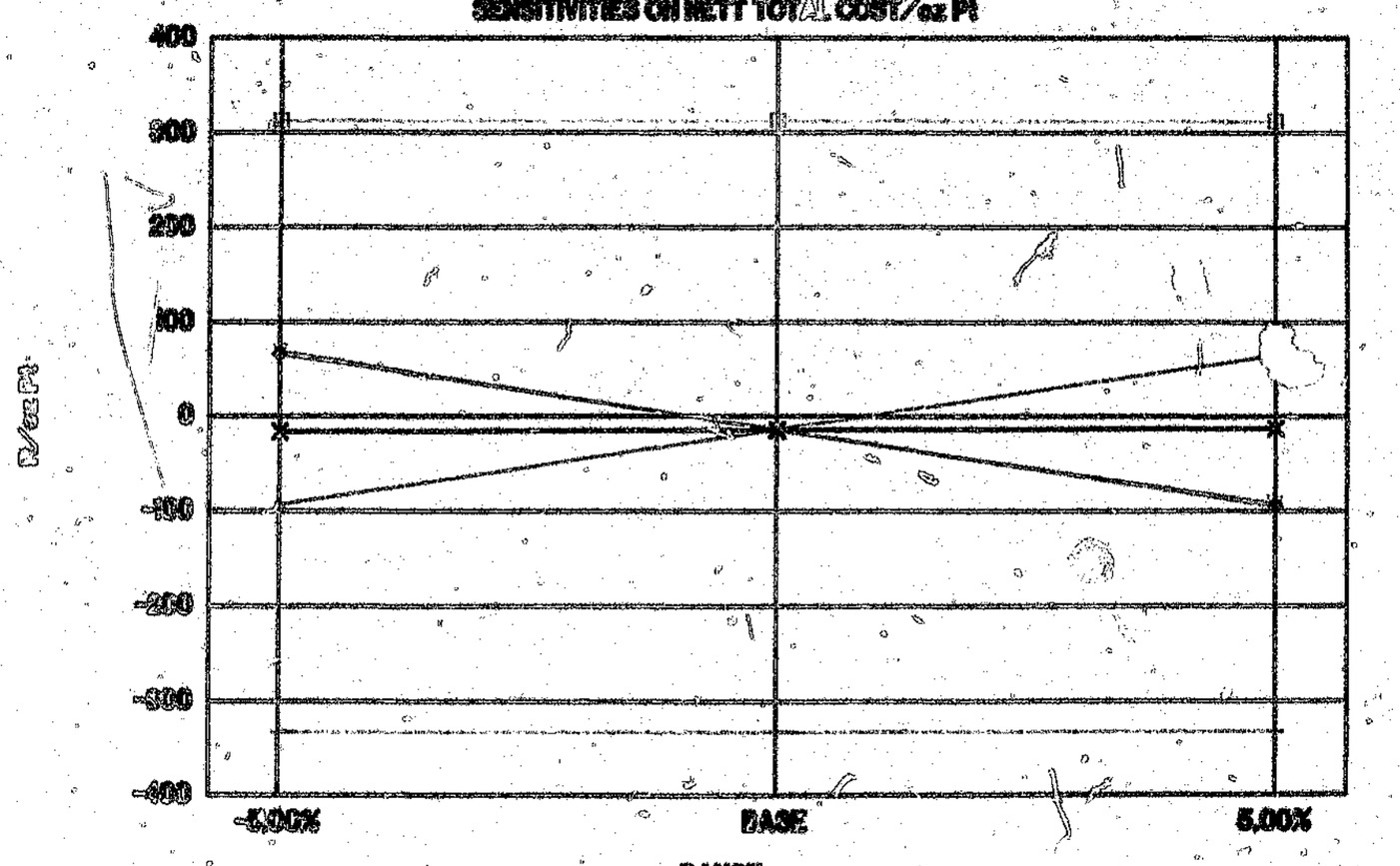


HARTLEY EVALUATION, JUL 1991

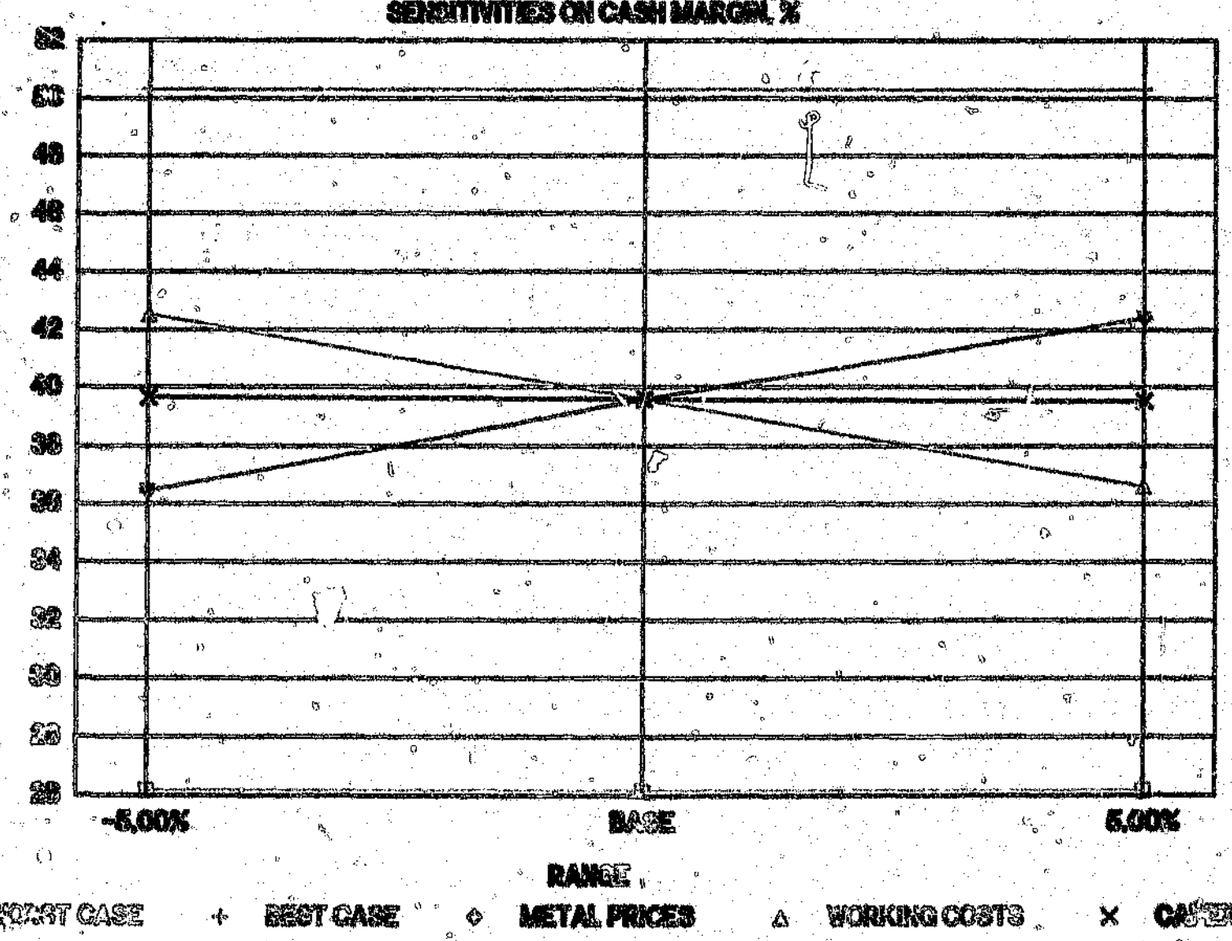
SENSITIVITIES ON NETT TOTAL COST/oz Pt



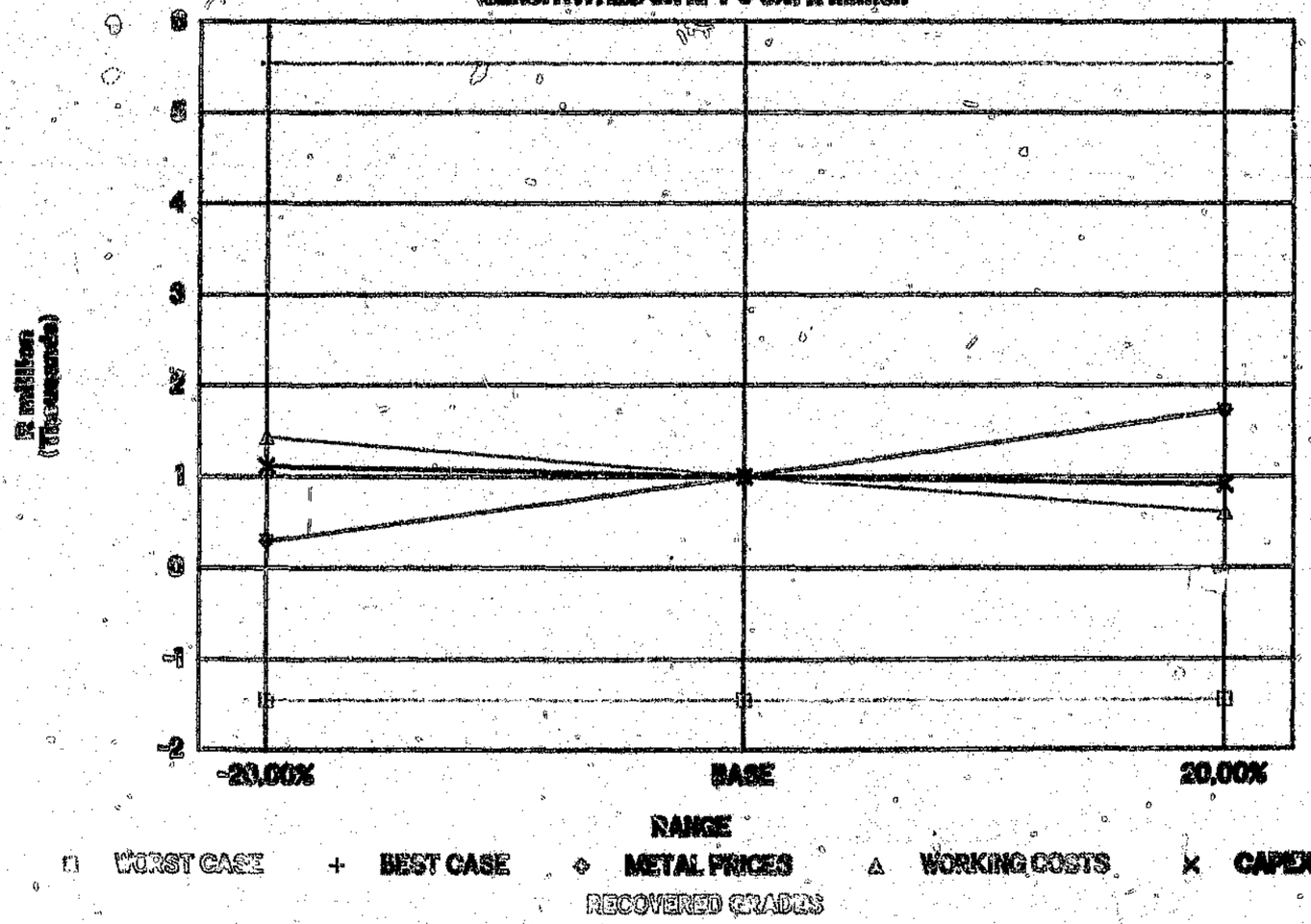
HARTLEY EVALUATION, JULY 1991



HARTLEY EVALUATION, JULY 1991

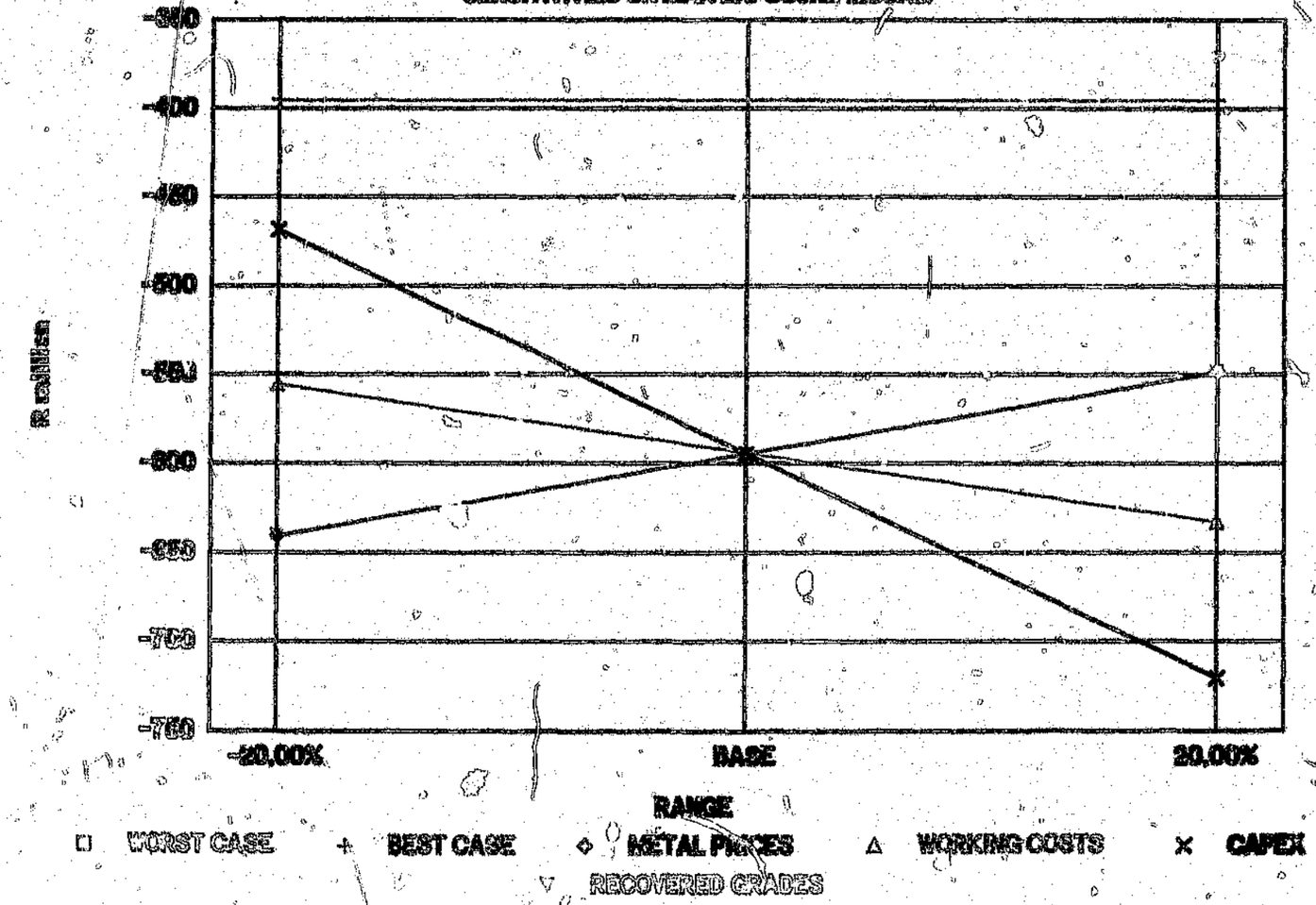


HARTLEY EVALUATION, JULY 1991

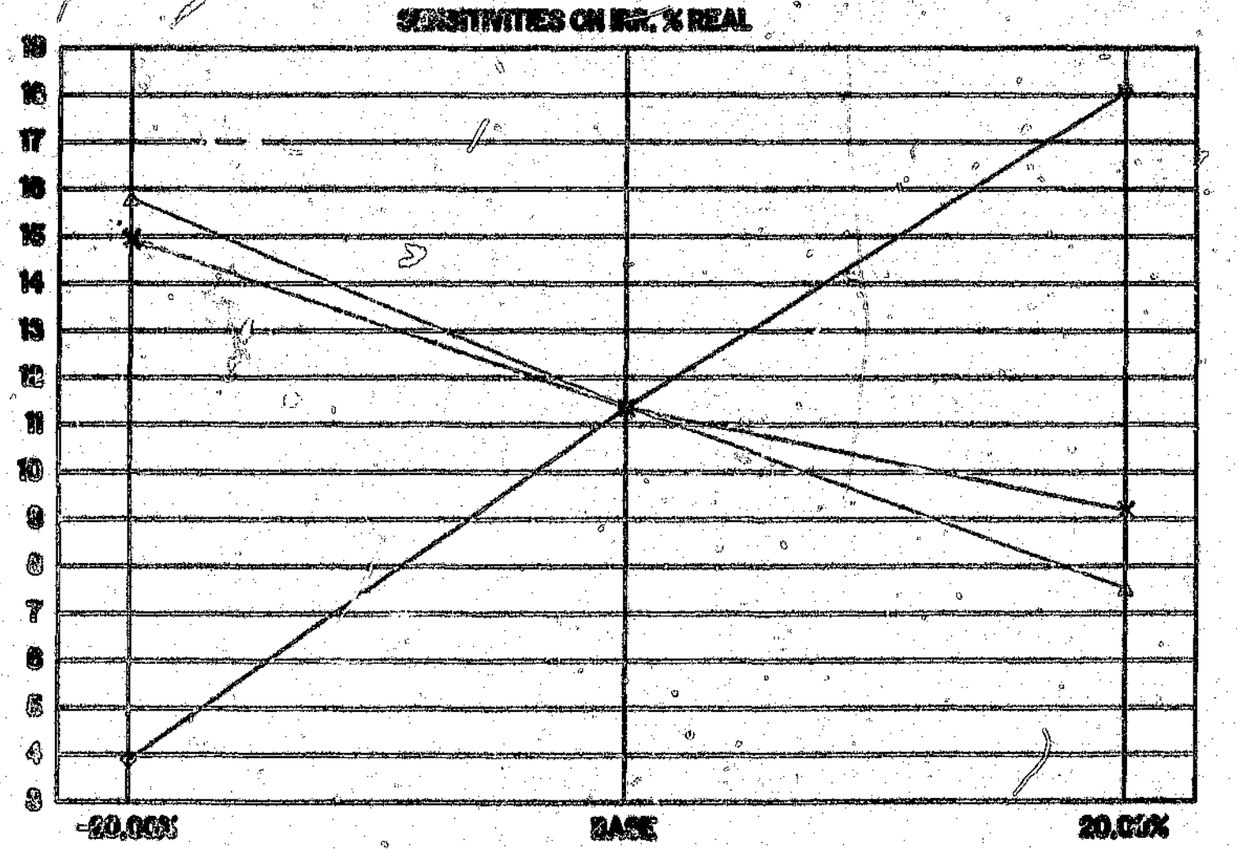


HARTLEY EVALUATION, JULY 1991

SENSITIVITIES ON MAX EXPOSURE (ESCAL)



HARTLEY EVALUATION, JULY 1991



4.3 RISK ANALYSIS RESULTS

Page 21 also shows the upper and lower potentials for input parameters ("upside" and "downside") in percentage terms assumed for the Hartley Project. The following should be noted :-

(i) The potential for metal prices to vary from forecast is based on recent variations of metal prices.

(ii) Working costs appear to be extremely low by South African standards. At R86/ton milled, compared to between R95 and R160/ton milled at South African operations, this is probably a justified concern. For this reason, the upside potential is assumed to be greater than the downside potential[7].

(iii) Capex also appears to be low in the Delta evaluation, especially when one considers the relatively high cost of capital goods in Zimbabwe. At R5 575 per annual oz Pt, compared to, say R5 703 per annual oz Pt (in July 1991 terms) for the original underground option at Potgietersrus Platinum (which has now opted for an opencast operation), it is not too low by South African terms, but the concern at high capital costs in Zimbabwe still remains. Again, therefore, the upside potential is assumed to be greater than the downside potential on this item[7].

(iv) General economic conditions for Zimbabwe may have a greater potential for being worse than being better than the forecasts shown on page 13. The upsides for SACPI and exchange rates have thus been given greater weighting than their downsides.

(v) It is also assumed that tax rates have a greater potential to increase than to decrease because of possible future Zimbabwean government intervention coupled with their possible need to increase fiscal spending on socio-economic programmes. Thus, the political risk of the project in Zimbabwe is addressed.

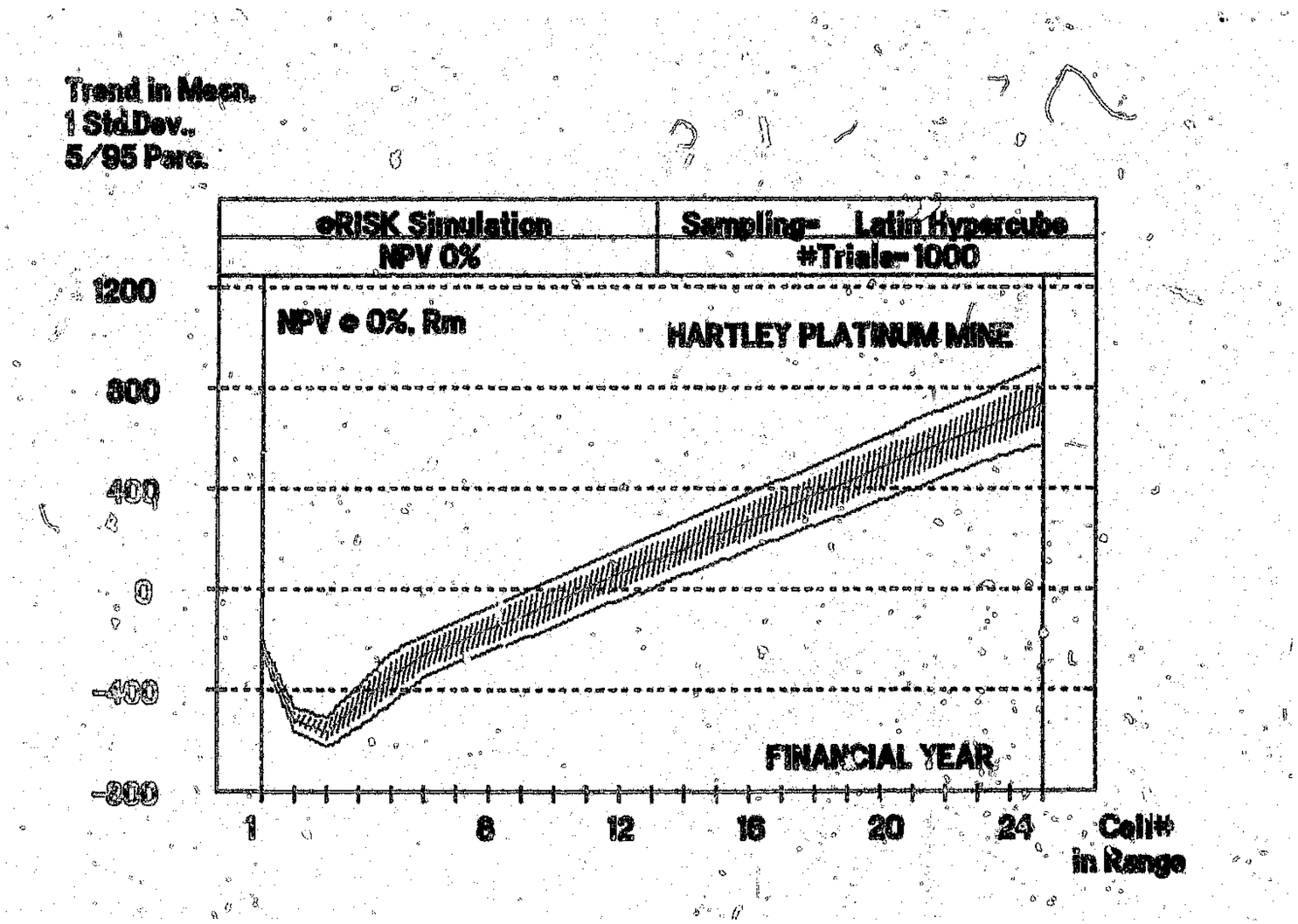
(vi) The timing and production build-up phase at Hartley appears to be extremely rapid. For example, Potgietersrus Platinum's original underground option was forecast to reach full production over five to six years, compared to three to four years for Hartley. Potgietersrus Platinum's original underground option is used as a comparison because it was also a shallow operation at a similar production rate. It has thus been assumed that there is a greater potential for a delay in production than there is for an acceleration.

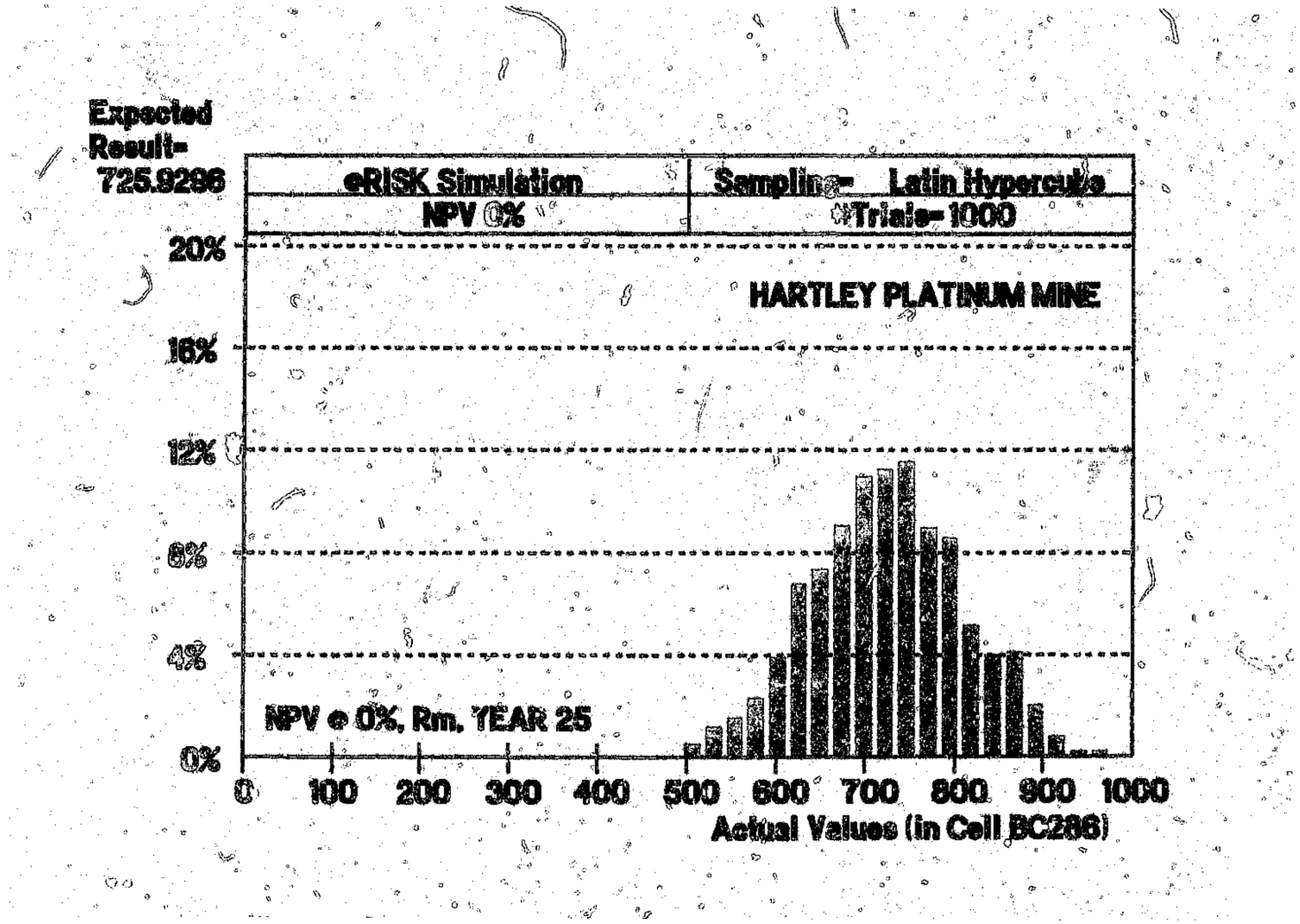
The results of the risk analysis for Hartley are shown graphically on pages 43 to 54. In summary, they are as follows :-

	Expected Result	Standard Deviation
Real IRR, %, 25 years :	8,826	1,010
NPV, R million, 25 years, @ 0% discount :	725,9	84,5
@ 3% discount :	351,8	58,0
@ 5% discount :	191,6	48,0
Maximum Exposure, escalated, R million :	639,8	38,8
Maximum Exposure, base date, R million :	553,8	31,3
Payback Period, years, escalated money :	7,0	0,8
Payback Period, years, base date money :	10,4	1,1

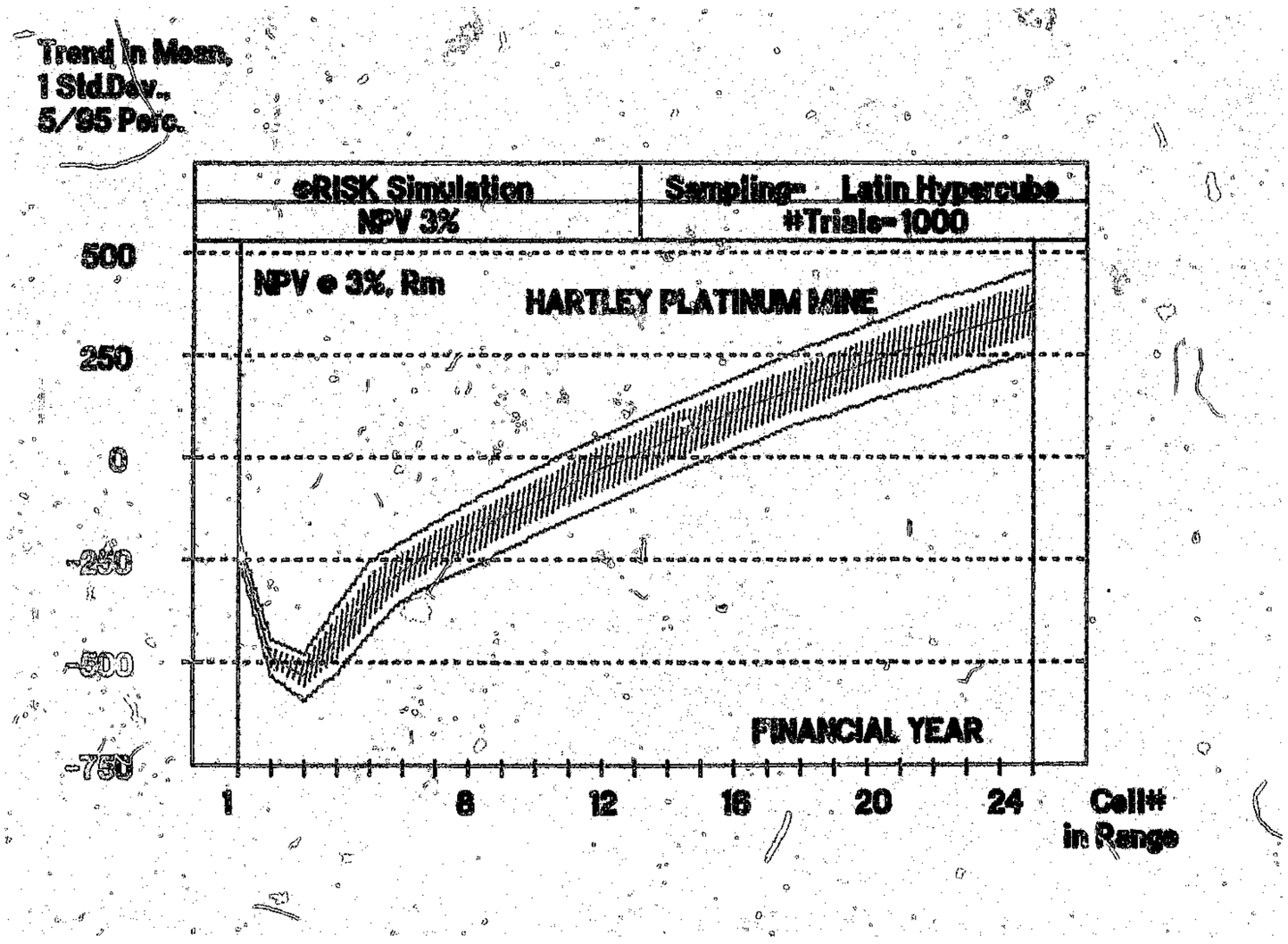
The above expected result for Real IRR after 25 years of 8,83% is 2,53% less than the conventional result of 11,36%. This amount could be considered to be the risk discount rate to be applied over and above a "normal" hurdle rate for an NPV analysis.

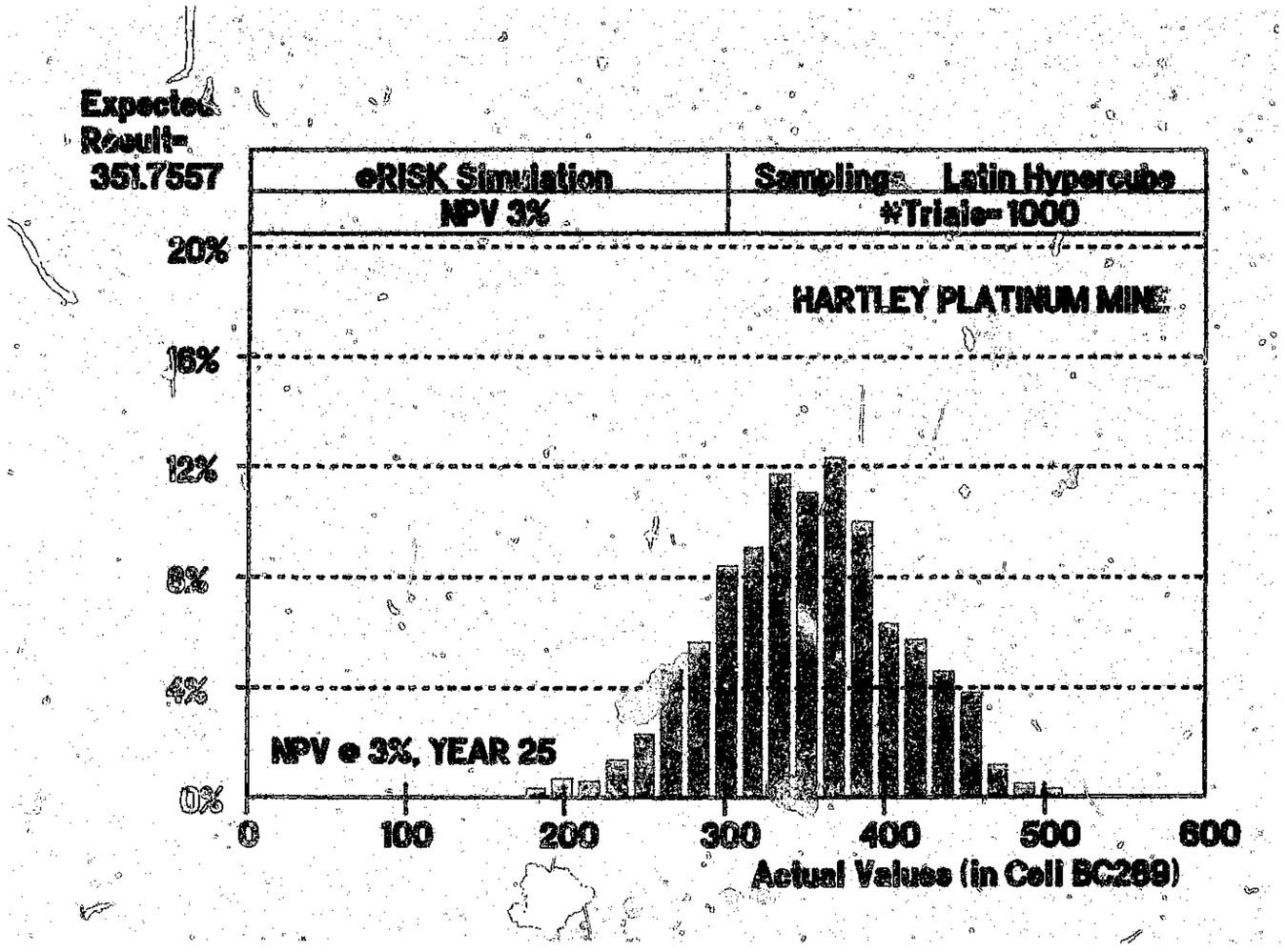
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



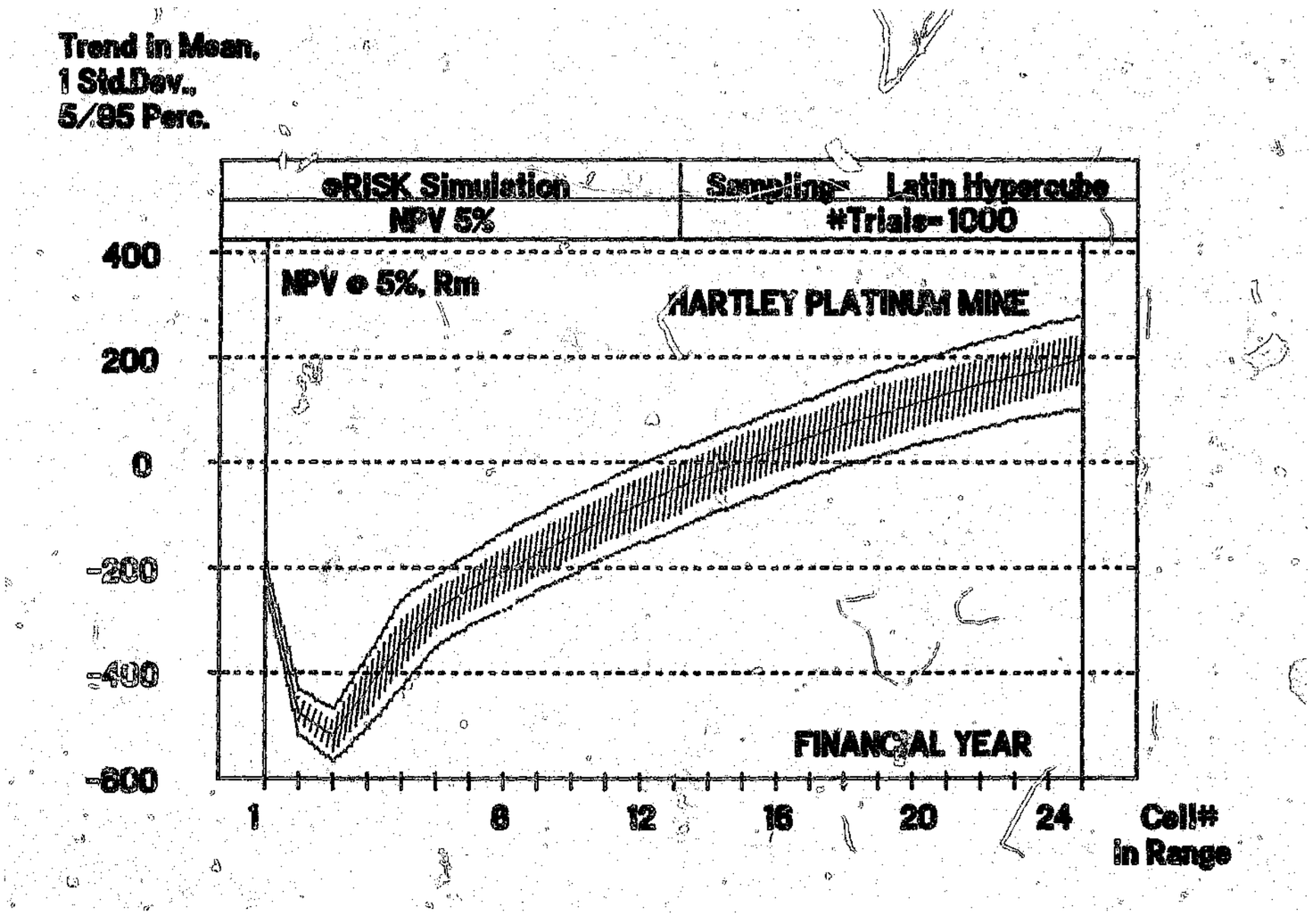

Expected
Result=
725.9296
eRISK Simulation
NPV @ 0%
Sampling= Latin Hypercube
Trials= 1000
20%
16%
12%
8%
4%
0%
HARTLEY PLATINUM MINE
NPV @ 0%, Rm, YEAR 25
0
100
200
300
400
500
600
700
800
900
1000
Actual Values (in Cell BC286)

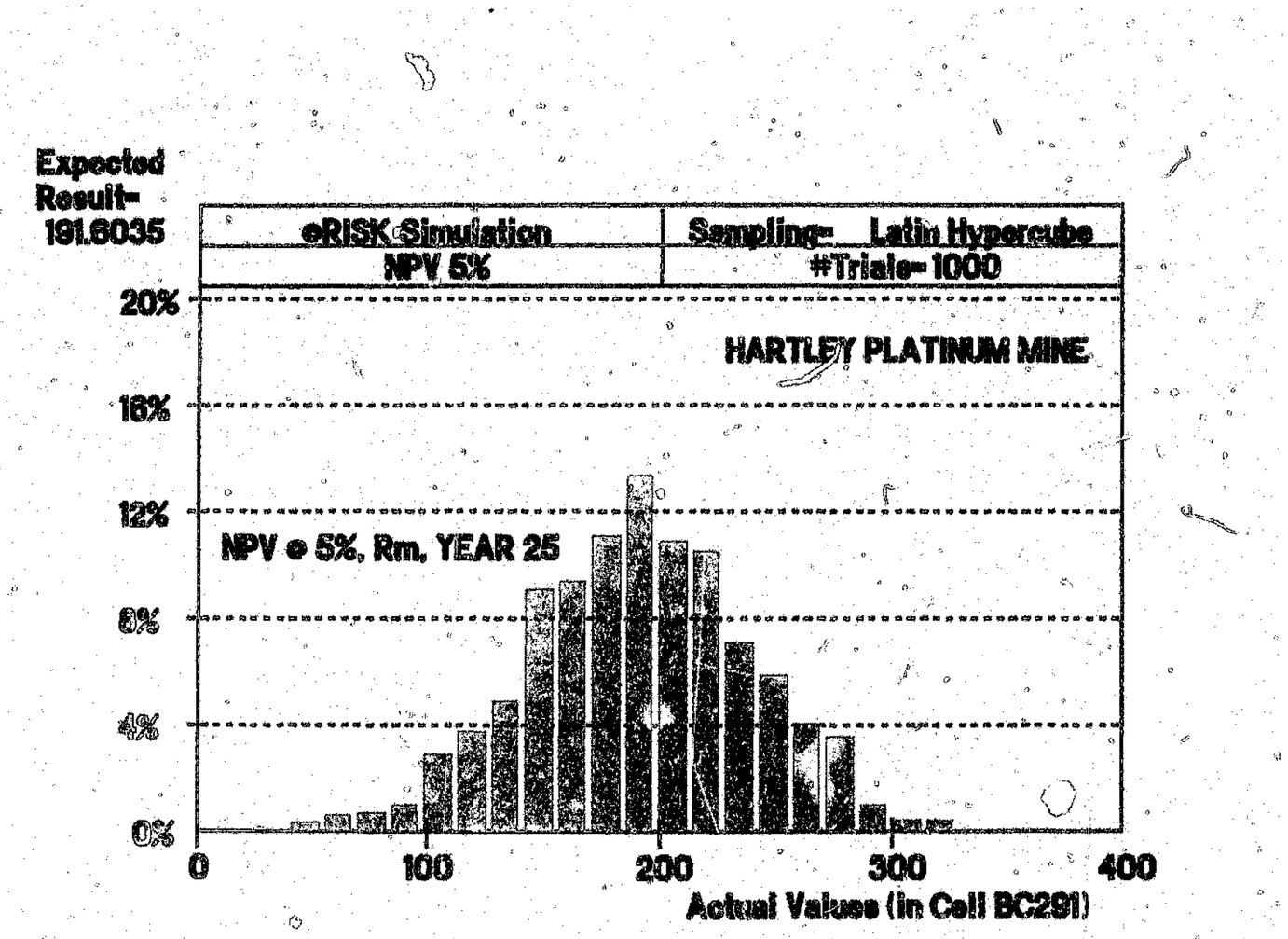
Trend in Mean,
1 Std.Dev.,
5/95 Perc.

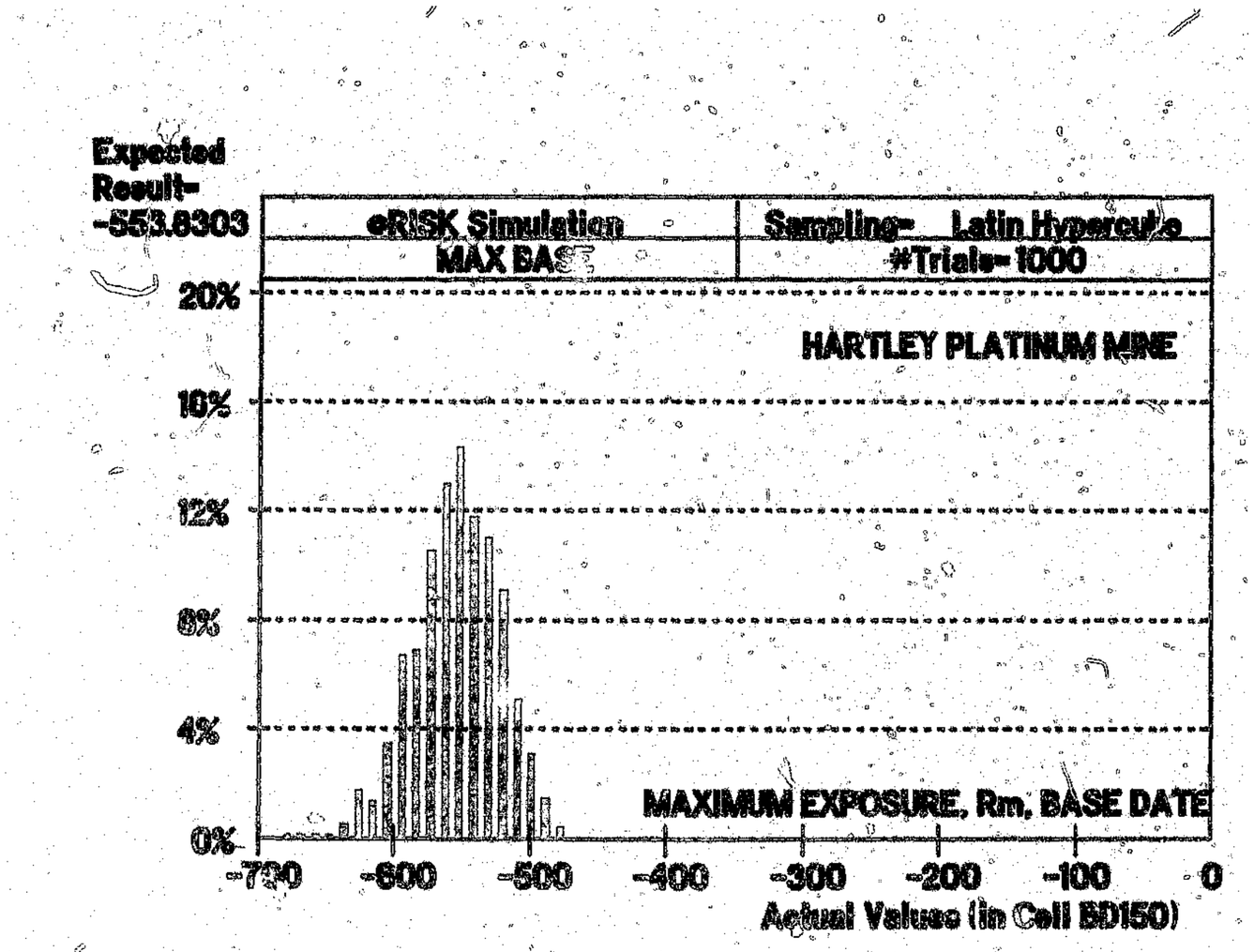


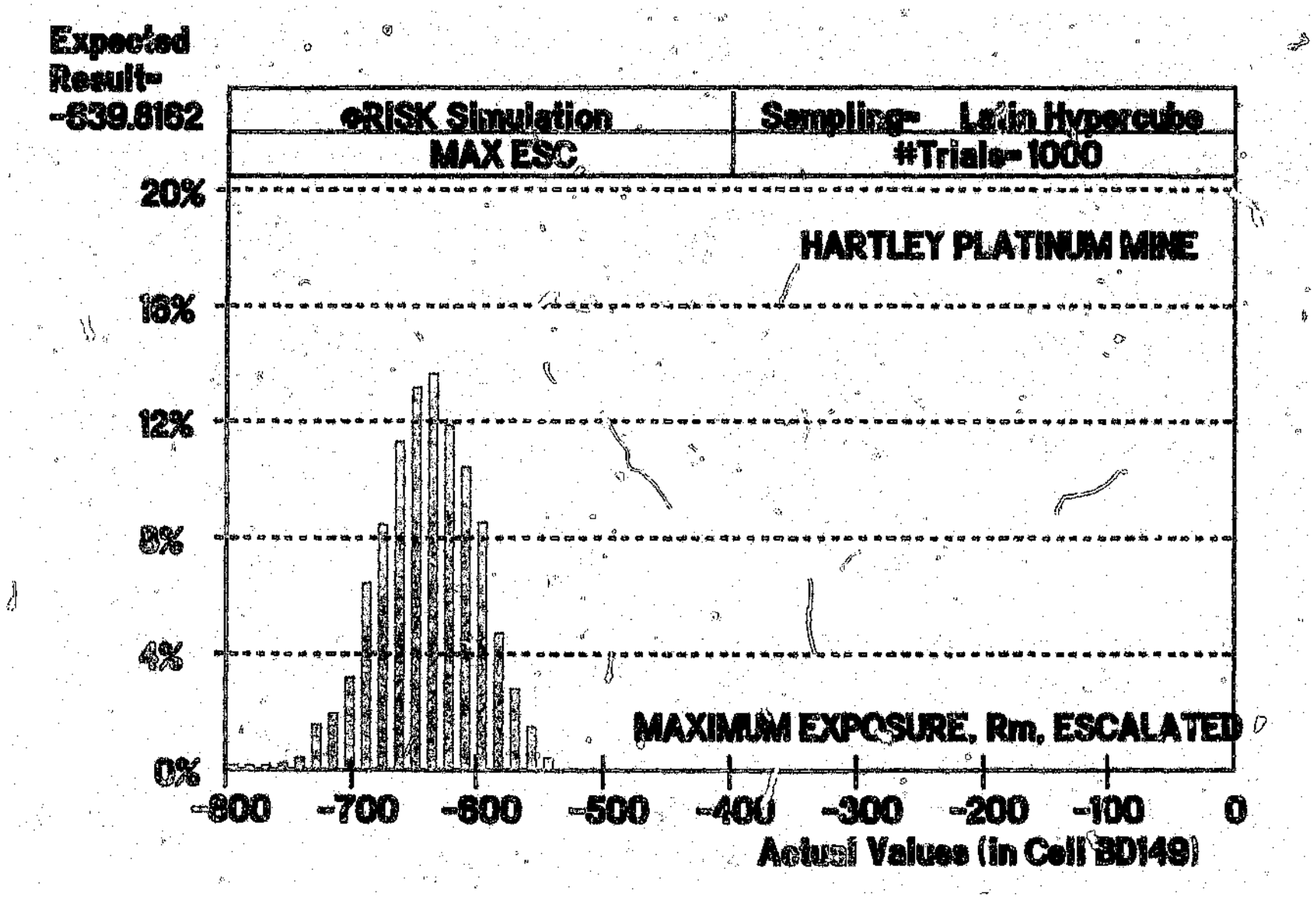

Expected Result= 351.7557
eRISK Simulation
NPV 3%
Sampling= Latin Hypercube
#Trials= 1000
20%
16%
12%
8%
4%
0%
HARTLEY PLATINUM MINE
NPV @ 3%, YEAR 25
0
100
200
300
400
500
600
Actual Values (in Cell BC289)

Trend in Mean,
1 Std.Dev.,
5/95 Perc.

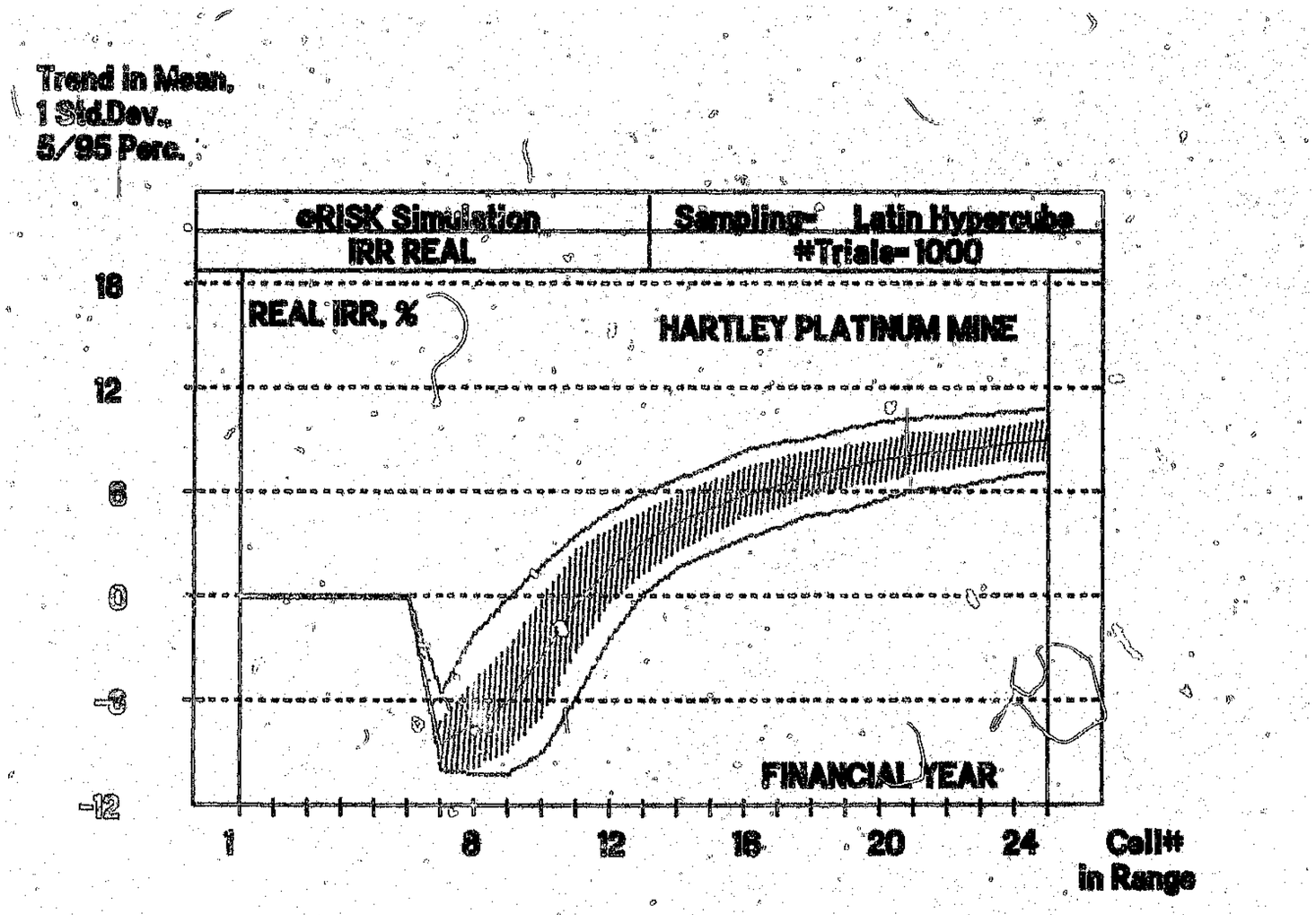



Expected
Result=
191.6035
eRISK Simulation
NPV 5%
Sampling= Latin Hypercube
#Trials= 1000
20%
16%
12%
8%
4%
0%
HARTLEY PLATINUM MINE
NPV @ 5%, Rm, YEAR 25
0
100
200
300
400
Actual Values (in Cell BC291)

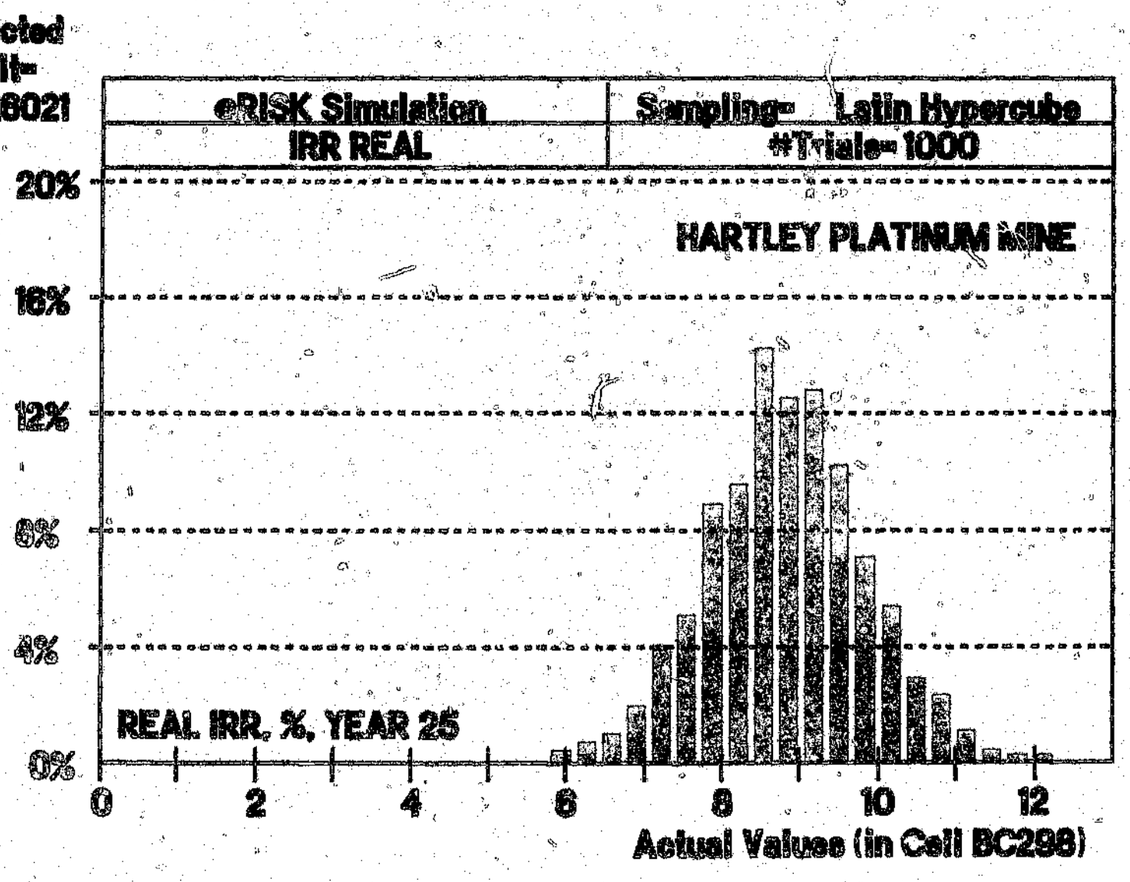

Expected Result= -553.8303
eRISK Simulation
MAX BASE
Sampling= Latin Hypercube
#Trials= 1000
HARTLEY PLATINUM MINE
20%
16%
12%
8%
4%
0%
-700
-600
-500
-400
-300
-200
-100
0
MAXIMUM EXPOSURE, Rm, BASE DATE
Actual Values (in Cell BD150)

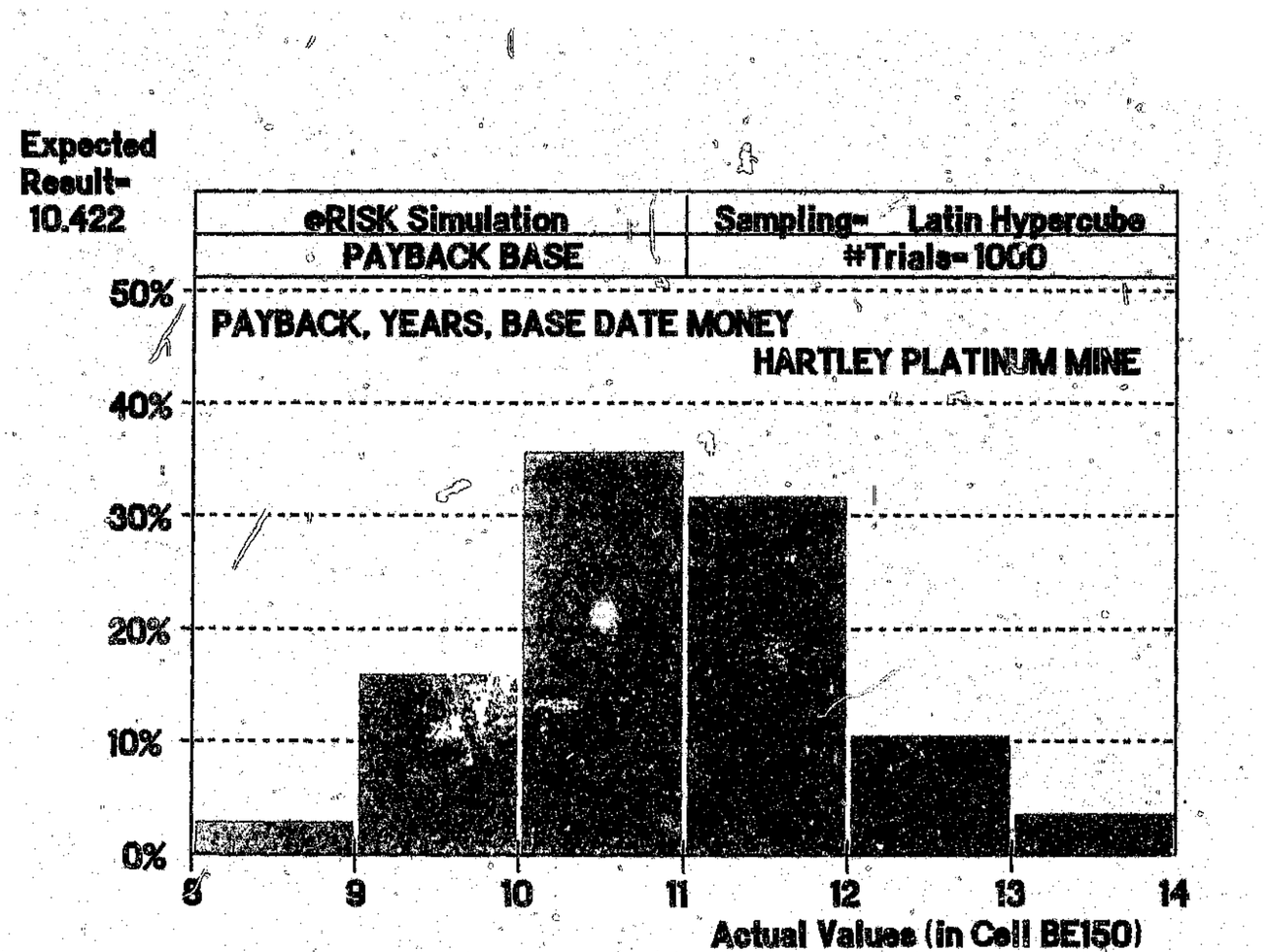

Expected
Result=
-639.8162
@RISK Simulation
MAX ESC
Sampling= Latin Hypercube
#Trials= 1000
20%
16%
12%
8%
4%
0%
HARTLEY PLATINUM MINE
MAXIMUM EXPOSURE, Rm, ESCALATED
-800
-700
-600
-500
-400
-300
-200
-100
0
Actual Values (in Cell BD149)

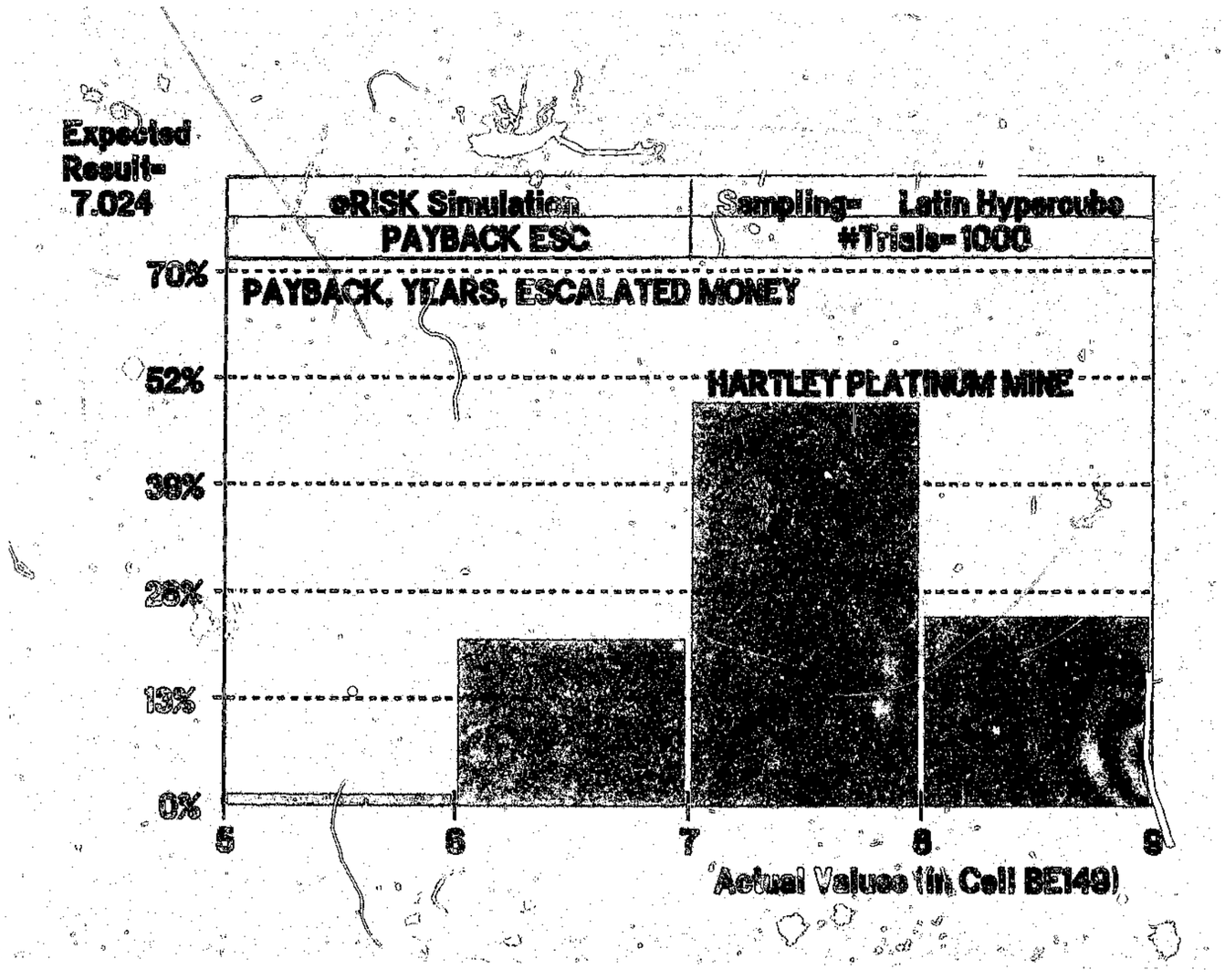
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



Expected Result= 8.826021




Expected Result= 10.422
eRISK Simulation
PAYBACK BASE
Sampling= Latin Hypercube
#Trials= 1000
50%
PAYBACK, YEARS, BASE DATE MONEY
HARTLEY PLATINUM MINE
40%
30%
20%
10%
0%
8
9
10
11
12
13
14
Actual Values (in Cell BE150)


Expected Result= 7.024
eRISK Simulation
PAYBACK ESC
Sampling= Latin Hypercube
#Trials= 1000
PAYBACK, YEARS, ESCALATED MONEY
70%
52%
39%
26%
13%
0%
HARTLEY PLATINUM MINE
5
6
7
8
9
Actual Values (in Cell BE149)

4.4 ROBUSTNESS CRITERIA

As mentioned in section 3.4, the objective is to find the variable, V, with an expected result closest to zero and with the smallest standard deviation.

The following robustness criteria were examined :-

N°	Robustness Criterion
1	Working costs per ton milled net of by-product revenue (R/t)
2	Working costs per ounce of platinum produced net of by-product revenue (R/oz Pt)
3	Profit per ton milled (R/t)
4	Profit per ounce of platinum produced (R/oz Pt)
5	Cut-off head grade (g PGM/t)
6	Cash margin (%)

The following results were produced (see pages 58 to 69 for graphical representations of these results), where E is the expected result and SD is the standard deviation for V for that year :-

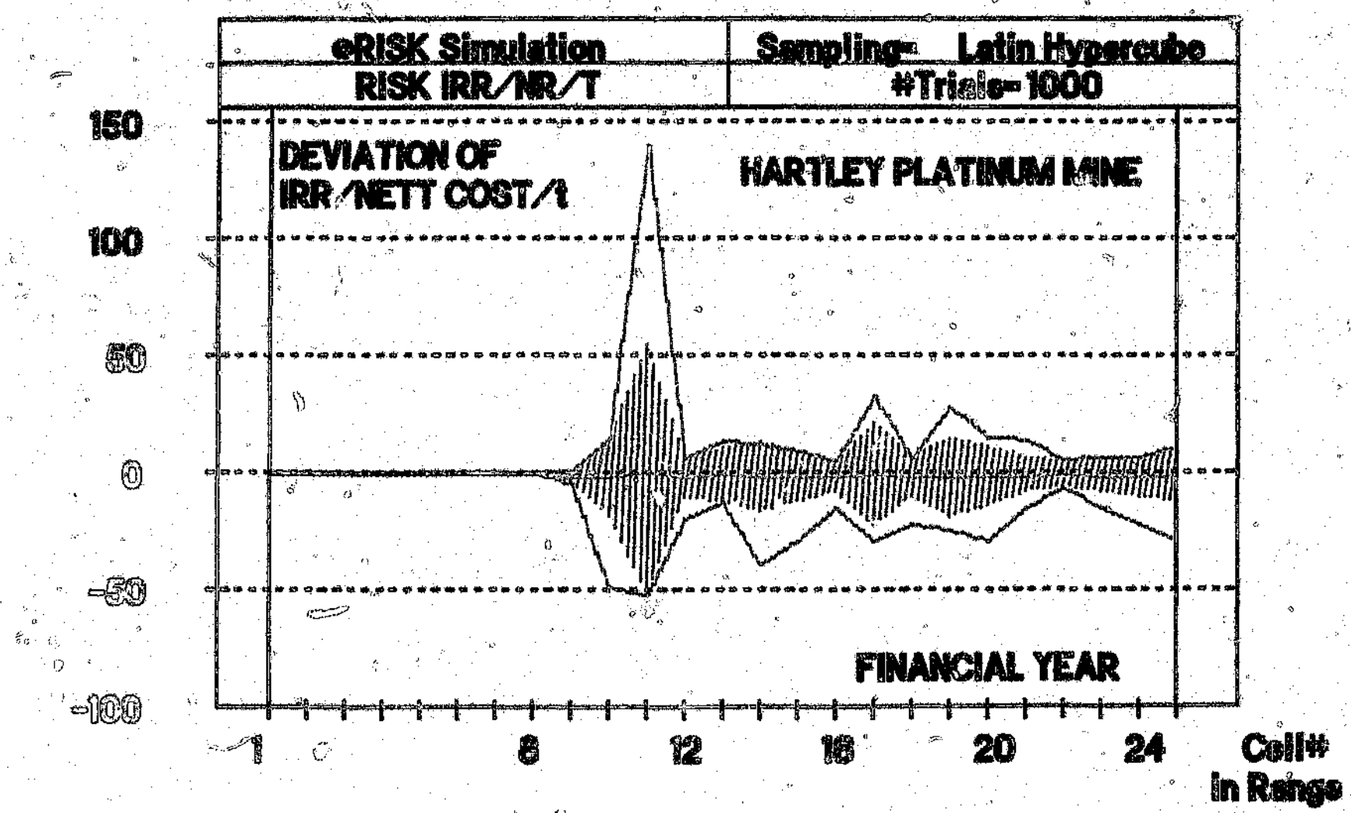
RESULTS FOR x/y = REAL IRR DIVIDED BY ROBUSTNESS CRITERIA 1 TO 6

Robustness Criterion	1 Net Cost (R/t)		2 Net Cost (R/oz Pt)		3 Profit (R/t)		4 Profit (R/oz Pt)		5 Cut-off Head Grade (g PGM/t)		6 Cash Margin (%)	
Financial Year	E	SD	E	SD	E	SD	E	SD	E	SD	E	SD
9	(1,042)	2,069	(1,045)	2,106	(0,239)	0,53[illegible]	(0,242)	0,306	(0,244)	0,410	(0,251)	0,432
10	(1,411)	16,016	(1,403)	16,321	0,542	1,789	0,529	1,735	0,348	1,391	0,474	1,605
11	1,240	52,017	1,233	51,606	(0,857)	21,247	(0,960)	18,220	(1,336)	3,222	(1,057)	13,508
12	(1,208)	8,197	(1,213)	8,032	(0,254)	1,925	(0,260)	1,737	(0,281)	0,895	(0,275)	1,435
13	(0,618)	11,561	(0,619)	11,546	(0,078)	0,977	(0,065)	0,905	(0,152)	0,535	(0,113)	0,738
14	(1,258)	13,503	(1,278)	14,193	(0,046)	0,554	(0,051)	0,521	(0,112)	0,880	(0,074)	0,448
15	(1,236)	10,765	(1,244)	10,873	(0,003)	0,712	(0,011)	0,649	(0,091)	0,304	(0,046)	0,650
16	(0,859)	6,186	(0,845)	6,186	0,002	0,524	(0,002)	0,486	(0,071)	0,284	(0,031)	0,378
17	(0,366)	21,214	(0,386)	21,478	0,082	1,721	0,067	1,476	(0,065)	0,245	0,025	1,098
18	(1,138)	7,635	(1,156)	7,898	0,021	0,710	0,013	0,468	(0,059)	0,223	(0,030)	0,934
19	(0,936)	16,250	(0,929)	17,019	0,045	0,515	0,037	0,470	(0,054)	0,217	0,007	0,364
20	(0,953)	12,459	(0,992)	12,767	0,063	0,618	0,054	0,553	(0,048)	0,202	0,019	0,421
21	(0,837)	7,695	(0,839)	7,759	0,059	0,548	0,051	0,496	(0,043)	0,205	0,019	0,373
22	(0,490)	5,288	(0,483)	5,466	0,077	0,563	0,068	0,531	(0,040)	0,195	0,031	0,399
23	(0,823)	7,067	(0,821)	7,104	0,084	0,826	0,071	0,715	0,038	0,189	0,038	0,569
24	(1,370)	8,376	(1,406)	8,893	0,139	1,093	0,120	0,948	(0,036)	0,190	0,076	0,956
25	(0,988)	10,185	(1,009)	10,445	0,133	0,702	0,109	0,673	(0,057)	0,170	0,070	0,489
OVERALL	(0,842)	12,734	(0,849)	12,920	(0,014)	2,092	(0,029)	1,840	(0,140)	0,545	(0,066)	1,448

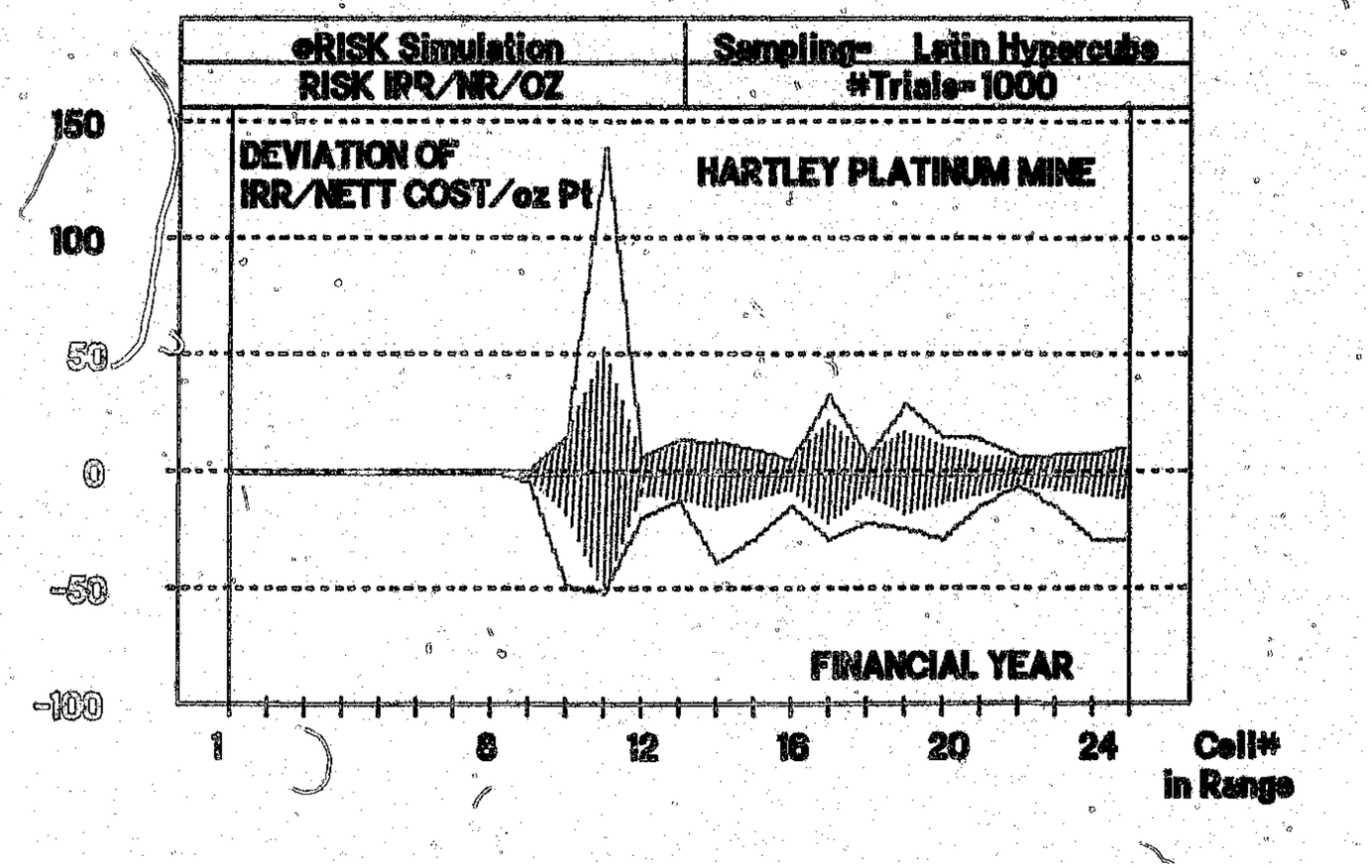
RESULTS FOR x/y = NPV @ 0% DISCOUNT DIVIDED BY ROBUSTNESS CRITERIA 1 TO 6

Robustness Criterion	1 Net Cost (R/t)		2 Net Cost (R/oz Pt)		3 Profit (R/t)		4 Profit (R/oz Pt)		5 Cutoff Head Grade (g PGM/t)		6 Cost Margin (%)	
Financial Year	E	SD	E	SD	E	SD	E	SD	E	SD	E	SD
3	0,076	0,378	0,058	0,390	(0,034)	19,840	(0,037)	19,915	(0,003)	0,105	(0,646)	10,264
4	0,243	12,052	0,256	12,183	0,176	0,681	0,173	0,642	0,023	0,107	0,128	[illegible]
5	(1,599)	24,434	(1,612)	25,000	0,210	0,746	0,199	0,680	0,041	0,159	[illegible]	[illegible]
6	(0,850)	6,654	(0,851)	6,805	0,192	1,144	0,178	0,991	0,075	0,171	0,152	[illegible]
7	(1,024)	0,711	(1,025)	0,712	0,173	0,622	0,163	0,570	0,048	0,240	0,12[illegible]	[illegible]
8	(0,658)	7,162	(0,676)	7,136	0,254	0,875	0,240	0,818	0,079	0,341	[illegible]	[illegible]
9	(0,951)	5,522	(0,946)	5,746	0,358	1,318	0,342	1,220	0,150	0,575	[illegible]	[illegible]
10	(1,547)	50,228	(1,657)	52,63[illegible]	0,913	2,770	0,894	2,685	0,475	1,70[illegible]	[illegible]	2,319
11	(0,948)	5,929	(0,961)	5,884	(0,865)	2,723	(0,85[illegible]	2,696	(0,685)	2,268	(0,824)	2,494
12	(0,953)	3,438	(0,953)	3,389	(0,258)	0,846	(0,255)	[illegible]	(0,022)	0,763	(0,257)	0,779
13	(1,130)	6,047	(1,123)	6,298	(0,120)	0,590	(0,123)	0,567	(0,153)	0,504	(0,141)	0,507
14	(0,845)	6,855	(0,871)	7,139	(0,068)	0,514	(0,071)	0,485	(0,116)	0,384	(0,09[illegible]	0,412
15	(0,878)	3,224	(0,879)	3,281	(0,031)	0,512	(0,036)	0,474	(0,098)	0,317	(0,061)	0,3[illegible]
16	(0,778)	13,405	(0,829)	14,354	0,006	1,258	(0,005)	1,033	(0,085)	0,284	(0,030)	[illegible]
17	(0,942)	4,983	(0,946)	5,204	(0,019)	0,425	(0,022)	0,392	(0,074)	0,263	(0,045)	0,300
18	(0,718)	8,280	(0,744)	8,092	0,083	1,641	0,066	1,454	(0,072)	0,238	0,022	1,086
19	(4,542)	119,252	(4,715)	124,524	0,016	0,472	0,010	0,433	(0,064)	0,235	(0,018)	0,330
20	0,604	90,942	0,629	93,510	0,035	0,634	0,027	0,564	(0,060)	0,217	(0,004)	0,428
21	(1,101)	25,788	(1,107)	26,269	0,045	0,587	0,037	0,541	(0,058)	0,215	0,005	0,405
22	(0,845)	11,824	(0,849)	12,102	0,047	0,974	0,040	0,877	(0,054)	0,207	0,001	0,827
23	(2,051)	29,259	(2,105)	30,721	0,054	0,796	0,043	0,680	(0,053)	0,200	0,013	0,552
24	(0,658)	11,956	(0,663)	12,283	0,067	0,690	0,058	0,659	(0,050)	0,190	0,023	0,477
25	0,142	24,133	0,051	21,466	0,083	0,553	0,060	0,514	(0,070)	0,182	0,020	0,632
OVERALL	(0,954)	20,545	(0,979)	21,090	0,057	1,792	0,049	1,731	(0,047)	0,430	(0,011)	1,525

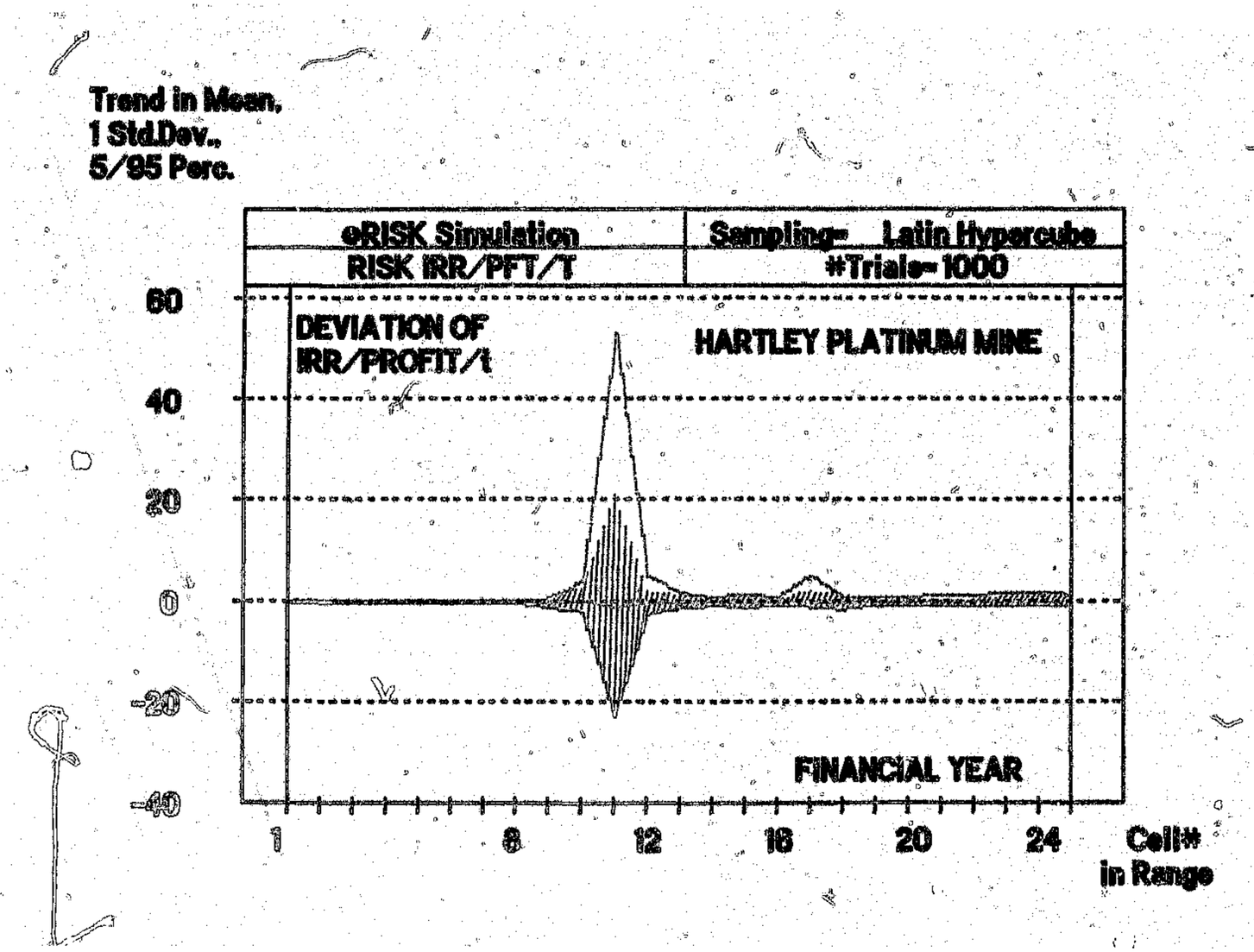
Trend in Mean,
1 Std Dev.,
5/95 Perc.

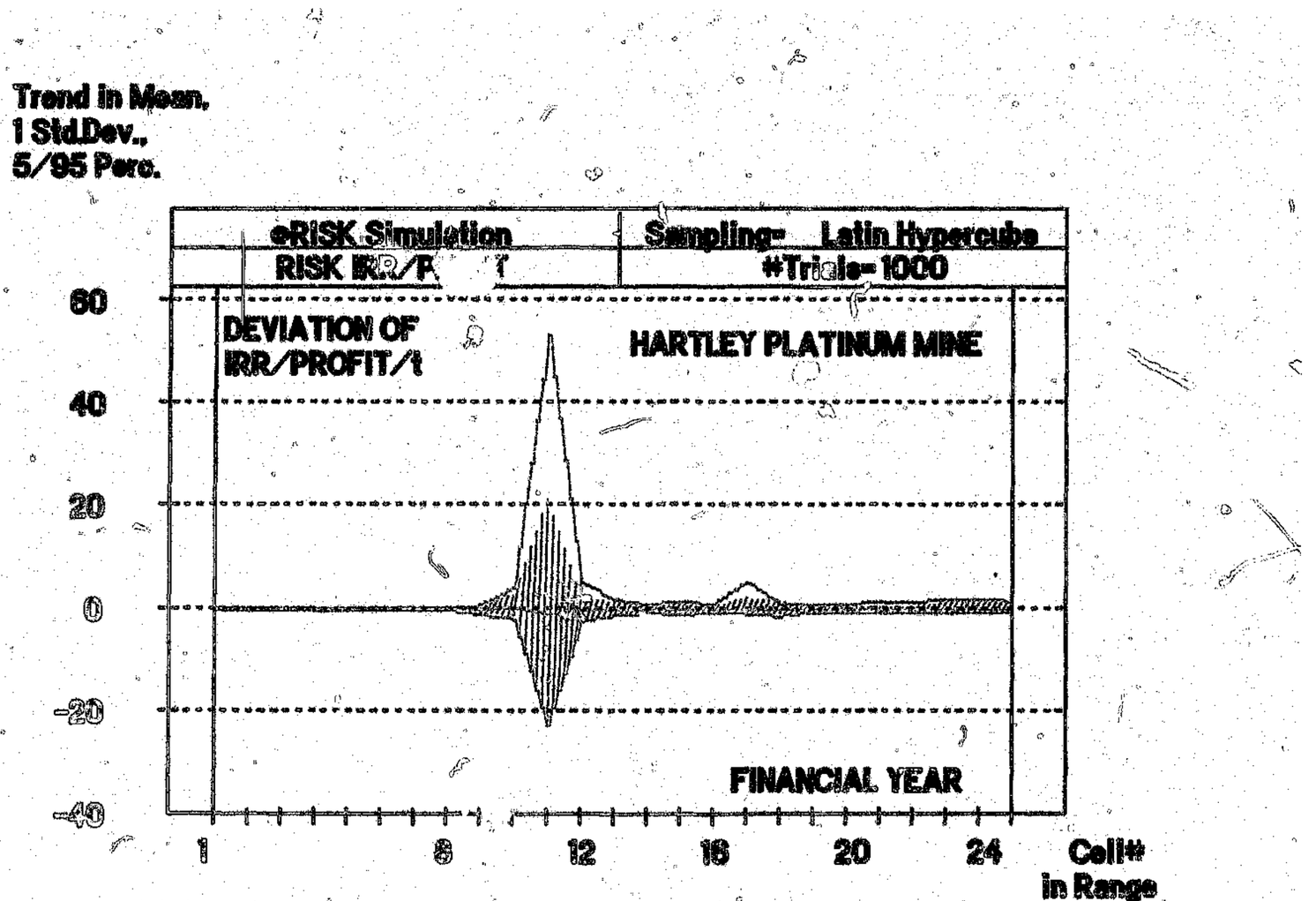


Trend in Mean,
1 Std.Dev.,
5/95 Perc.

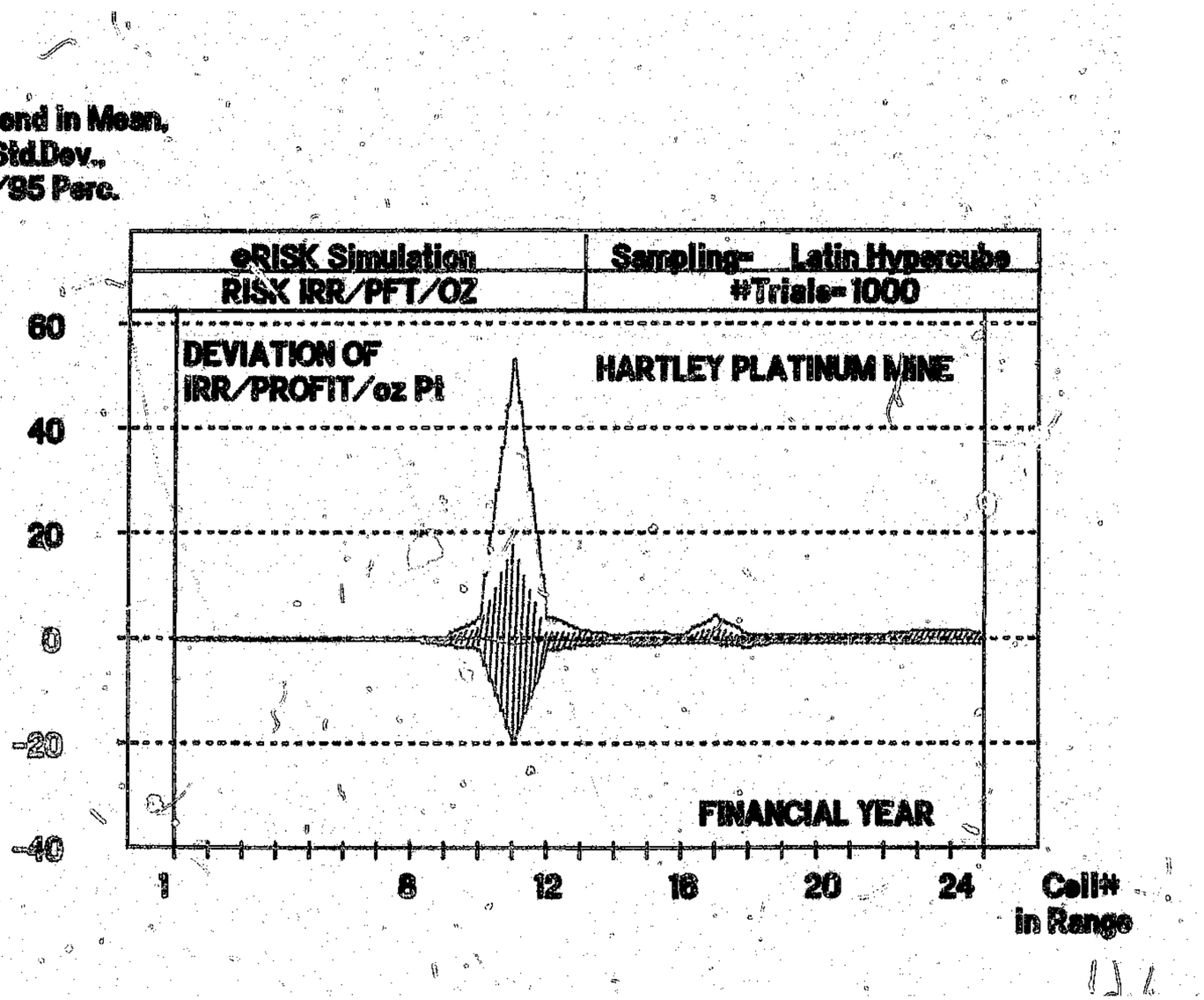


Trend in Mean,
1 Std.Dev.,
5/95 Perc.

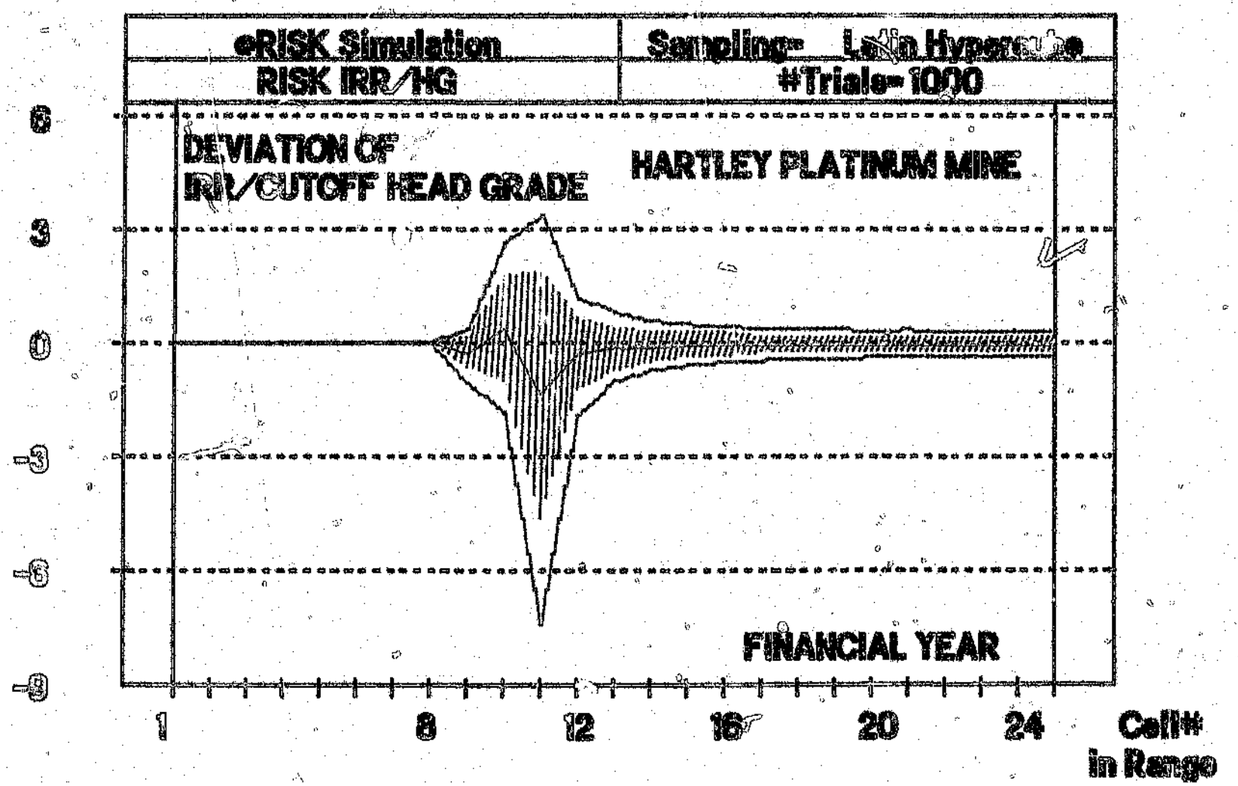



Trend in Mean,
1 Std.Dev.,
5/95 Perc.
eRISK Simulation
RISK IRR/P 1
Sampling= Latin Hypercube
#Trials= 1000
DEVIATION OF
IRR/PROFIT/t
HARTLEY PLATINUM MINE
FINANCIAL YEAR
60
40
20
0
-20
-40
1
8
12
16
20
24
Cell#
in Range

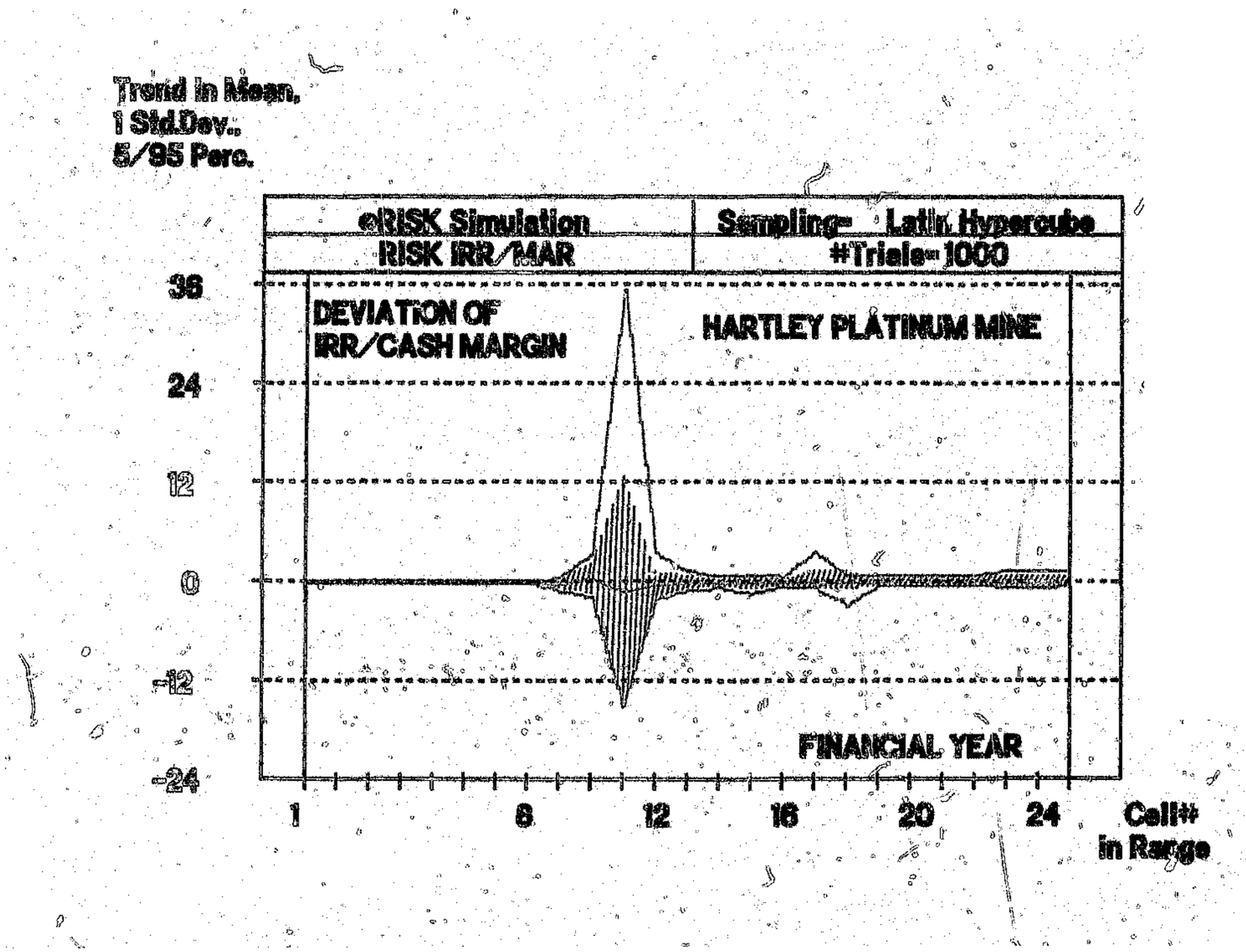
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



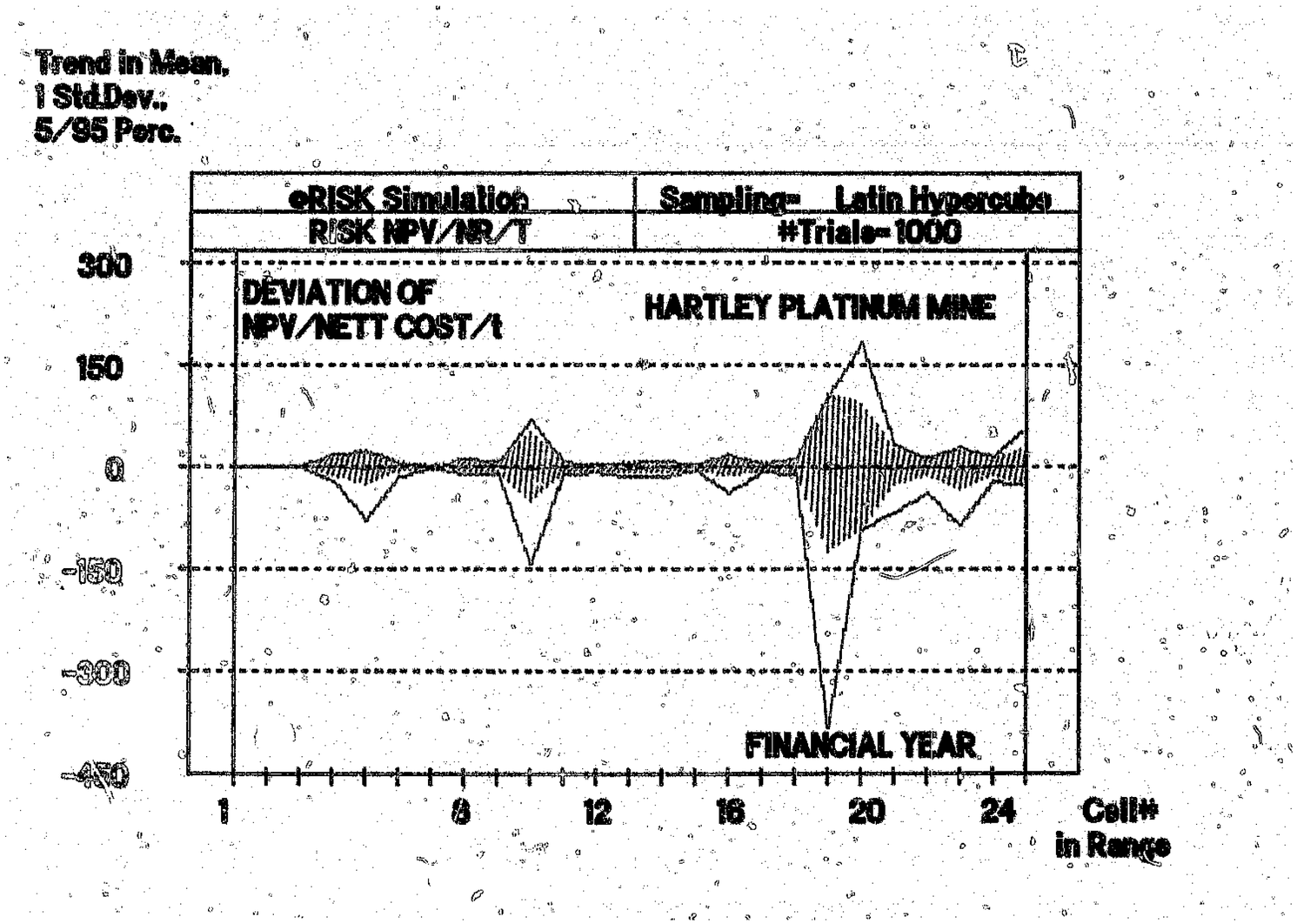
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



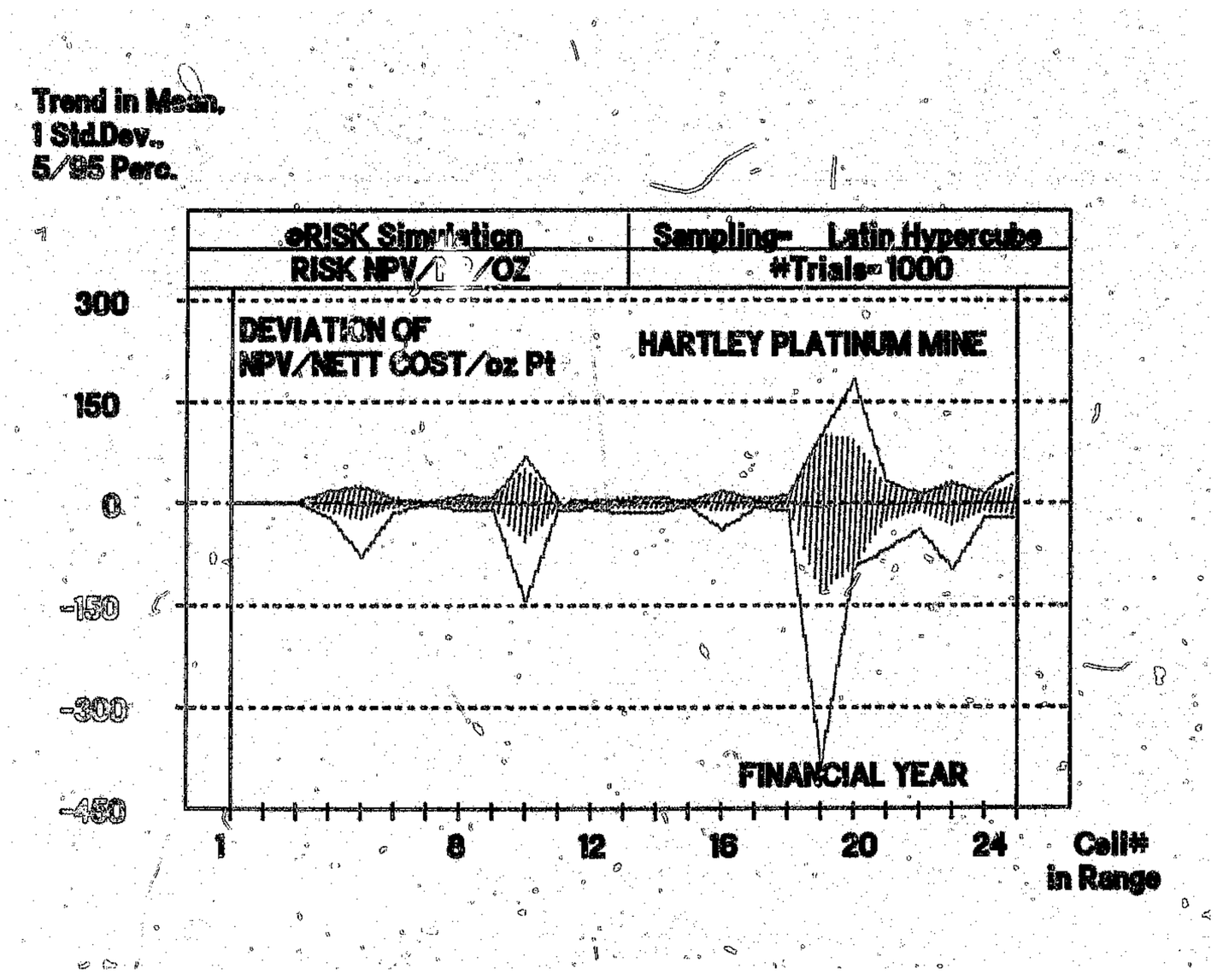
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



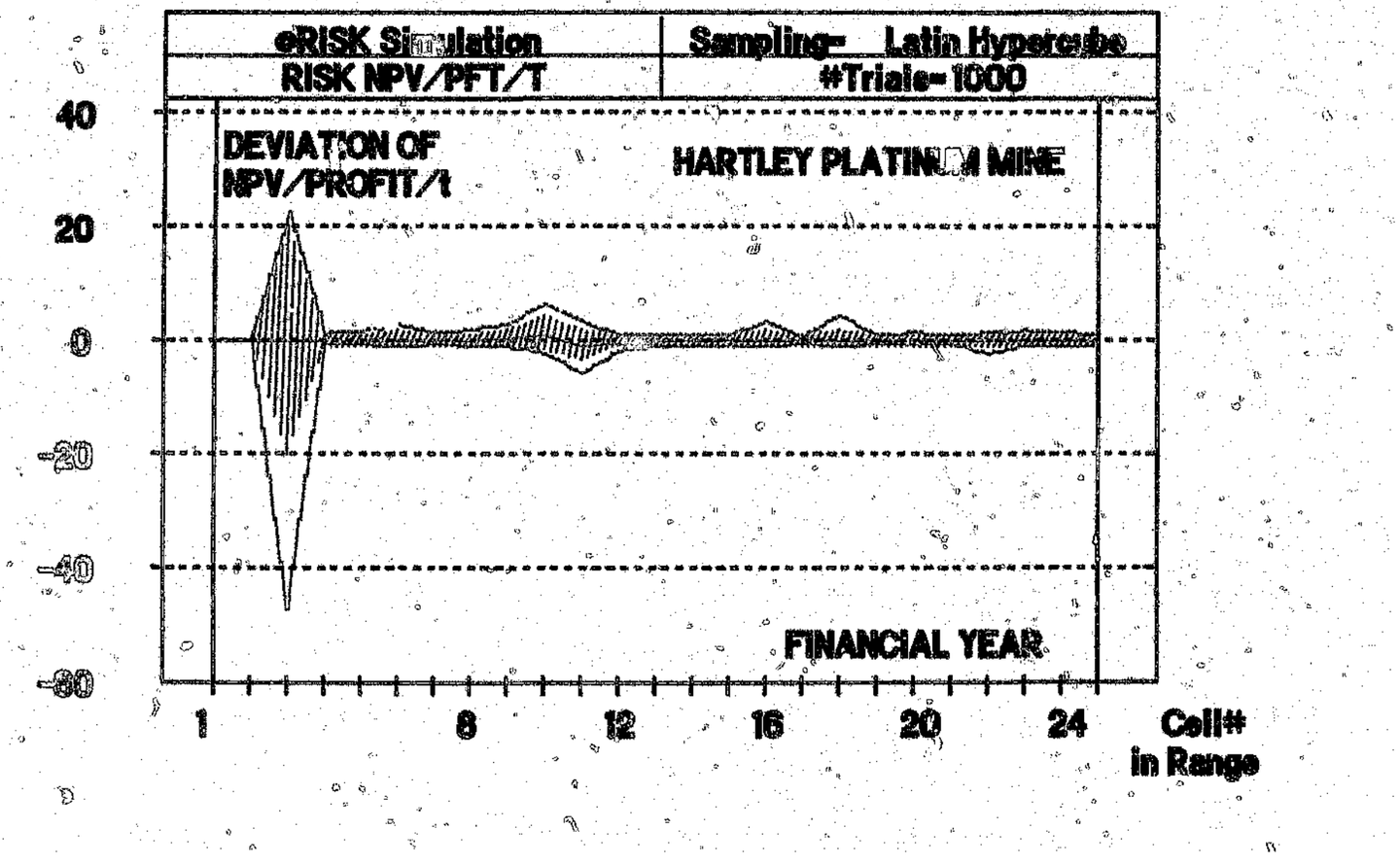
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



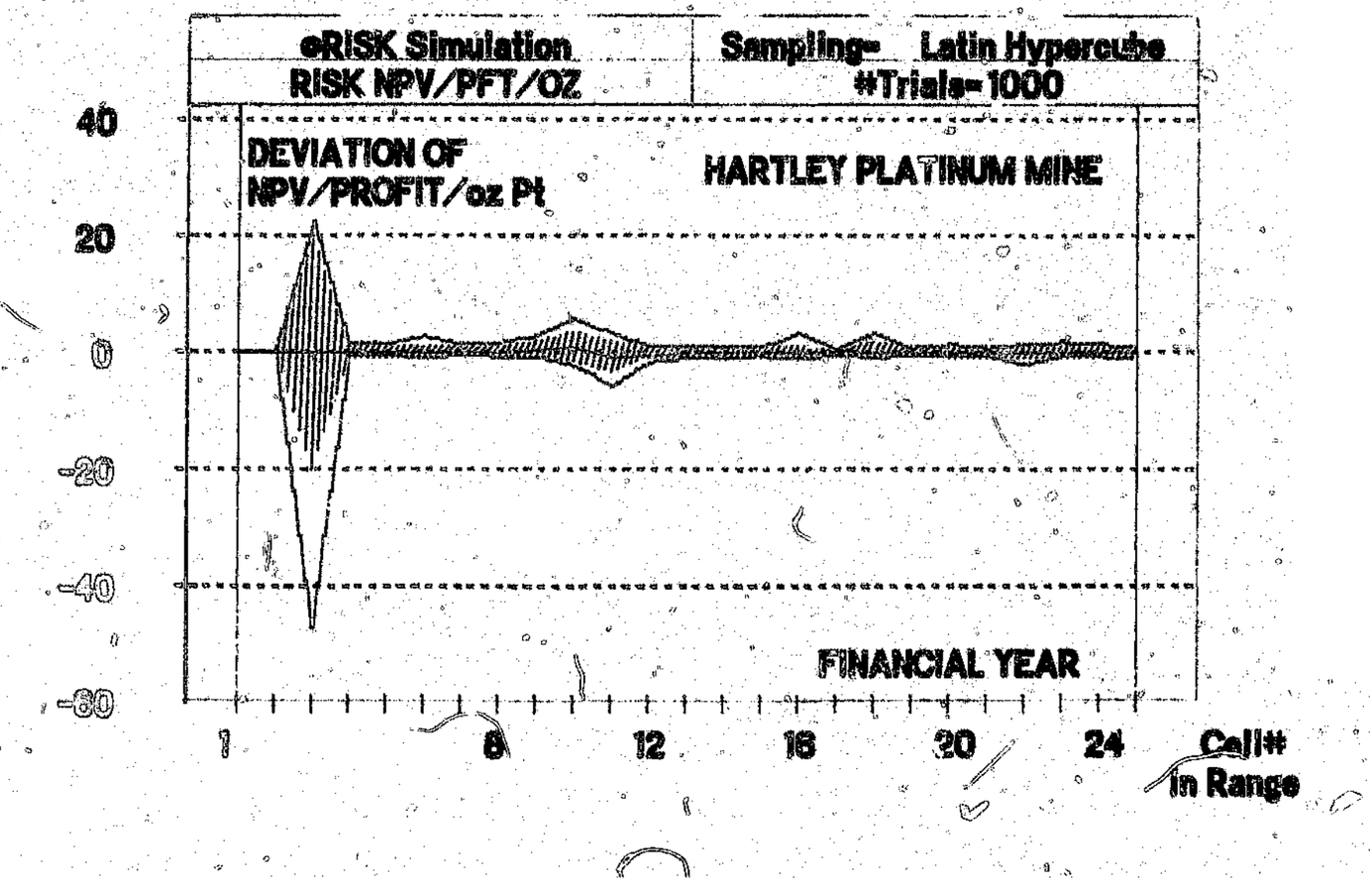
Trend in Mean,
1 Std.Dev.,
5/95 Perc.

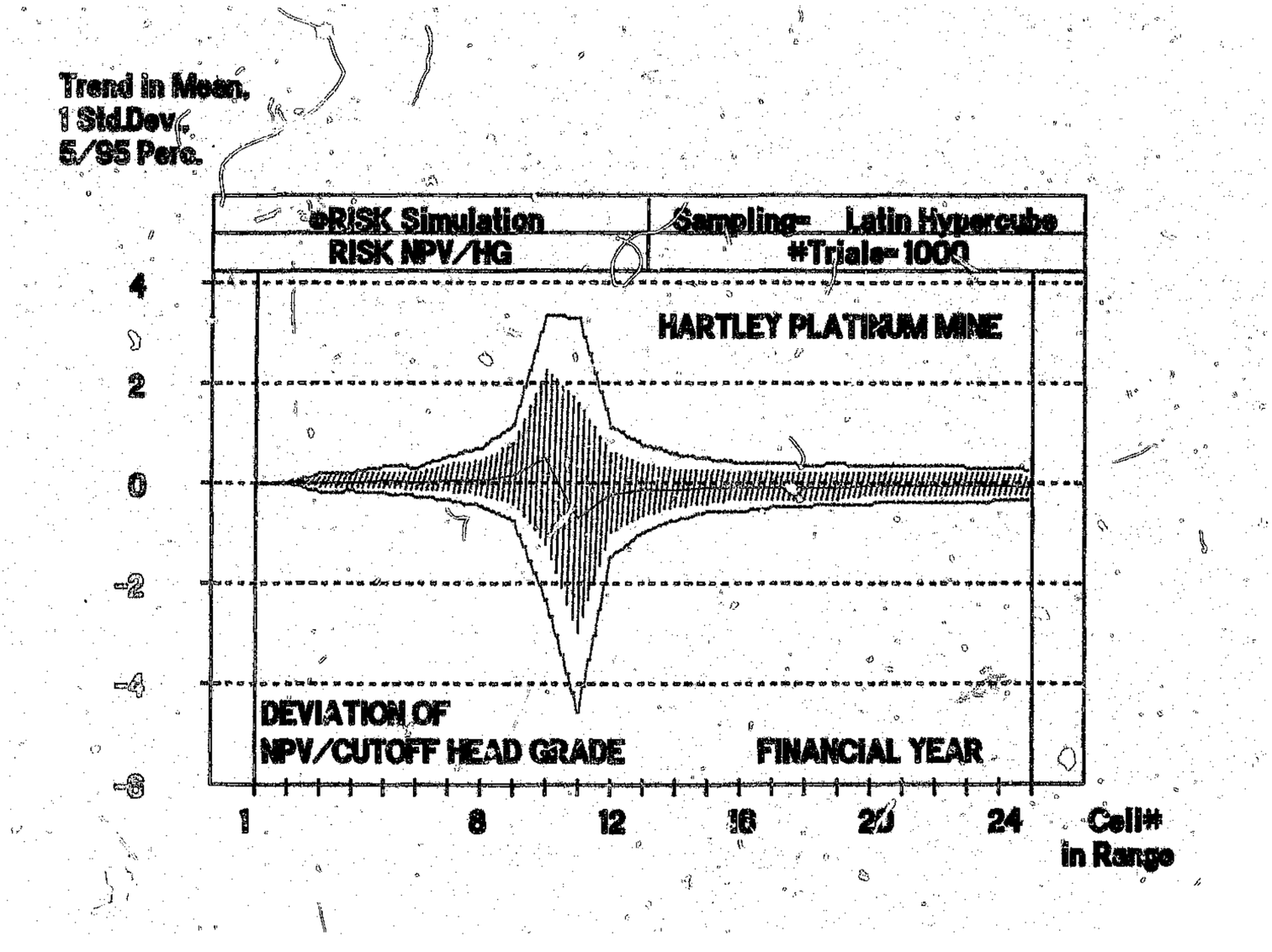


Trend in Mean,
1 Std.Dev.,
5/95 Perc.



Trend in Mean,
1 Std.Dev.,
5/95 Perc.




Trend in Mean,
1 Std.Dev.,
5/95 Perc.
@RISK Simulation
RISK NPV/HG
Sampling= Latin Hypercube
#Trials= 1000
HARTLEY PLATINUM MINE
4
2
0
-2
-4
-6
DEVIATION OF
NPV/CUTOFF HEAD GRADE
FINANCIAL YEAR
1
8
12
16
20
24
Cell#
in Range

91-07-23 INPUT PARAMETERS

Company : XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

METAL	%ST YR PIPELINE
Pt	95.00%
Pd	75.00%
Au	75.00%
Rh	50.00%
Ru	50.00%
Ir	50.00%
Ni	90.00%
Cu	90.00%

INPUT FACTORS :

LEASE FORMULA : Y = 12.50 MINUS 1*0.60 /X
ROYALTY PERCENTAGE 5.00%
TAX RATE 48.00%
TAX BASE? (Y/N) N

BASE DATE CALCULATION : JUL 1991 TERMS
MONTHS FROM JULY 1991? 0

	BOTTOM	MIDDLE	TOP
Pt PRICE :	70.00%	100.00%	130.00%
Pd PRICE :	70.00%	100.00%	130.00%
Au PRICE :	64.00%	100.00%	136.00%
Rh PRICE :	50.00%	100.00%	130.00%
Ru PRICE :	64.00%	100.00%	136.00%
Ir PRICE :	64.00%	100.00%	136.00%
Ni PRICE :	50.00%	100.00%	130.00%
Cu PRICE :	64.00%	100.00%	136.00%
WORKING COSTS :	90.00%	100.00%	110.00%
CAPEX :	80.00%	100.00%	120.00%
RECOVERED GRADE :	95.00%	100.00%	105.00%
MILLED TONNAGES :	90.00%	100.00%	110.00%
SACP? :	90.00%	100.00%	110.00%
USCP? :	90.00%	100.00%	110.00%
R/US$ EXCHANGE RATE :	90.00%	100.00%	125.00%
R/£ EXCHANGE RATE :	90.00%	100.00%	125.00%
LEASE PAYMENT :	0.00%	100.00%	150.00%
ROYALTY PAYMENT :	80.00%	100.00%	120.00%
TAX RATE :	90.00%	100.00%	150.00%
TIMING :	90.00%	100.00%	110.00%

SALES CONTRACTS :

Pt PRICE	97.30%
Pd PRICE	97.39%
Au PRICE	97.39%
Rh PRICE	97.39%
Ru PRICE	97.39%
Ir PRICE	97.39%
Ni PRICE	97.39%
Cu PRICE	97.39%

SENSITIVITIES :

Pt PRICE :	100.00%
Pd PRICE :	105.00%
Au PRICE :	100.00%
Rh PRICE :	100.00%
Ru PRICE :	105.00%
Ir PRICE :	100.00%
Ni PRICE :	100.00%
Cu PRICE :	100.00%
ALL PRICES :	100.00%
WORKING COSTS :	100.00%
CAPEX :	100.00%
RECOVERED GRADE :	100.00%
MILLED TONNAGES :	100.00%
SACP? :	100.00%
USCP? :	100.00%
R/US$ EXCHANGE RATE :	100.00%
R/£ EXCHANGE RATE :	100.00%
LEASE PAYMENT :	100.00%
ROYALTY PAYMENT :	100.00%
TAX RATE :	100.00%
TIMING :	100.00%

RISK ANALYSIS (Y/N) :N

STARTING POINTS : 90/91

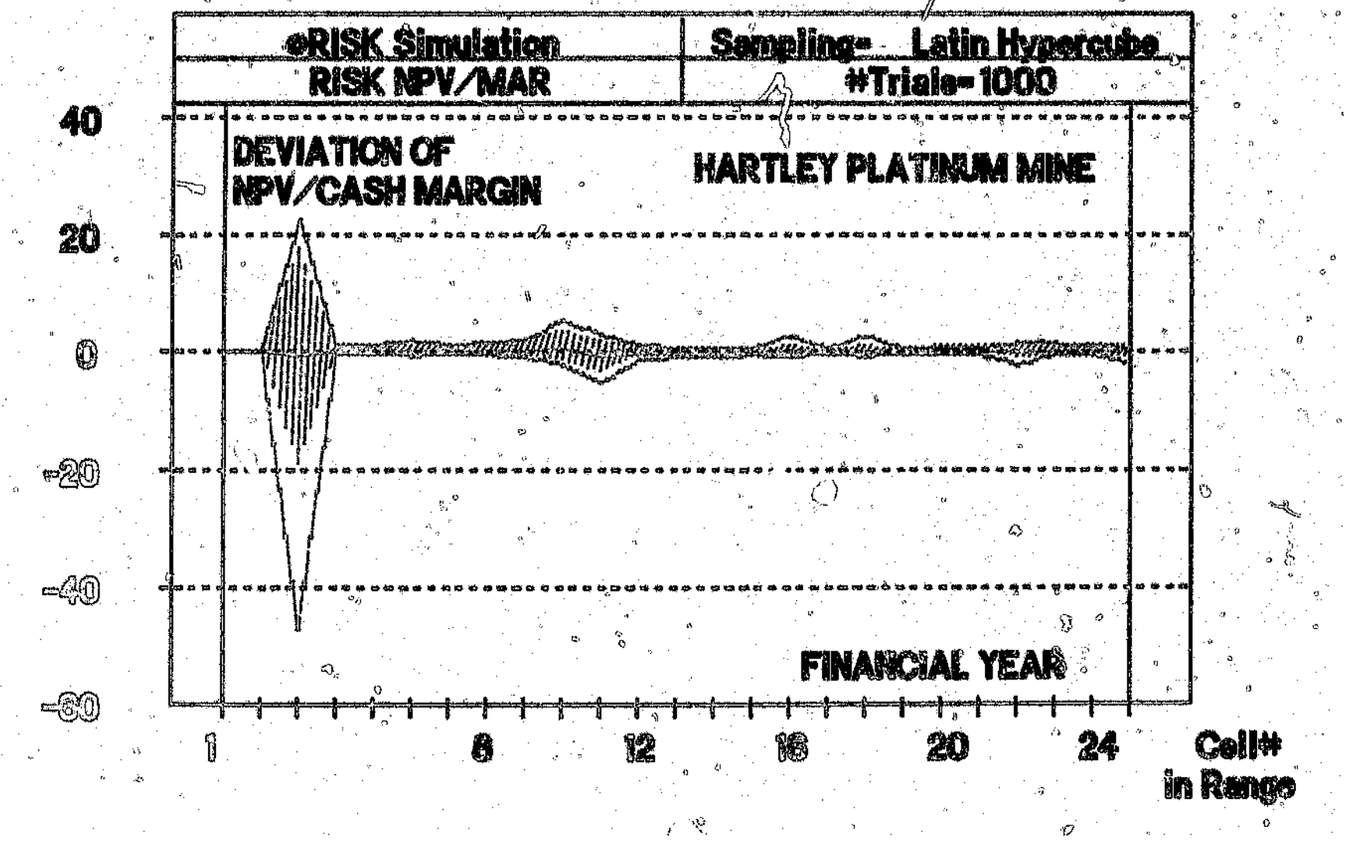
MERENSKY HEAD GRADE, g/t	5.260
UG2 HEAD GRADE, g/t	5.000
MERENSKY TONS MILLED	0
UG2 TONS MILLED	0
UNREDEEMED CAPEX, R million	0

91-07-23

INPUT DATA

XYZ.Wk1 FINANCIAL YEARS		91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04
SACRI		12,75%	12,00%	11,25%	12,75%	13,75%	13,00%	10,00%	10,00%	10,00%	10,00%	10,00%	10,00%	10,00%
SA DISCOUNT FACTOR		1,062	1,189	1,323	1,465	1,615	1,777	1,955	2,150	2,365	2,602	2,862	3,148	3,463
MERENSKY HEAD GRADE	g/t	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
UG2 HEAD GRADE	g/t	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200
MERENSKY MILLED	t	0	0	0	0	0	0	0	0	0	0	0	0	0
UG2 MILLED	t	0	0	0	0	0	750 000	1 500 000	2 000 000	2 300 000	2 500 000	2 750 000	2 750 000	2 750 000
TOTAL MILLED	t	0	0	0	0	0	750 000	1 500 000	2 000 000	2 300 000	2 500 000	2 750 000	2 750 000	2 750 000
PERCENTAGE UG2	%	0,00	0,00	0,00	0,00	0,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
PT PRODUCED	oz	0	0	0	0	0	33 964	70 249	113 213	134 348	152 461	163 702	166 846	166 846
PD PRODUCED	oz	0	0	0	0	0	72 889	63 497	96 286	90 536	102 745	110 375	111 991	111 991
AU PRODUCED	oz	0	0	0	0	0	716	1 671	2 987	2 232	3 214	3 453	3 531	3 531
RH PRODUCED	oz	0	0	0	0	0	2 205	9 616	14 957	18 376	20 948	22 599	23 594	23 594
RU PRODUCED	oz	0	0	0	0	0	5 704	17 112	26 618	32 782	37 265	40 687	41 020	41 020
IR PRODUCED	oz	0	0	0	0	0	580	2 883	3 116	3 820	4 362	4 753	4 886	4 886
NI PRODUCED	t	0	0	0	0	0	102	216	285	344	389	414	416	416
CU PRODUCED	t	0	0	0	0	0	51	108	148	172	195	207	208	208
PT PRICE, FREE MARKET	US$/oz	388,99	455,23	513,80	575,00	613,00	638,00	665,00	690,00	729,00	781,61	796,00	831,91	869,35
PD PRICE, FREE MARKET	US$/oz	97,51	113,00	133,00	148,00	163,00	175,00	185,00	195,00	210,00	219,45	229,33	239,64	250,43
AU PRICE, FREE MARKET	US$/oz	373,63	428,00	478,00	498,00	518,00	530,00	555,00	652,00	605,00	715,83	740,84	781,78	816,88
RH PRICE, FREE MARKET	US$/oz	3 925,00	3 628,49	4 864,50	4 372,00	4 525,00	4 875,00	5 250,00	4 050,00	5 250,00	5 486,25	5 793,13	5 991,12	6 258,72
RU PRICE, FREE MARKET	US$/oz	37,51	50,00	61,00	64,00	66,00	69,00	73,00	77,00	81,00	84,65	88,45	92,43	96,59
IR PRICE, FREE MARKET	US$/oz	320,13	205,00	310,00	322,00	335,00	352,00	369,00	388,00	407,00	425,32	444,45	464,45	485,36
NI PRICE, FREE MARKET	US$/t	8 133,47	8 181,32	8 886,00	9 280,00	9 688,00	10 108,00	10 550,00	11 000,00	11 750,00	12 278,75	12 831,25	13 408,76	14 012,96
CU PRICE, FREE MARKET	R/t	1 294,26	1 391,61	1 575,00	1 575,00	1 835,00	1 675,00	1 725,00	1 775,00	1 825,00	1 880,80	1 934,00	2 023,41	2 894,23
EXCHANGE RATE	R/US$	2,80	3,03	3,68	3,13	3,74	3,42	3,58	3,80	4,00	4,21	4,43	4,67	4,91
EXCHANGE RATE	R/£	5,45	5,69	5,73	6,08	6,93	6,51	6,78	7,16	7,53	8,38	8,51	9,04	9,51

Trend in Mean,
1 Std.Dev.,
5/95 Perc.



The underlined numbers on pages 56 and 57 are the lowest SD figures or the E figures closest to zero for V for each particular year and overall. The following notes can be made :-

- the Net R/t and Net R/oz Pt criteria produce the worst SD and E results of the ones considered. Net R/oz Pt is slightly worse that Net R/t.

- Although the actual numbers are different, criteria 3 to 6 show similar patterns over time for SD and E. This is probably to be expected since all of these are related to profit.

- Cut-off head grade, however, stands out as producing the lowest SD for V, especially in years 3, 9 - 11 and 17 - 19.

- The Profit/t, Cash Margin and Cut-Off Head Grade criteria stand out as producing values for E closest to zero.

- Years 3, 9 - 11 and 17 - 19 are the periods when (1) production starts, (2) Real IRR and NPV @ 0% discount first become positive and (3) a fresh capital injection is required, respectively.

5. XYZ PGM MINE

5.1 GENERAL

XYZ acts as a test of the results produced for Hartley. It is a fictitious South African UG2 mine, although it is loosely based on several declared results of UG2 project evaluations. No inference can or should be drawn from the results for XYZ on anyone's view of any particular project.

UG2 Reef was chosen as the reef to be mined at XYZ since Hartley mines a reef more similar to the Bushveld Igneous Complex's Merensky Reef. It is a deeper mine than Hartley with consequently higher capex and working costs. Maximum production is 2 750 000 t milled pa and 166 000 oz Pt pa.

The forecast economic parameters used are as per page 13. Refer to pages 72 to 75 for details of all input parameters used.

23-Jul-01 JUL 1991 TERMS — XYZ.XLS — INTRAMARGINAL ANALYSIS OF PLATINUM PRODUCERS — XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE.

RACF's	
MERENSKY	1,15
UG2	1,27

	GEOLOGICAL	RESERVES (TONS) INSITU	MINEABLE	t p.a.	oz Pt p.a.	LIFE years
MERENSKY						
UG2						

EXCHANGE RATES: JUL 1991 TERMS — R/US$ 2,835 — US$/£ 1,559

METAL PRICES : JUL 1991 TERMS

	FREE MARKET SALES US$/oz	R/oz
Pt	370,20	1 046,97
Pd	95,50	269,60
Au	361,40	1 020,11
Rh	3 275,00	9 242,30
Ru	58,30	161,52
Ir	285,00	814,59
Ni	9 135,46	22 468,70
Cu	1 202,98	3 548,99

MERENSKY	% SPLIT IN-SITU	CORRECTED IN-SITU	CORRECTED HEAD	ESTIMATED CONCENTRATOR	ESTIMATED SMELTER	RECOVERIES NOR	RECOVERIES PMR	YIELD g/t	% SPLIT (BASE/Pt)	REVENUE R/t
TOTALS		4,200	3,580							
Pt	52,00%	2,184	1,028	87,00%	97,50%	88,80%	99,00%	1,198	52,51%	58,42
Pd	28,00%	1,210	1,015	87,00%	97,50%	88,80%	99,00%	0,935	28,45%	7,90
Au	0,00%	0,938	0,205	87,00%	97,50%	97,00%	97,00%	0,223	7,08%	1,23
Rh	3,00%	0,126	0,105	87,00%	97,50%	94,50%	95,50%	0,008	12,03%	23,97
Ru	7,00%	0,294	0,245	87,00%	97,50%	94,00%	92,50%	0,169	8,34%	8,93
Ir	7,00%	0,242	0,095	87,00%	97,50%	94,00%	70,00%	0,028	0,69%	0,51
TOTALS	100,00%	4,200	3,580	87,00%	97,50%	97,50%	97,50%	2,036	100,00%	99,54
Ni	g/t	1 000	1500	87,00%	95,00%	96,00%		1 198	795	26,73
Cu	g/t	900	750	87,00%	95,00%	96,00%		595	397	2,11

MINING EXTRACTION 89,39% — UNCORRECTED IN-SITU 9,550 — UNCORRECTED HEAD 3,849

TOTAL REVENUE 110,80
OVERALL RECOVERY 81,
MATTE kg/t

UG2	% SPLIT IN-SITU	CORRECTED IN-SITU	CORRECTED HEAD	ESTIMATED CONCENTRATOR	ESTIMATED SMELTER	RECOVERIES NOR	RECOVERIES PMR	YIELD g/t	% SPLIT (BASE/Pt)	REVENUE R/t
		7,900	5,200							
Pt		3,634	2,392	83,00%	97,50%	88,80%	99,00%	1,070	47,22%	53,22
Pd		2,148	1,612	83,00%	97,50%	88,50%	99,00%	1,265	31,02%	18,75
Au		0,079	0,052	83,00%	97,50%	97,00%	97,00%	0,048	1,06%	1,20
Rh	7,00%	0,553	0,364	83,00%	97,50%	94,50%	95,50%	0,265	6,50%	77,28
Ru	13,00%	1,027	0,676	83,00%	97,50%	94,00%	92,00%	0,473	11,05%	2,46
Ir	2,00%	0,150	0,104	83,00%	97,50%	94,00%	70,00%	0,055	1,39%	1,45
TOTALS	100,00%	7,900	5,200	83,00%	97,50%	97,15%	97,25%	3,970	100,00%	156,42
Ni	g/t	304	200	83,00%	95,00%	96,00%		151	01	3,40
Cu	g/t	152	100	83,00%	95,00%	96,00%		75	48	0,27

MINING EXTRACTION 65,12% — UNCORRECTED IN-SITU 6,245 — UNCORRECTED HEAD 4,111

TOTAL REVENUE 160,00
OVERALL RECOVERY 76,45%
MATTE kg/t 0,207

COMBINED MERENSKY & UG2

	YIELD g/t	% SPLIT (BASE/Pt)	REVENUE R/t
Pt	1,070	47,22%	53,22
Pd	1,265	31,02%	18,75
Au	0,048	1,06%	1,20
Rh	0,265	6,50%	77,28
Ru	0,473	11,05%	2,46
Ir	0,055	1,39%	1,45
TOTAL	3,970	100,00%	156,42
Ni	151	01	3,40
Cu	75	48	0,27

TOTAL REVENUE 160,00
OVERALL RECOVERY 76,40%
MATTE kg/t 0,207

NOTE: IN-SITU GRADE IS QUOTED ACROSS THE THEORETICAL IDEAL CHANNEL WIDTH

COMBINED MERENSKY & UG2

	IN-SITU	HEAD
UNCORRECTED	6,245	4,111
CORRECTED	7,900	5,200

			MERENSKY	UG2	COMBINED (UG2 @ 100,00%)
(a) TOTAL REVENUE PER t		R/t	110,80	150,00	160,00
(b) TOTAL COSTS PER t		R/t	110,20	93,75	93,75
(c) BY-PRODUCT CREDITS PER t		R/t	67,95	96,07	66,07
(d) TOTAL REVENUE PER oz Pt		R/oz Pt	2 450	2 651	2 651
(e) TOTAL COSTS PER oz Pt		R/oz Pt	2 436	1 553	1 553
(f) BY-PRODUCT CREDITS PER oz Pt		R/oz Pt	1 411	1 594	1 594
(g) TOTAL COSTS NET OF BY-PRODUCT CREDITS	(b)-(c)	R/t	58,32	(3,12)	(3,32)
(h) TOTAL COSTS NET OF BY-PRODUCT CREDITS	(e)-(f)	R/oz Pt	1 045	(52)	(52)
(i) PROFIT PER TON	(a)-(b)	R/t	0,10	56,34	66,34
(j) PROFIT PER oz Pt	(d)-(e)	R/oz Pt	2	960	1 099
(k) CASH MARGIN PER TON	(i)/(d)	t/t	0,00	0,44	41,44
(l) CASH MARGIN PER oz Pt	(j)/(d)	t/oz Pt	0,00	0,44	41,44
(m) CUT-OFF HEAD GRADE	(b)/(a)*MG	g PGM/t	3,497	3,045	3,845 (CORRECTED)
(n) CUT-OFF YEAR GRADE	(b)/(a)*MG	g PGM/t	3,845	2,487	2,497 (UNCORRECTED)

WORKING COSTS : JUL 1991 TERMS

	MERENSKY R/t	UG2 R/t	TOTAL R/t
(1) MINING, R/t :	64,00	69,00	66,00
(2) MINERAL PROCESSING			
CONCENTRATING, R/t :	11,50	11,50	11,50
% CONCENTRATION RATIO OF			
MERENSKY : 29			
UG2 : 75			
SMELTING, R/PT CONC : 250,00			
SMELTING, R/t :	10,07	3,33	3,33
(3) REFINING			
NCR, R/t MATTE : 7 550,00			
NCR, R/t :	17,53	2,23	2,23
PMR, R/oz Pt : 120,00			
PMR, R/t :	5,73	7,25	7,25
SUB TOTAL	100,07	84,31	84,31
(4) MARKETING			
% OF REVENUE : 2,00%			
MARKETING, R/t :	2,37	3,26	3,20
(5) HEAD OFFICE, ETC	2,00	2,00	2,00
TOTAL WORKING COST	114,04	89,51	89,51
(6) ONGOING CAPEX, R/t	3,00	3,00	3,00
TOTAL COSTS	117,04	92,51	92,51
TOTAL COSTS WITH ROYALTY	110,20	93,75	93,75

SOURCES OF INPUT DATA

GEOLOGICAL/MINING DATA :	AS PER PLB, JUNE 1991
METALLURGICAL DATA :	AS PER MUM, JUNE 1991
WORKING COST DATA :	AS PER PLO, JUNE 1991
METAL PRICES :	AS PER PLB, JUNE 1991

YEARLY PRODUCTION STATISTICS :	BUDGET	ANNUALISED	% VARIANCE
'000 t MILLED, MERENSKY	0	0	ERR
'000 t MILLED, UG2	2 759	2 759	0,00%
'000 oz Pt	166	166	0,00%
'000 oz Pd	112	112	0,00%
'000 oz Rh	24	24	0,00%
t Ni	416	416	0,00%
t Cu	200	200	0,00%

01-07-23

INPUT DATA

XV2.WK1 FINANCIAL YEARS		04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
SACPT		10,00%	10,00%	10,00%	10,00%	10,00%	10,00%	10,00%	10,00%	10,00%	10,00%	10,00%	10,00%
SA DISCOUNT FACTOR		3,982	4,198	4,889	5,978	6,577	6,195	6,748	7,423	8,165	8,982	9,880	10,868
MERENSKY HEAD GRADE	g/t	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
UG2 HEAD GRADE	g/t	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200
MERENSKY MILLED	t	0	0	0	0	0	0	0	0	0	0	0	0
UG2 MILLED	t	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000
TOTAL MILLED	t	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000	2 750 000
PERCENTAGE UG2	%	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Pt PRODUCED	oz	166 046	166 046	166 046	166 046	166 046	166 046	166 046	166 046	166 046	166 046	166 046	166 046
Pd PRODUCED	oz	111 901	111 901	111 901	111 901	111 901	111 901	111 901	111 901	111 901	111 901	111 901	111 901
Au PRODUCED	oz	3 501	3 501	3 501	3 501	3 501	3 501	3 501	3 501	3 501	3 501	3 501	3 501
Rh PRODUCED	oz	23 504	23 504	23 504	23 504	23 504	23 504	23 504	23 504	23 504	23 504	23 504	23 504
Ru PRODUCED	oz	41 828	41 828	41 828	41 828	41 828	41 828	41 828	41 828	41 828	41 828	41 828	41 828
Ir PRODUCED	oz	4 096	4 096	4 896	4 896	4 896	4 896	4 896	4 896	4 896	4 896	4 896	4 896
Ni PRODUCED	t	416	416	416	416	416	416	416	416	416	416	416	416
Cu PRODUCED	t	208	208	208	208	208	208	208	208	208	208	208	208
Pt PRICE, FREE MARKET	US$/oz	908,47	949,35	992,07	1 036,71	1 083,36	1 132,11	1 183,06	1 236,30	1 291,93	1 350,07	1 410,82	1 474,31
Pd PRICE, FREE MARKET	US$/oz	261,78	273,47	285,76	298,64	312,00	326,12	340,80	356,14	372,16	388,91	406,41	424,78
Au PRICE, FREE MARKET	US$/oz	853,69	892,05	932,19	974,14	1 017,90	1 063,76	1 111,85	1 161,99	1 213,95	1 268,58	1 325,67	1 385,32
Rh PRICE, FREE MARKET	US$/oz	5 542,95	6 836,87	7 144,52	7 466,03	7 802,00	8 153,09	9 519,98	8 903,36	9 304,02	9 722,71	10 160,29	10 617,44
Ru PRICE, FREE MARKET	US$/oz	100,94	105,48	110,23	115,19	120,37	125,79	131,45	137,37	143,55	150,01	156,76	163,81
Ir PRICE, FREE MARKET	US$/oz	507,20	530,02	553,87	578,79	604,84	632,06	660,50	690,22	721,28	753,74	787,66	823,10
Ni PRICE, FREE MARKET	US$/t	14 642,64	15 301,56	15 988,13	16 709,60	17 461,52	18 247,89	19 069,52	19 926,61	22 823,30	21 765,36	22 736,57	23 762,85
Cu PRICE, FREE MARKET	R/t	2 167,59	2 243,90	2 321,91	2 403,19	2 487,29	2 574,34	2 664,44	2 757,70	2 854,22	2 954,12	3 057,61	3 164,52
EXCHANGE RATE	R/US$	5,17	5,44	5,73	6,03	6,35	6,68	7,03	7,40	7,79	8,20	8,63	9,09
EXCHANGE RATE	R/£	10,21	10,85	11,53	12,26	13,03	13,85	14,72	15,64	16,62	17,67	18,78	19,95

5.2 CONVENTIONAL RESULTS

Pages 77 to 84 show the detailed results, with graphs, of the standard project evaluation of XYZ. In summary, they are as follows :-

Real IRR, %, 25 years :	6,85
NPV, R million, 25 years, @ 0% discount :	928
@ 3% discount :	363
@ 5% discount :	139
Maximum Exposure, escalated, R million :	1 305
Maximum Exposure, base date, R million :	851
Payback Period, years, escalated money :	11
Payback Period, years, base date money :	15

In addition, sensitivities were run (see pages 85 to 91), showing that the project was most sensitive to variations in metal prices and recovered grade.

91-07-23

ANALYSIS RESULTS

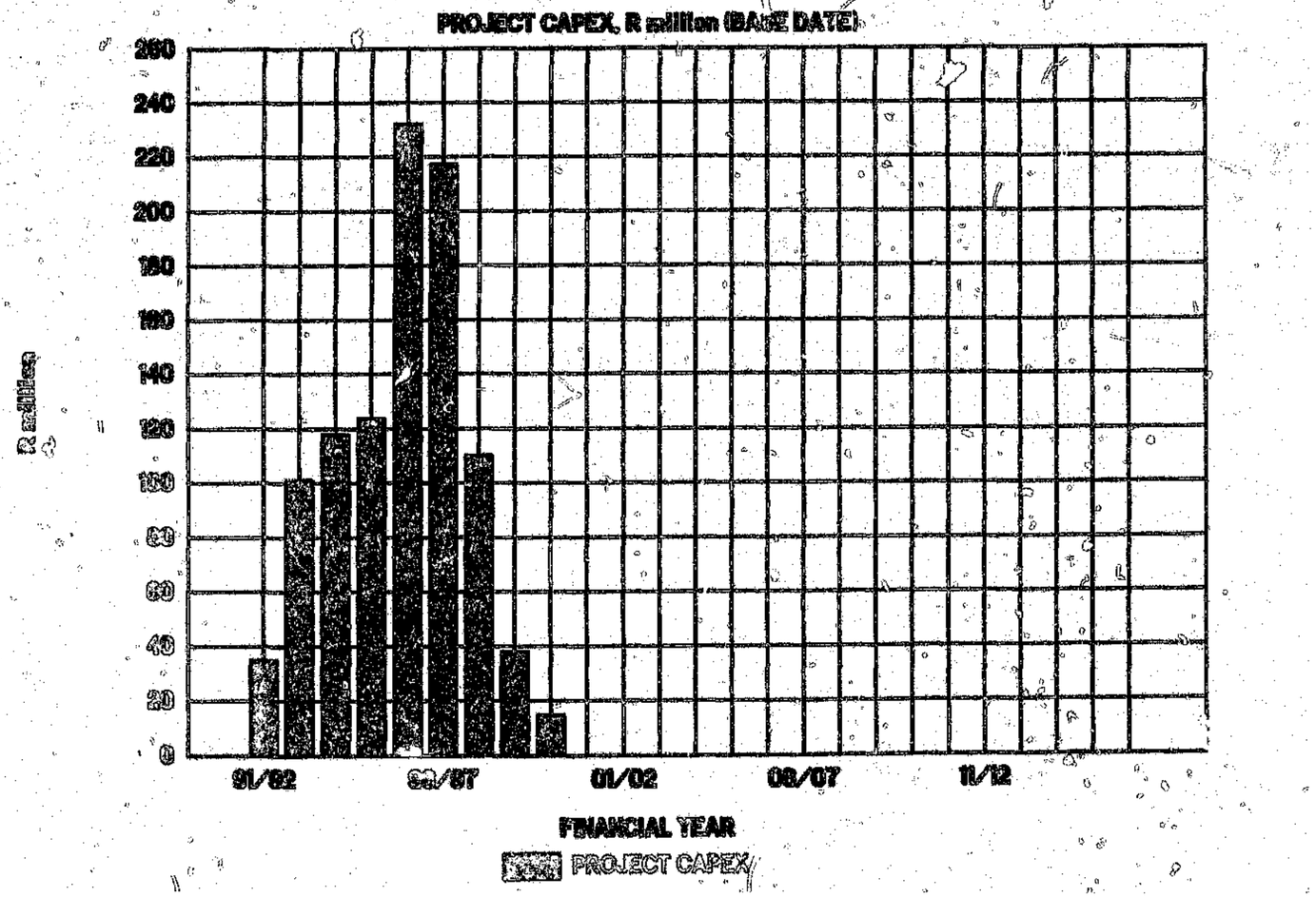
XYZ VKT	FINANCIAL YEARS	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04
ESCALATED	R million													
REVENUE		0	0	0	0	0	145	416	648	879	1 002	1 388	1 459	1 605
TOTAL WORKING COST		0	0	0	0	0	119	262	305	407	585	784	775	852
WORKING PROFIT		0	0	0	0	0	26	153	283	386	497	605	684	752
WORKING CAPEX		0	0	0	0	0	0	0	0	0	0	0	0	0
PROJECT CAPEX		37	120	155	182	375	388	215	82	35	0	0	0	0
ONGOING CAPEX		0	0	0	0	0	4	9	13	16	-20	24	26	29
TOTAL CAPEX		37	120	155	182	375	393	224	95	51	20	24	26	29
LEASE PAYMENT		0	0	0	0	0	0	0	0	0	0	59	60	76
ROYALTY PAYMENT		0	0	0	0	0	0	0	0	0	4	6	7	8
Y&X PAYABLE		0	0	0	0	0	0	0	0	0	143	243	279	307
TOTAL GOVERNMENT		0	0	0	0	0	0	0	0	0	147	302	346	393
ESCALATED CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		(37)	(120)	(155)	(182)	(375)	(365)	(71)	188	395	316	269	283	339
BASE DATE CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		(35)	(101)	(110)	(124)	(232)	(205)	(36)	70	142	121	97	96	95
ESCALATED CUMULATIVE CASH FLOW	R million	(37)	(157)	(313)	(495)	(870)	(1 235)	(1 305)	(1 197)	(802)	(487)	(223)	79	412
BASE DATE CUMULATIVE CASH FLOW	R million	(35)	(136)	(254)	(378)	(610)	(815)	(851)	(773)	(632)	(510)	(418)	(322)	(226)
BASE DATE REVENUE PER t MILLED	R/t	0,00	0,00	0,00	0,00	0,00	100,38	141,85	158,05	160,55	161,47	165,17	160,49	168,48
BASE DATE REVENUE PER oz Pt	R/oz Pt	0	0	0	0	0	2 387	2 605	2 651	2 748	2 754	2 773	2 781	2 781
BASE DATE TOTAL COSTS PER t MILLED	R/t	0,00	0,00	0,00	0,00	0,00	92,51	92,51	92,51	92,51	92,51	92,51	92,51	92,51
BASE DATE TOTAL COSTS PER oz Pt	R/oz Pt	0	0	0	0	0	2 043	1 781	1 694	1 584	1 578	1 653	1 592	1 592
BASE DATE BY-PRODUCT CREDITS PER t MILLED	R/t	0,00	0,00	0,00	0,00	0,00	54,49	79,03	82,65	92,42	91,06	93,86	96,30	96,00
BASE DATE BY-PRODUCT CREDITS PER oz Pt	R/oz Pt	0	0	0	0	0	1 283	1 492	1 468	1 540	1 553	1 579	1 599	1 599
BASE DATE NETT TOTAL COSTS PER t MILLED	R/t	0,00	0,00	0,00	0,00	0,00	38,02	13,68	9,86	2,89	1,45	(1,15)	(3,40)	(3,49)
BASE DATE NETT TOTAL COSTS PER oz Pt	R/oz Pt	0	0	0	0	0	340	290	174	36	25	(19)	(50)	(59)
BASE DATE WORKING PROFIT PER t MILLED	R/t	0,00	0,00	0,00	0,00	0,00	16,05	49,34	58,14	68,04	69,86	72,66	75,80	75,98
BASE DATE WORKING PROFIT PER oz Pt	R/oz Pt	0	0	0	0	0	354	834	1 022	1 168	1 176	1 228	1 259	1 258
CASH MARGIN, PROFIT/REVENUE	%	0,00	0,00	0,00	0,00	0,00	14,70	34,70	30,59	42,38	42,35	43,56	44,59	44,59
MEREMSKY CUT-OFF HEAD GRADE	g PGM/t	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
UGZ CUT-OFF HEAD GRADE	g PGM/t	0,000	0,000	0,000	0,000	0,000	4,431	3,391	3,103	2,906	2,979	2,912	2,855	2,855
TOTAL CUT-OFF HEAD GRADE	g PGM/t	0,000	0,000	0,000	0,000	0,000	4,431	3,391	3,103	2,906	2,979	2,912	2,855	2,855
NPV CASH FLOW, 0%	R million	(35)	(135)	(264)	(370)	(610)	(815)	(851)	(773)	(632)	(510)	(418)	(322)	(226)
NPV CASH FLOW, 1%	R million	(35)	(134)	(260)	(367)	(606)	(797)	(815)	(743)	(613)	(494)	(421)	(328)	(251)
NPV CASH FLOW, 2%	R million	(34)	(131)	(245)	(357)	(587)	(758)	(781)	(714)	(596)	(486)	(422)	(346)	(272)
NPV CASH FLOW, 3%	R million	(34)	(129)	(237)	(347)	(568)	(719)	(748)	(689)	(579)	(480)	(422)	(354)	(288)
NPV CASH FLOW, 4%	R million	(34)	(127)	(232)	(338)	(529)	(691)	(718)	(661)	(562)	(480)	(420)	(360)	(302)
NPV CASH FLOW, 5%	R million	(33)	(125)	(227)	(329)	(511)	(664)	(690)	(637)	(545)	(471)	(417)	(364)	(313)
NPV CASH FLOW, 6%	R million	(33)	(123)	(222)	(320)	(494)	(638)	(662)	(613)	(528)	(462)	(413)	(365)	(328)
NPV CASH FLOW, 7%	R million	(33)	(121)	(217)	(312)	(477)	(614)	(637)	(591)	(514)	(452)	(409)	(366)	(325)
NPV CASH FLOW, 8%	R million	(32)	(119)	(213)	(304)	(462)	(591)	(612)	(570)	(499)	(443)	(403)	(365)	(338)
NPV CASH FLOW, 9%	R million	(32)	(117)	(209)	(296)	(447)	(569)	(589)	(550)	(485)	(433)	(396)	(364)	(332)
NPV CASH FLOW, 10%	R million	(32)	(115)	(204)	(289)	(433)	(548)	(567)	(531)	(471)	(424)	(392)	(361)	(339)
NPV CAPEX, 0%	R million	35	135	254	370	610	827	938	976	998	900	938	908	908
IRR CASH FLOW, %		ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	(0,02)

01-07-23

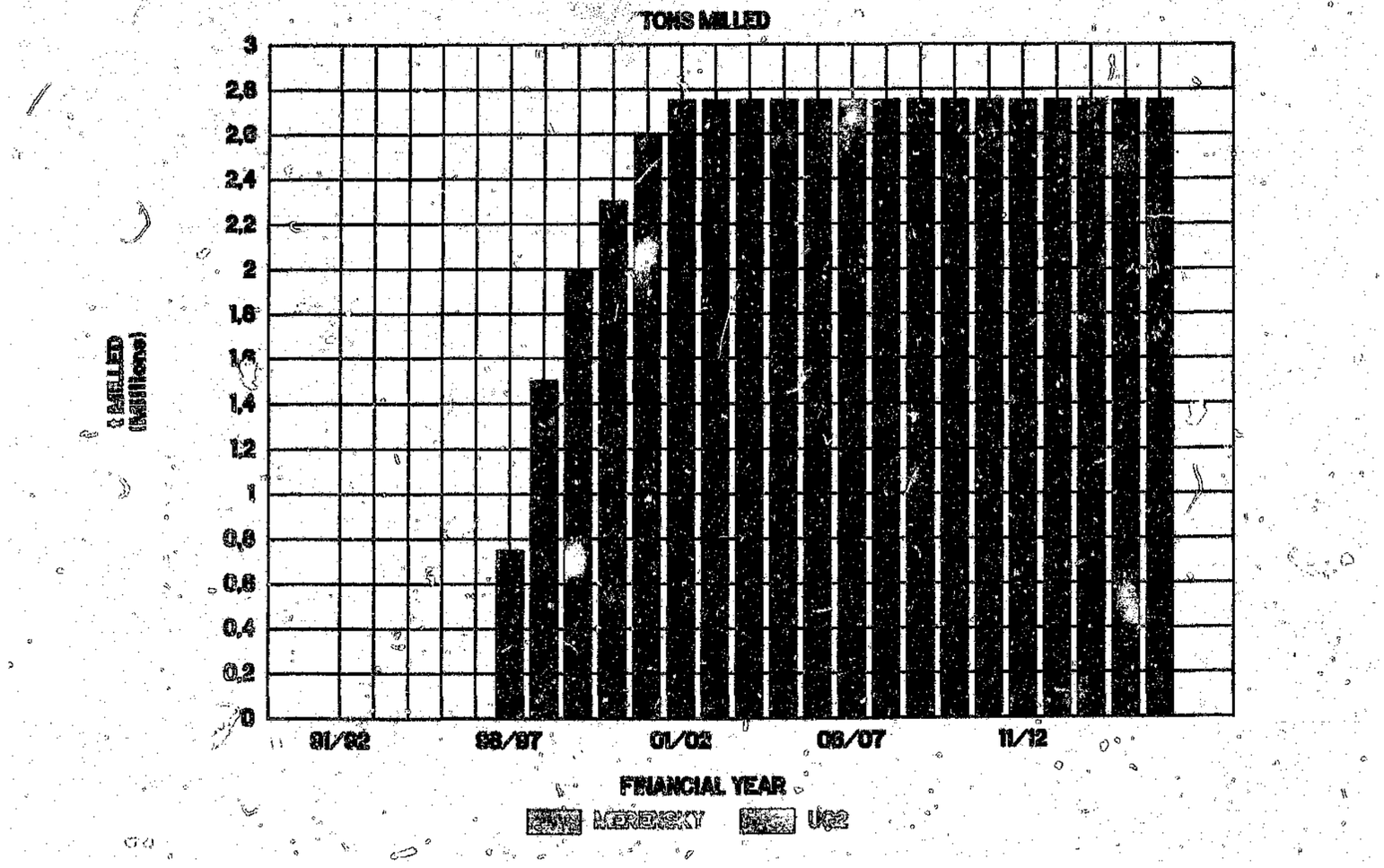
ANALYSIS RESULTS

XYZ,MS1	FINANCIAL YEARS	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
ESCALATED R million													
REVENUE		1 705	1 942	2 136	2 349	2 584	2 843	3 127	3 440	3 784	4 162	4 578	5 036
TOTAL WORKING COST		938	1 041	1 135	1 249	1 373	1 510	1 661	1 827	2 010	2 211	2 432	2 675
WORKING PROFIT		827	916	1 001	1 101	1 211	1 333	1 466	1 613	1 774	1 951	2 146	2 361
WORKING CAPEX		0	0	0	0	0	0	0	0	0	0	0	0
PROJECT CAPEX		0	0	0	0	0	0	0	0	0	0	0	0
ONGOING CAPEX		31	35	38	42	46	51	56	61	67	74	82	90
TOTAL CAPEX		31	35	38	42	46	51	56	61	67	74	82	90
LEASE PAYMENT		83	91	100	110	121	133	147	161	177	195	215	236
ROYALTY PAYMENT		9	10	11	12	13	14	16	17	19	21	23	25
TAX PAYABLE		338	372	409	450	495	544	599	659	725	797	877	965
TOTAL GOVERNMENT		421	463	509	560	616	678	746	820	902	992	1 092	1 201
ESCALATED CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		366	403	443	487	536	590	649	714	785	864	950	1 045
BASE DATE CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		96	96	96	96	96	96	96	96	96	96	96	96
ESCALATED CUMULATIVE CASH FLOW	R million	778	1 181	1 624	2 112	2 647	3 238	3 887	4 600	5 386	6 249	7 199	8 244
BASE DATE CUMULATIVE CASH FLOW	R million	(198)	(34)	62	159	255	351	447	543	639	735	832	928
BASE DATE REVENUE PER t MILLED	R/t	168,49	168,49	168,49	168,49	168,49	168,49	168,49	168,49	168,49	168,49	168,49	168,49
BASE DATE REVENUE PER oz Pt	R/oz Pt	2 791	2 791	2 791	2 791	2 791	2 791	2 791	2 791	2 791	2 791	2 791	2 791
BASE DATE TOTAL COSTS PER t MILLED	R/t	92,51	92,51	92,51	92,51	92,51	92,51	92,51	92,51	92,51	92,51	92,51	92,51
BASE DATE TOTAL COSTS PER oz Pt	R/oz Pt	1 532	1 532	1 532	1 532	1 532	1 532	1 532	1 532	1 532	1 532	1 532	1 532
BASE DATE BY-PRODUCT CREDITS PER t MILLED	R/t	96,00	96,00	96,00	96,00	96,00	96,00	96,00	96,00	96,00	96,00	96,00	96,00
BASE DATE BY-PRODUCT CREDITS PER oz Pt	R/oz Pt	1 590	1 590	1 590	1 590	1 590	1 590	1 590	1 590	1 590	1 590	1 590	1 590
BASE DATE NETT TOTAL COSTS PER t MILLED	R/t	(3,49)	(3,49)	(3,49)	(3,49)	(3,49)	(3,49)	(3,49)	(3,49)	(3,49)	(3,49)	(3,49)	(3,49)
BASE DATE NETT TOTAL COSTS PER oz Pt	R/oz Pt	(58)	(58)	(58)	(58)	(58)	(58)	(58)	(58)	(58)	(58)	(58)	(58)
BASE DATE WORKING PROFIT PER t MILLED	R/t	75,98	75,98	75,98	75,98	75,98	75,98	75,98	75,98	75,98	75,98	75,98	75,98
BASE DATE WORKING PROFIT PER oz Pt	R/oz Pt	1 258	1 258	1 258	1 258	1 258	1 258	1 258	1 258	1 258	1 258	1 258	1 258
CASH MARGIN, PROFIT/REVENUE	%	44,59	44,59	44,59	44,59	44,59	44,59	44,59	44,59	44,59	44,59	44,59	44,59
KERENSKY CUT-OFF HEAD GRADE	g PGM/t	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
UG2 CUT-OFF HEAD GRADE	g PGM/t	2,055	2,055	2,055	2,055	2,055	2,055	2,055	2,055	2,055	2,055	2,055	2,055
TOTAL CUT-OFF HEAD GRADE	g PGM/t	2,055	2,055	2,055	2,055	2,055	2,055	2,055	2,055	2,055	2,055	2,055	2,055
NPV CASH FLOW, 0%	R million	(198)	(34)	62	159	255	351	447	543	639	735	832	928
NPV CASH FLOW, 1%	R million	(169)	(05)	(3)	76	159	238	319	395	472	549	624	699
NPV CASH FLOW, 2%	R million	(199)	(120)	(90)	11	76	144	209	272	334	395	455	514
NPV CASH FLOW, 3%	R million	(223)	(164)	(134)	(.6)	11	66	119	171	221	270	317	363
NPV CASH FLOW, 4%	R million	(247)	(192)	(142)	(93)	(45)	0	44	87	127	166	204	240
NPV CASH FLOW, 5%	R million	(264)	(218)	(174)	(132)	(92)	(54)	(10)	17	50	81	111	139
NPV CASH FLOW, 6%	R million	(278)	(239)	(208)	(170)	(131)	(99)	(69)	(40)	(14)	11	35	58
NPV CASH FLOW, 7%	R million	(289)	(254)	(221)	(191)	(162)	(136)	(111)	(88)	(66)	(46)	(27)	(9)
NPV CASH FLOW, 8%	R million	(297)	(267)	(230)	(213)	(189)	(166)	(146)	(127)	(109)	(93)	(78)	(63)
NPV CASH FLOW, 9%	R million	(303)	(277)	(253)	(231)	(219)	(191)	(174)	(159)	(144)	(131)	(118)	(100)
NPV CASH FLOW, 10%	R million	(308)	(285)	(264)	(246)	(228)	(212)	(199)	(189)	(173)	(162)	(152)	(143)
NPV CAPEX, 0%	R million	999	998	998	998	998	998	998	998	998	998	998	998
IRR CASH FLOW, %		(4,08)	(1,16)	0,05	2,18	3,18	4,01	4,76	5,28	5,77	6,10	6,54	6,85

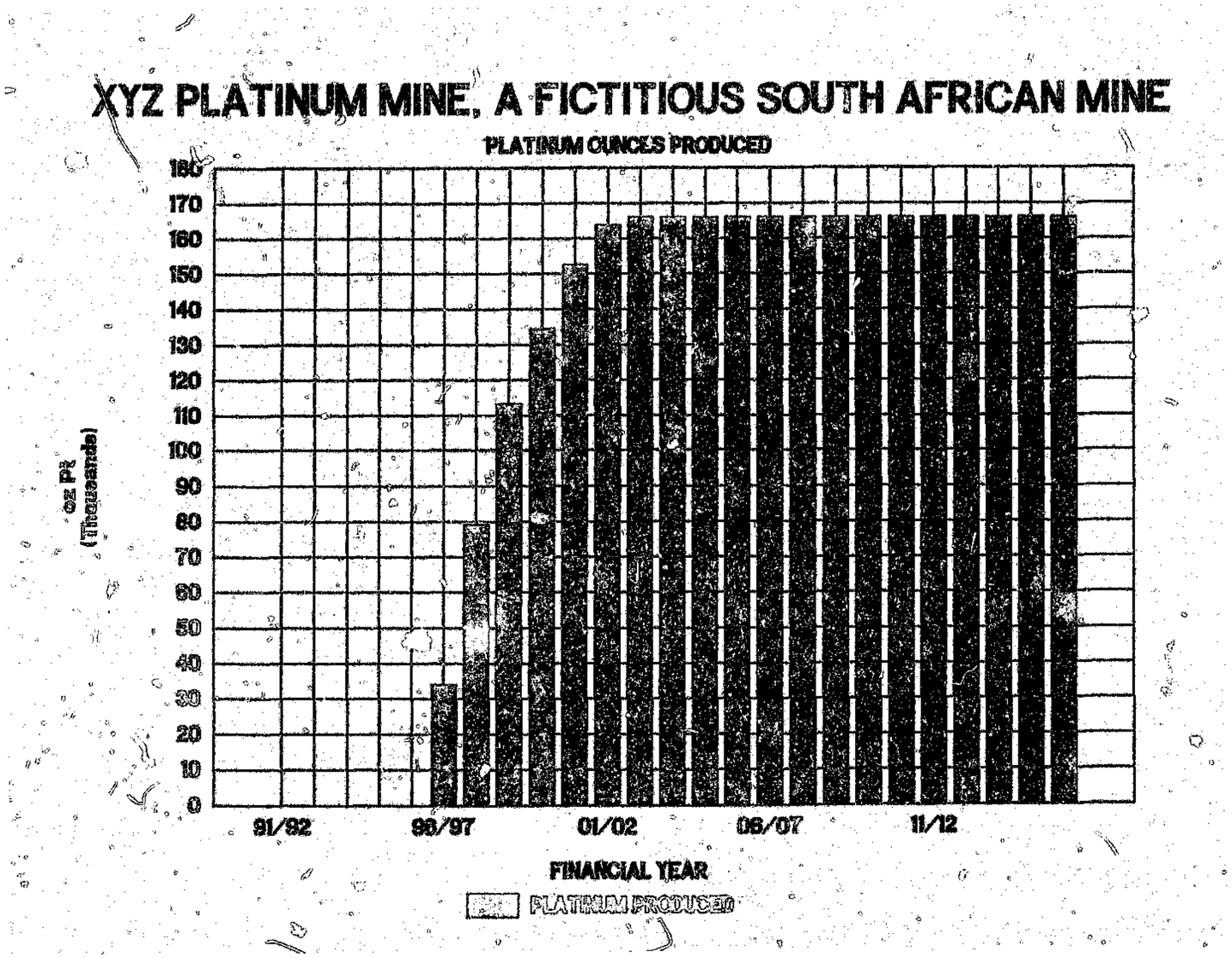
XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



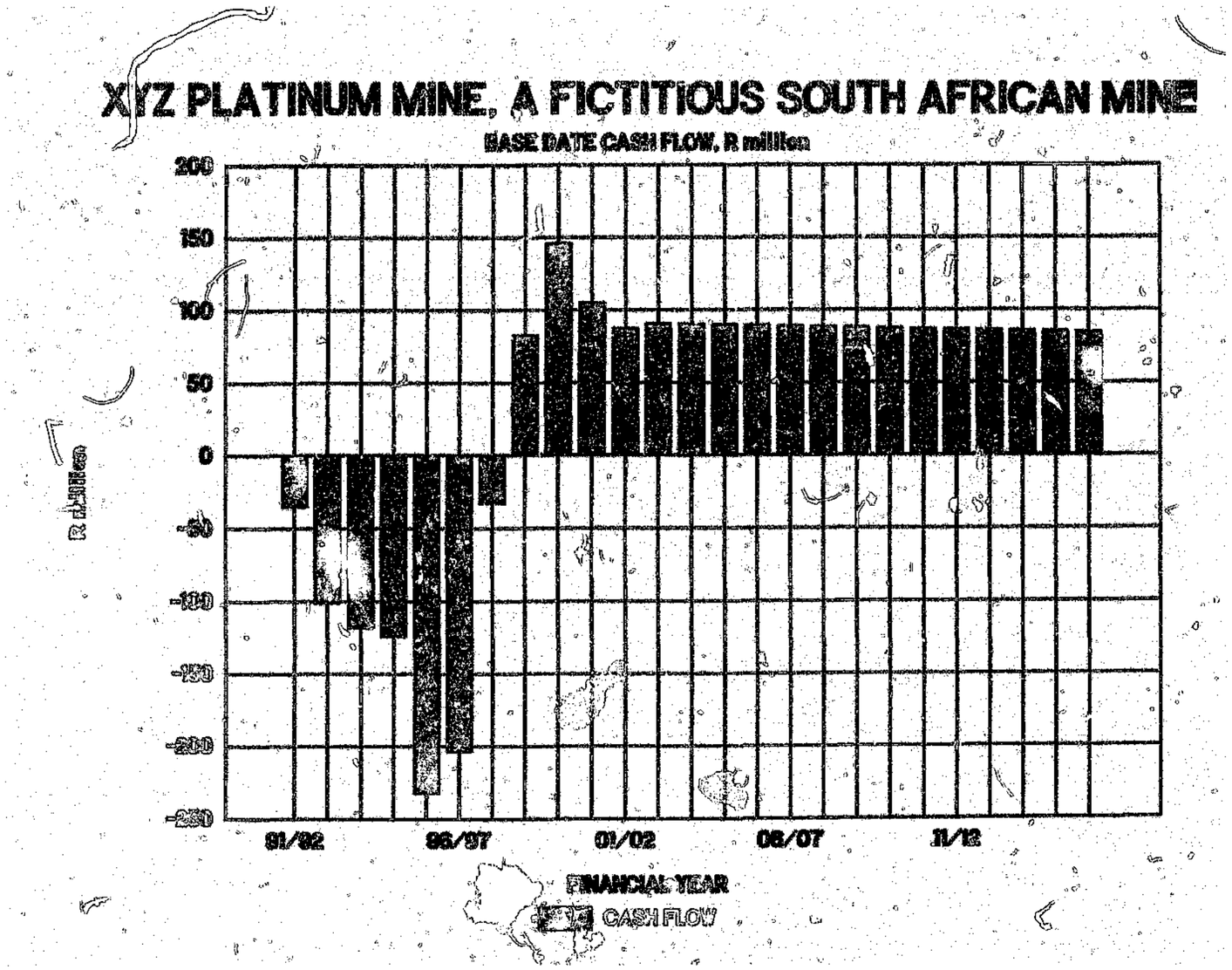
XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



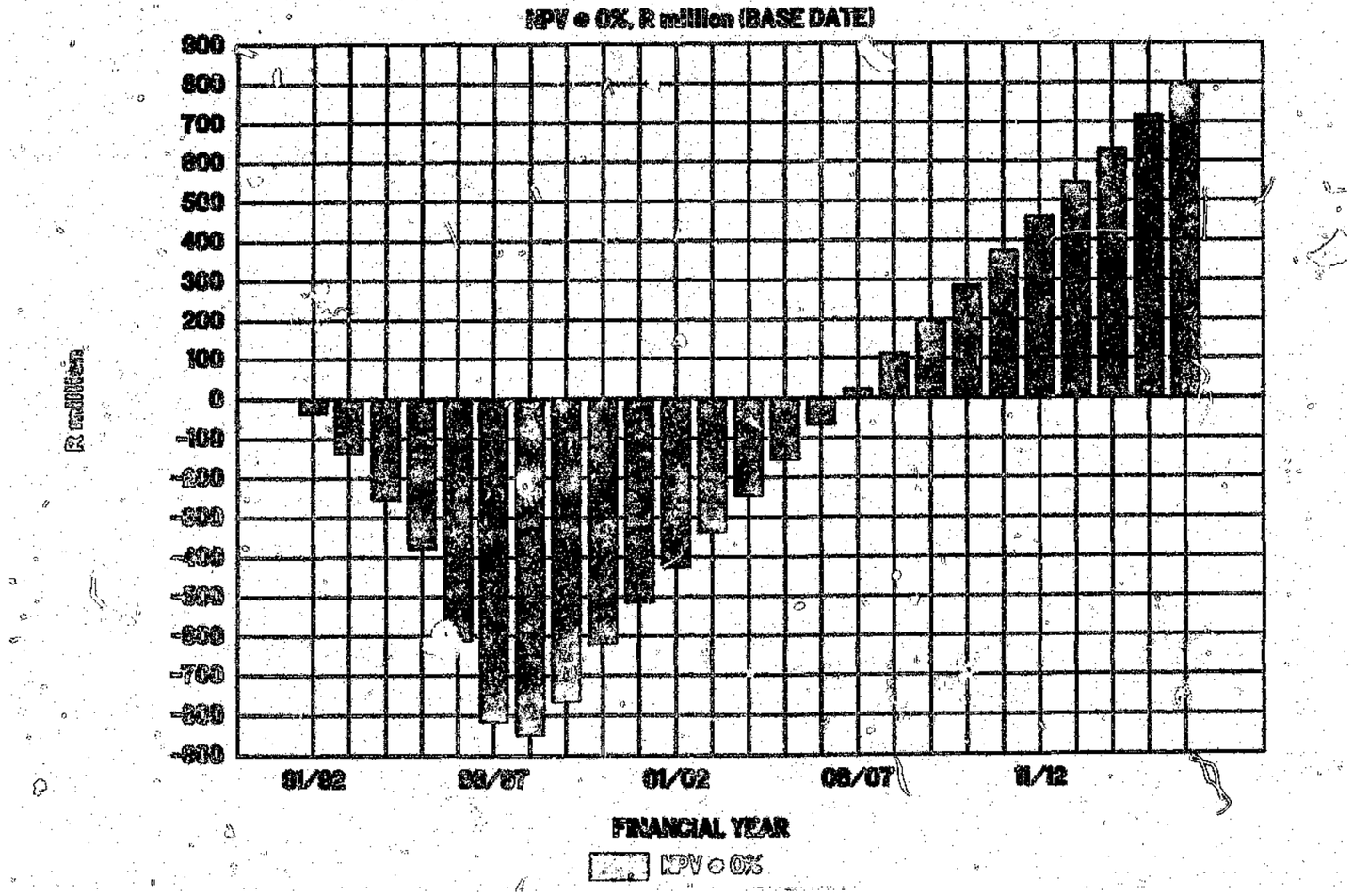
XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



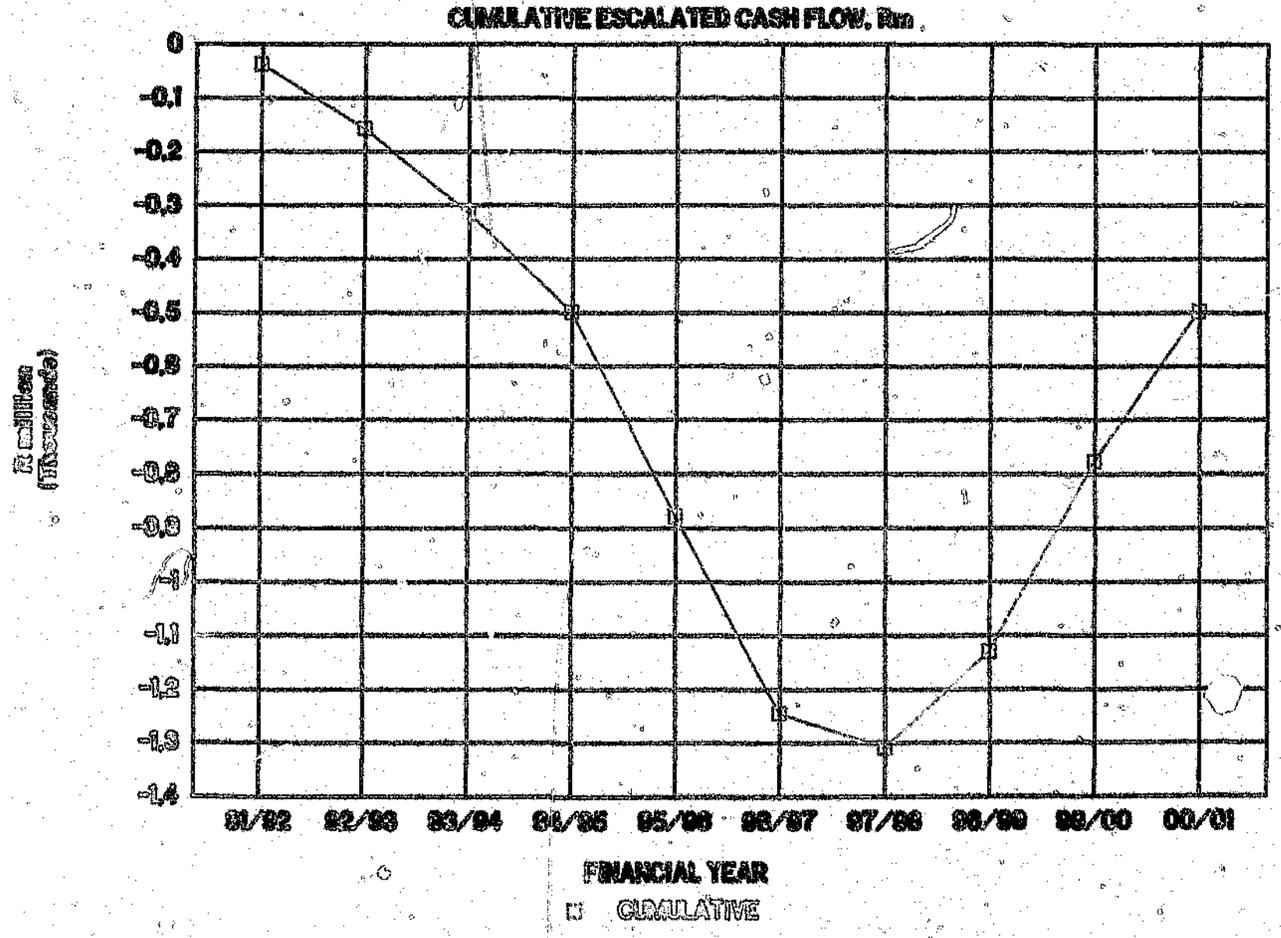
XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



Company : XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

SENSITIVITIES ON NETT TOTAL COSTS PER t, R/t

	-5%	BASE	5%
METAL PRICES	1,41	(3[illegible]	(7,66)
WORK COSTS	(7,52)	(3,12)	1,27
CAPEX	(3,27)	(3,12)	(2,98)
REC GRADES	8,95	(3,12)	(7,19)
MILLED TONS	(3,13)	(3,12)	(3,12)
SACPI	(3,06)	(3,12)	(3,13)
USCPI	(3,09)	(3,12)	(3,15)
R/US$	1,57	(3,12)	(7,76)
R/£	(3,12)	(3,12)	(3,12)
LEASE	(3,11)	(3,12)	(3,13)
ROYALTY	(3,19)	(3,12)	(3,06)
TAX RATE	(3,12)	(3,12)	(3,12)
WORST CASE		13,92	
BEST CASE		(21,60)	

SENSITIVITIES ON NETT TOTAL COSTS PER oz Pt, R/oz Pt

	-5%	BASE	5%
METAL PRICES	23	(52)	(127)
WORK COSTS	(124)	(52)	21
CAPEX	(54)	(52)	(49)
REC GRADES	17	(52)	(113)
MILLED TONS	(52)	(52)	(52)
SACPI	(51)	(52)	(53)
USCPI	(51)	(52)	(52)
R/US$	25	(52)	(139)
R/£	(52)	(52)	(52)
LEASE	(52)	(52)	(52)
ROYALTY	(53)	(52)	(51)
TAX RATE	(52)	(52)	(52)
WORST CASE		249	
BEST CASE		(342)	

SENSITIVITIES ON CASH MARGIN, %

	-5%	BASE	5%
METAL PRICES	38,56	41,44	44,85
WORK COSTS	44,18	41,44	38,69
CAPEX	41,53	41,44	41,35
REC GRADES	38,07	41,44	43,77
MILLED TONS	41,44	41,44	41,44
SACPI	41,40	41,44	41,48
USCPI	41,42	41,44	41,46
R/US$	39,49	41,44	44,11
R/£	41,44	41,44	41,44
LEASE	41,43	41,44	41,44
ROYALTY	41,48	41,44	41,40
TAX RATE	41,44	41,44	41,44
WORST CASE		29,35	
BEST CASE		51,19	

SENSITIVITIES ON NPV @ 0%, R million

	-20%	BASE	20%
METAL PRICES	145	928	1 733
WORK COSTS	1 361	928	498
CAPEX	1 092	928	788
REC GRADES	184	928	1 695
MILLED TONS	590	928	1 [illegible]
SACPI	1 272	928	575
USCPI	1 146	928	739
R/US$	717	928	1 123
R/£	926	928	930
LEASE	961	928	894
ROYALTY	931	928	924
TAX RATE	1 204	928	561
TIMING	988	928	920
WORST CASE		(1 957)	
BEST CASE		6 522	

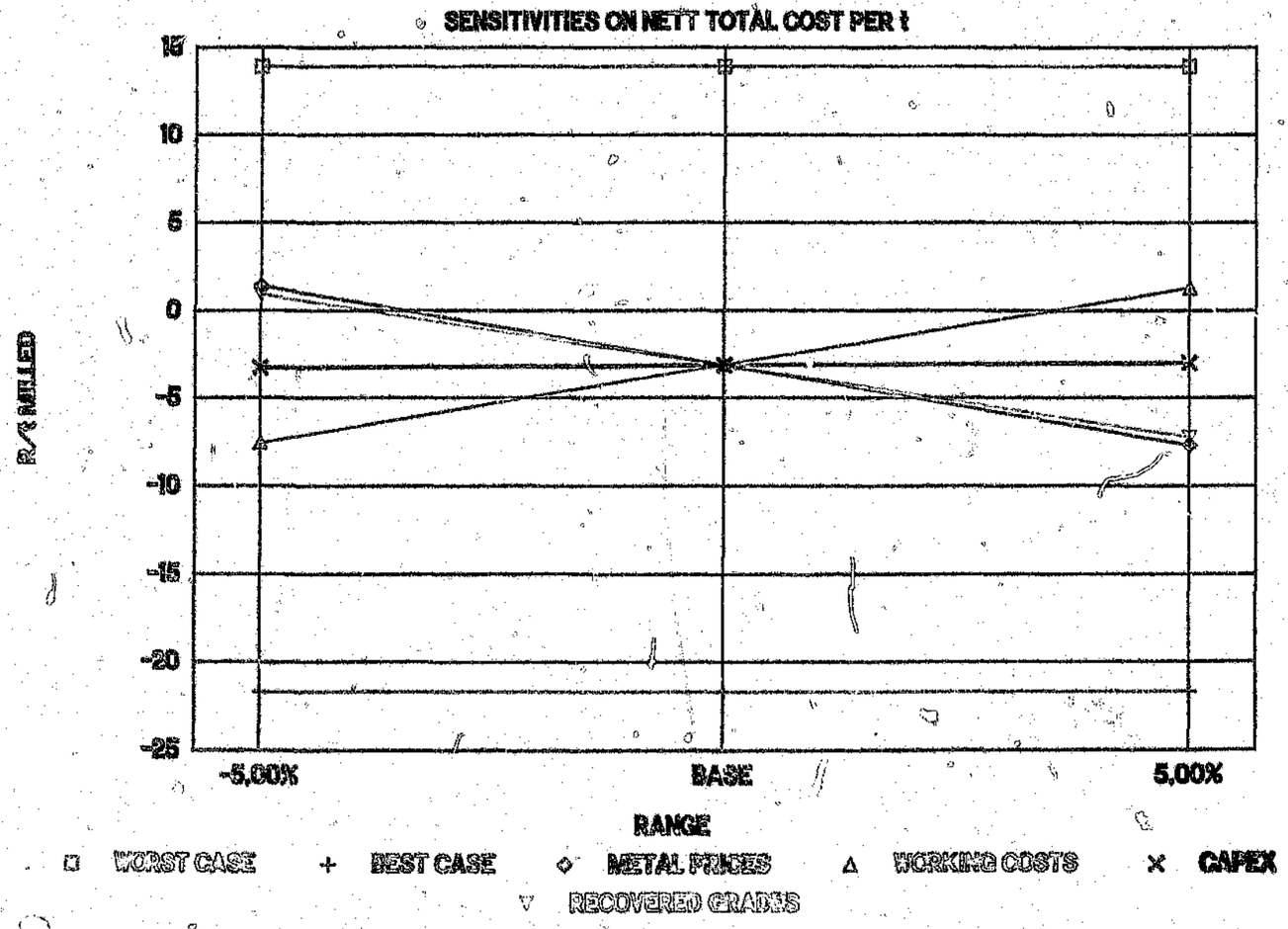
SENSITIVITIES ON IRR, % REAL

	-20%	BASE	20%
METAL PRICES	1,29	6,85	11,31
WORK COSTS	9,40	6,85	4,08
CAPEX	9,25	6,85	5,21
REC GRADES	1,62	6,85	11,04
MILLED TONS	4,75	6,85	8,76
SACPI	7,80	6,85	4,86
USCPI	7,64	6,85	6,08
R/US$	5,13	6,85	8,49
R/£	6,64	6,85	6,88
LEASE	7,02	6,85	6,66
ROYALTY	6,87	6,85	6,83
TAX RATE	8,20	6,85	5,28
TIMING	7,01	6,85	6,74
WORST CASE		ERR	
BEST CASE		20,11	

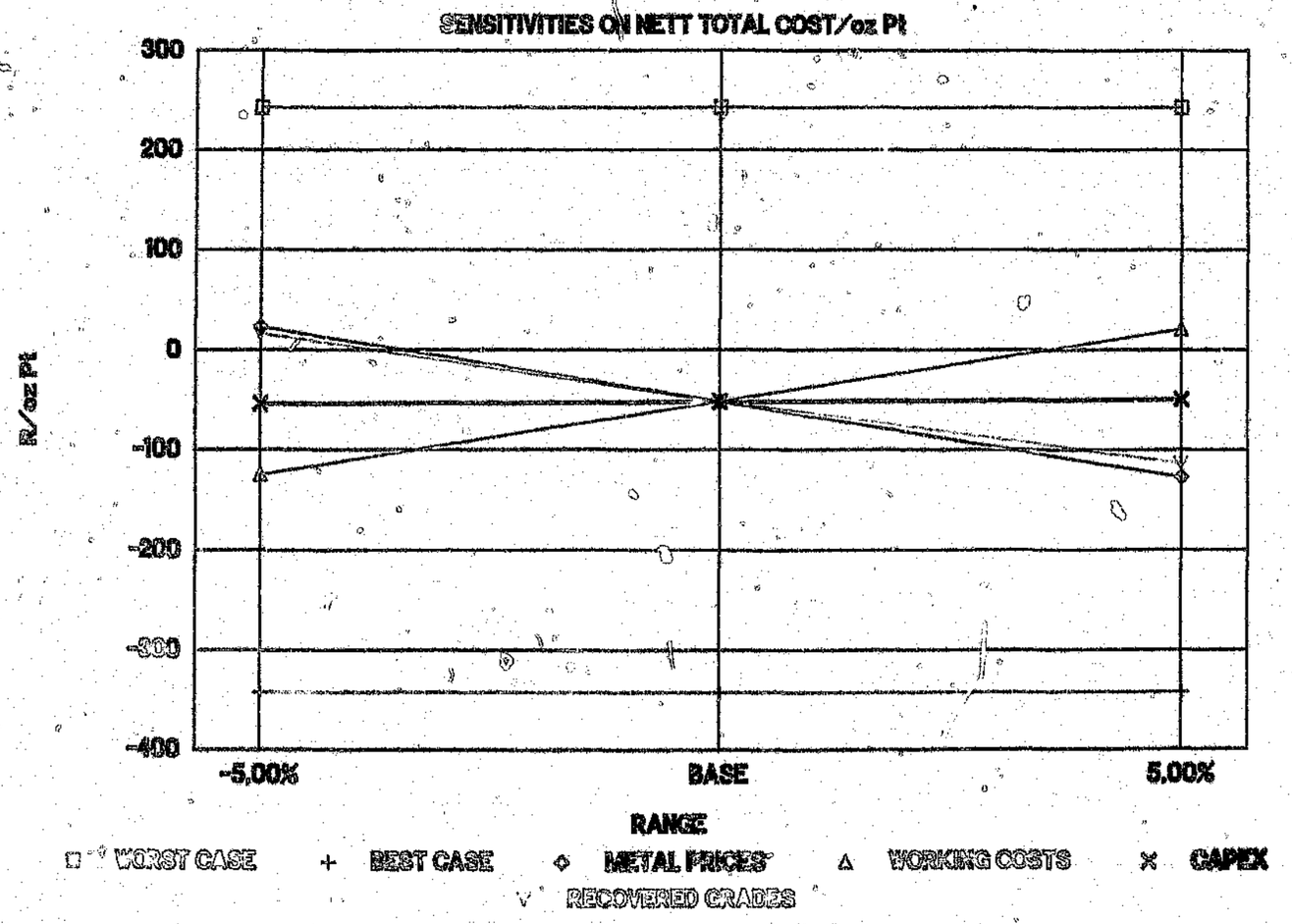
SENSITIVITIES ON MAX EXPOSURE, R million

	-20%	BASE	20%
METAL PRICES	(1 415)	(1 305)	(1 207)
WORK COSTS	(1 229)	(1 305)	(1 302)
CAPEX	(1 011)	(1 305)	(1 600)
REC GRADES	(1 407)	(1 305)	(1 209)
MILLED TONS	(1 [illegible])	(1 305)	(1 272)
SACPI	(1 247)	(1 305)	(1 379)
USCPI	(1 271)	(1 305)	(1 337)
R/US$	(1 318)	(1 305)	(1 279)
R/£	(1 305)	(1 305)	(1 305)
LEASE	(1 305)	(1 305)	(1 305)
ROYALTY	(1 305)	(1 305)	(1 305)
TAX RATE	(1 305)	(1 305)	(1 305)
TIMING	(1 259)	(1 305)	(1 333)
WORST CASE		ERR	
BEST CASE		(750)	

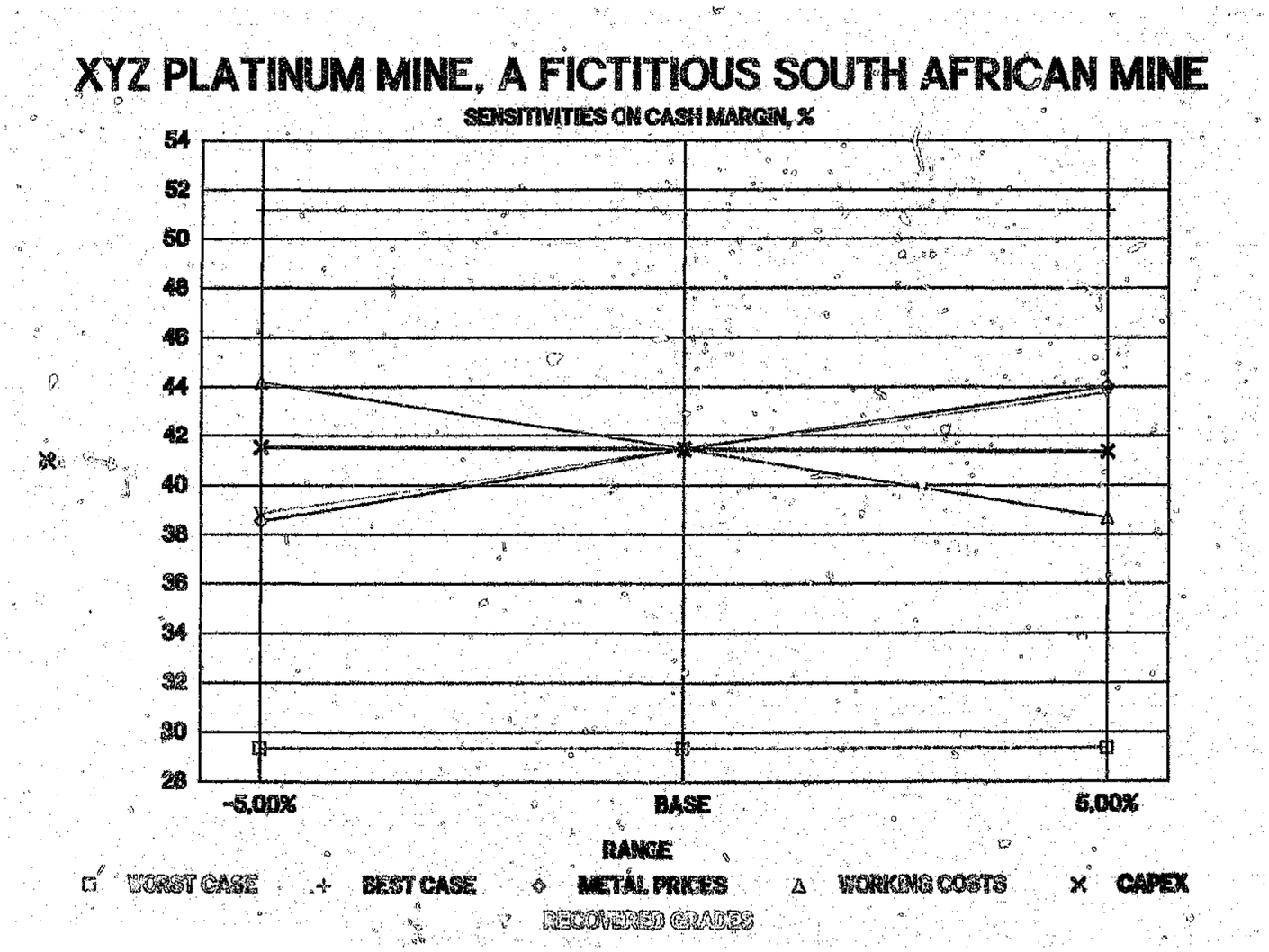
XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



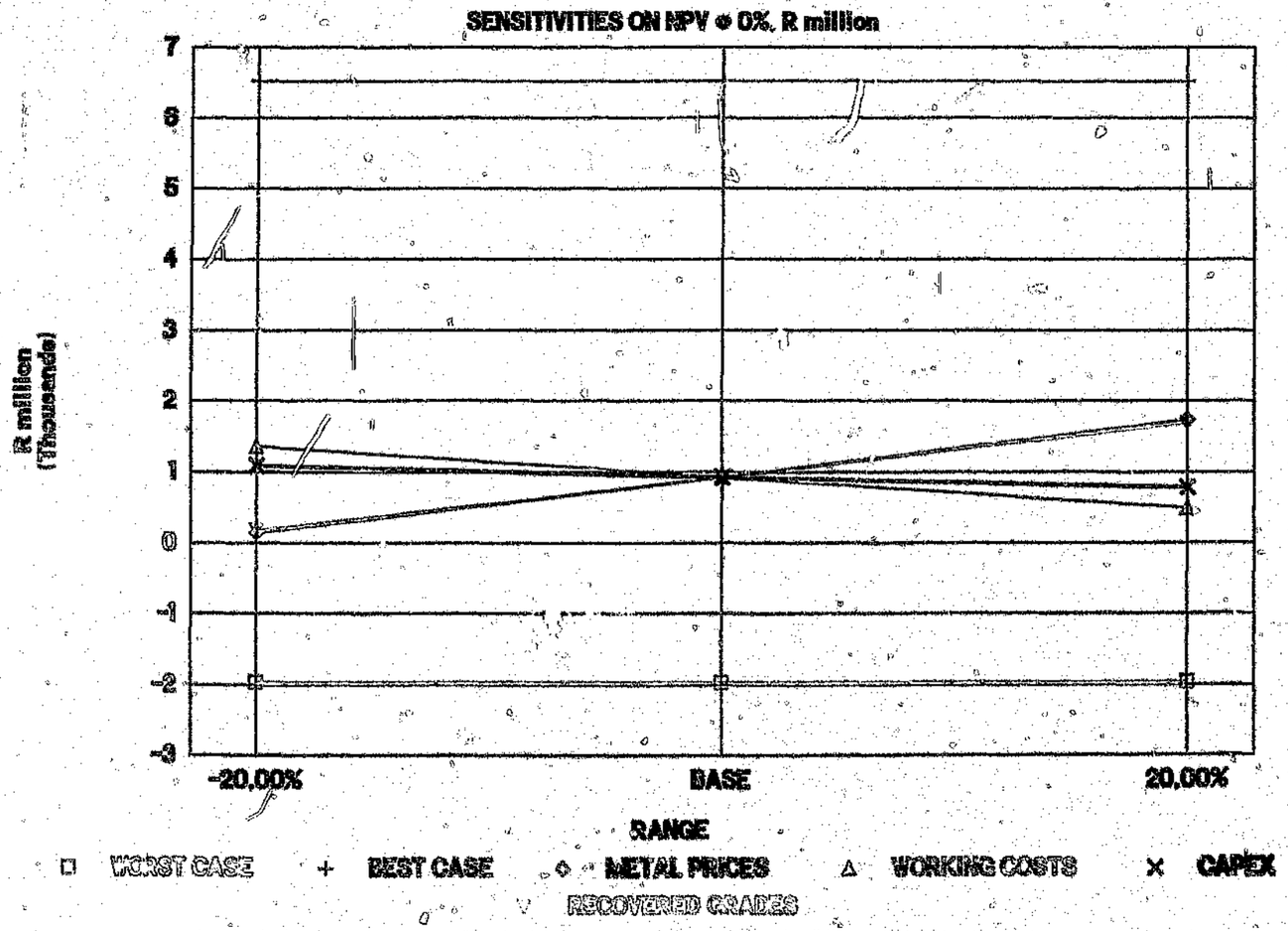
XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



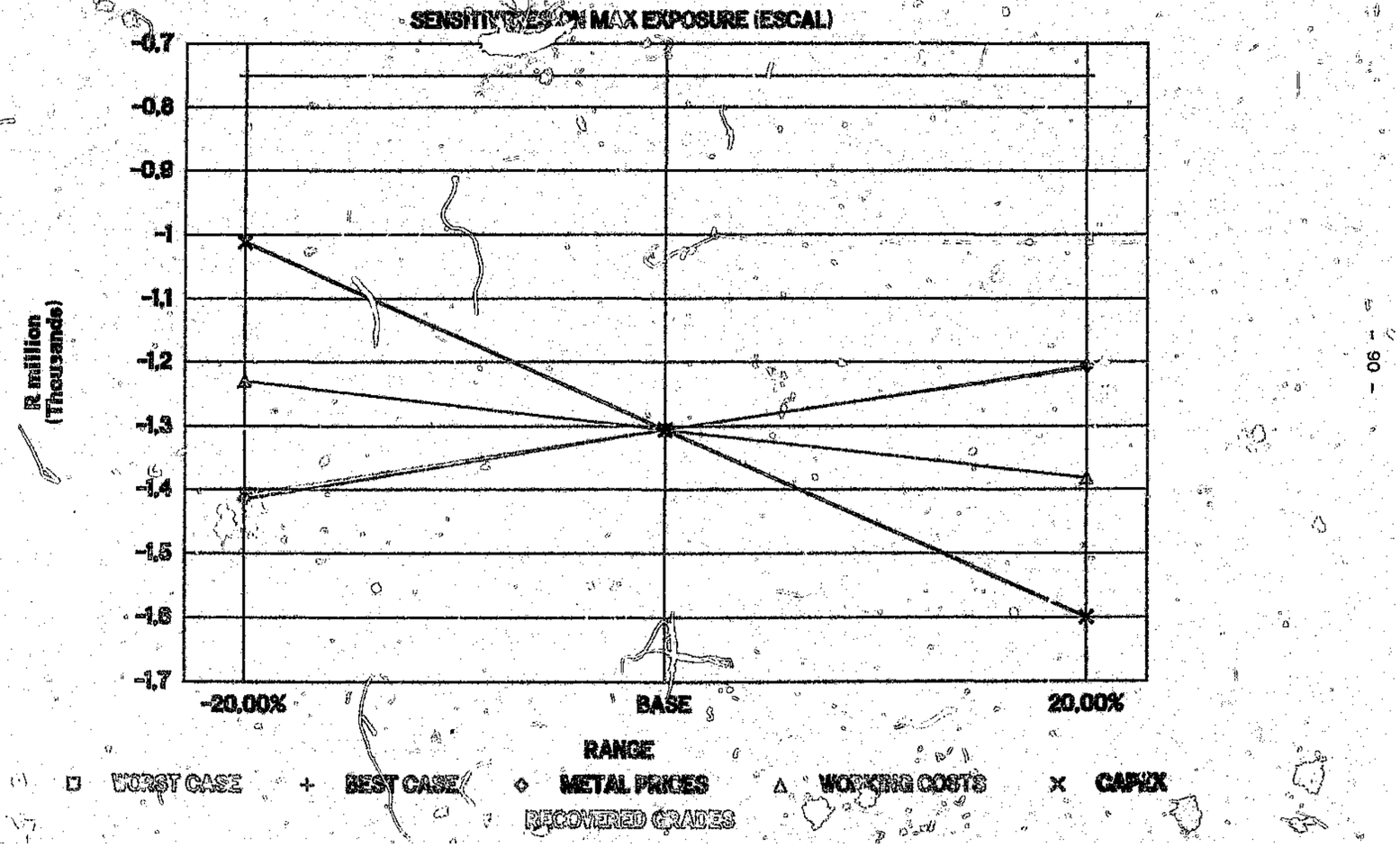
XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



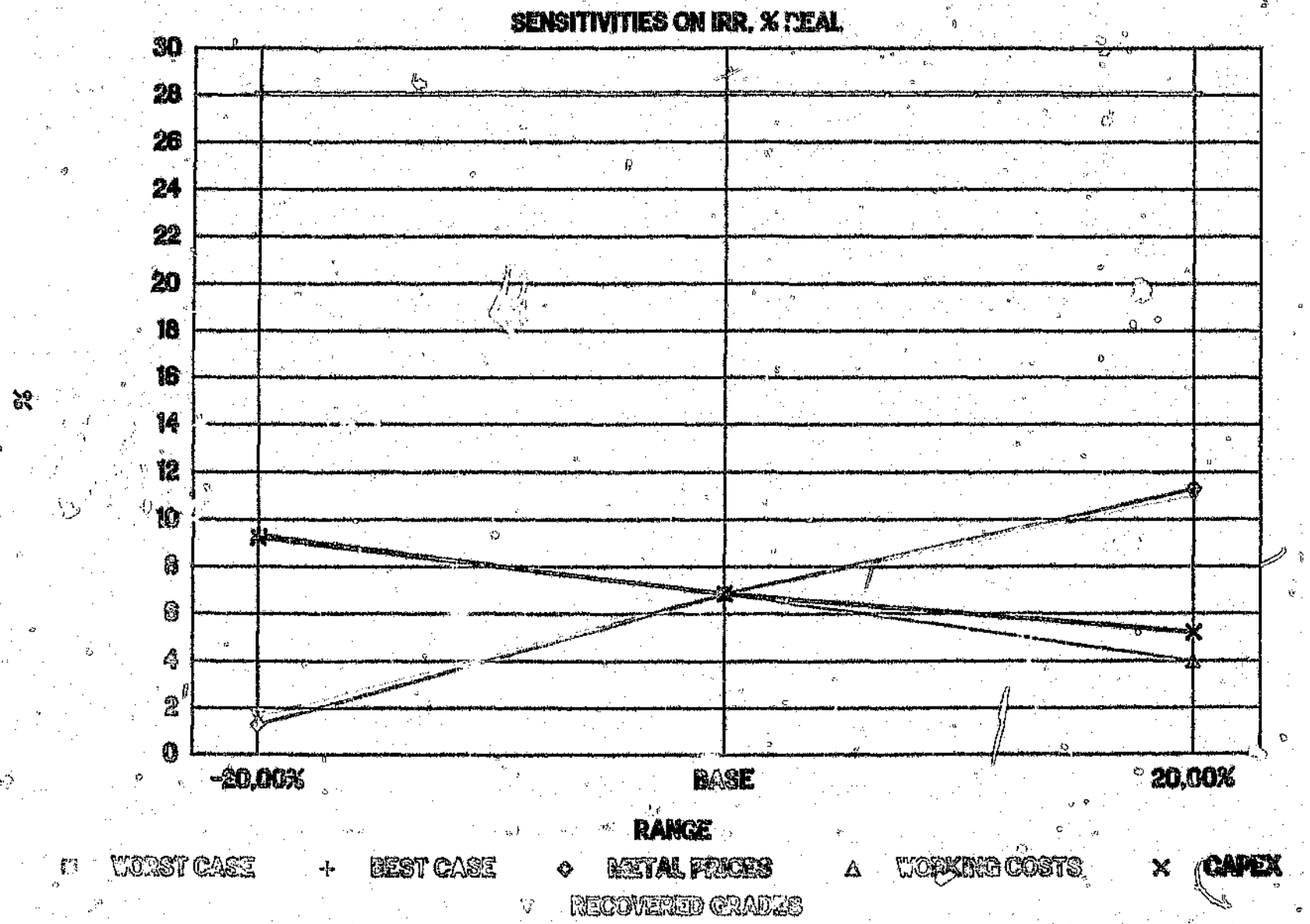
XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



5.3 RISK ANALYSIS RESULTS

Page 73 also shows the upside and downside percentages assumed for the XYZ Project. The following should be noted :-

(i) Metal prices variations are the same as those used for Hartley.

(ii) Working costs are assumed to be known with a fair degree of certainty.

(iii) Capex is also a relatively certain figure, compared to Hartley.

(iv) General economic conditions for South Africa may have a greater potential for being worse than being better than the forecasts shown on page 13. The upsides for SACPI and exchange rates have thus been given greater weighting than their downsides, as for Hartley.

(v) For XYZ mine, there is a possibility of lease agreements being scrapped with the new Minerals Bill. On the other hand, a new government may replace the lease system with another system in order to pay for socio-economic programmes. Thus, both the upside and downside potentials on this item are large.

(vi) It is also assumed that tax rates have a greater potential to increase in a future dominated by government intervention coupled with their possible need to increase fiscal spending on socio-economic programmes.

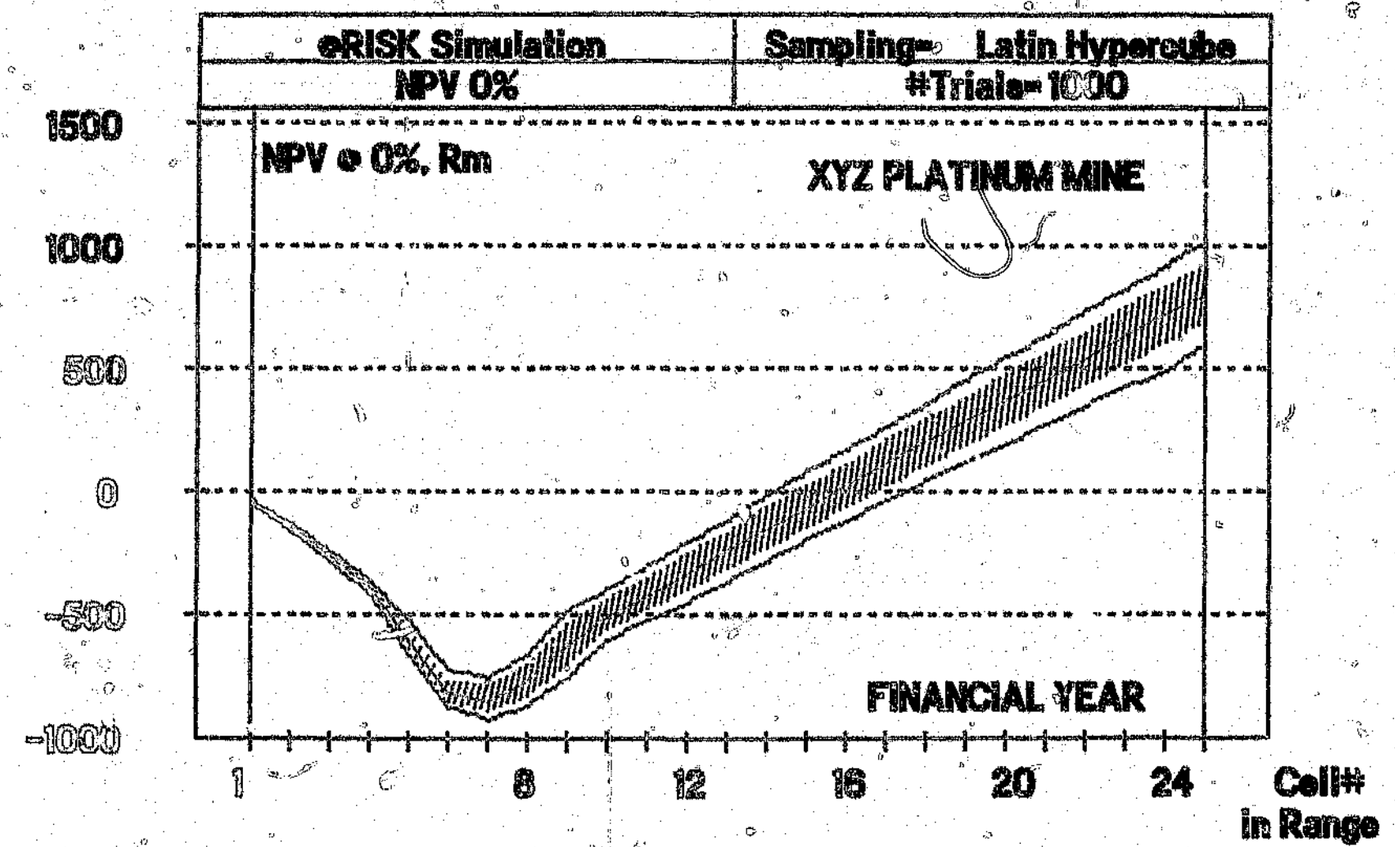
(vii) The timing and production build-up phase at XYZ are considered to be more well-defined that at Hartley.

The results of the risk analysis for XYZ are shown graphically on pages 94 to 105. In summary, they are as follows :-

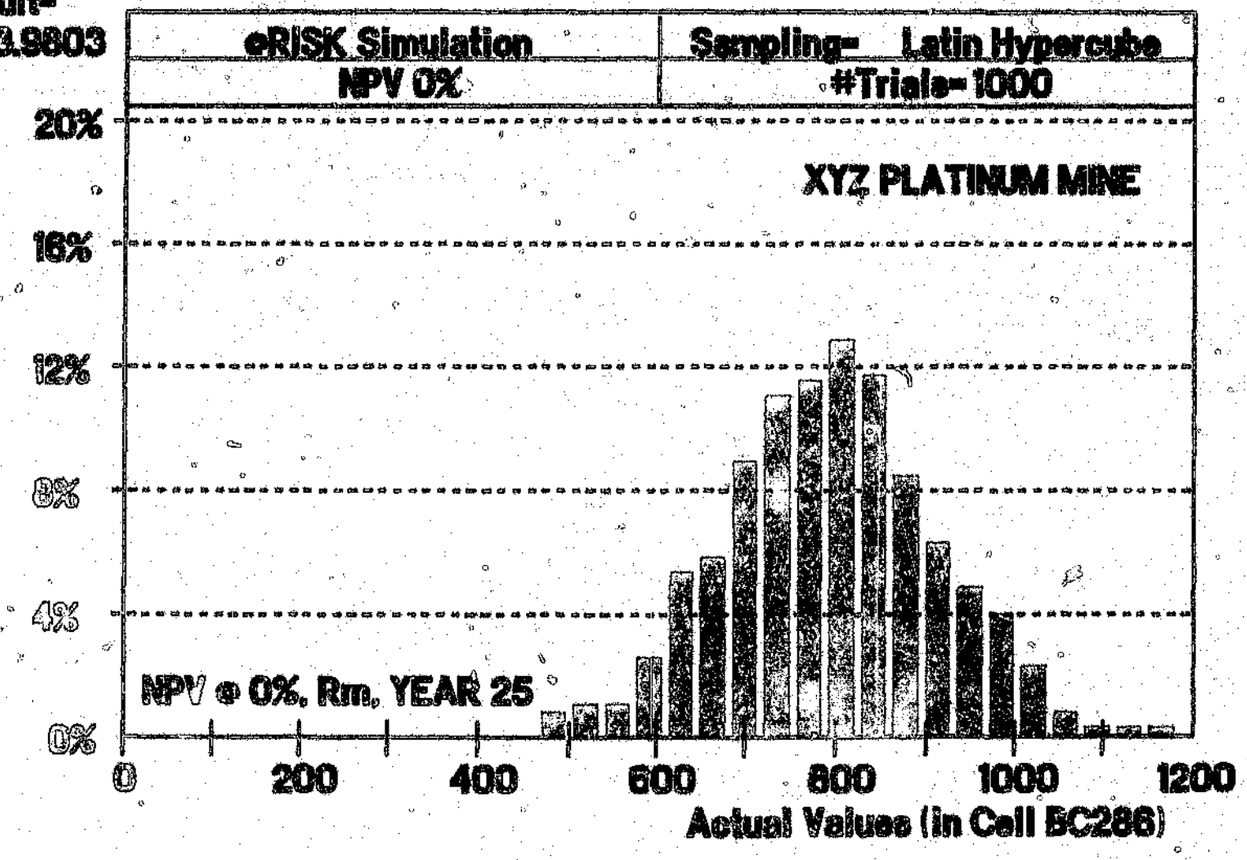
	Expected Result	Standard Deviation
Real IRR, %, 25 years :	6,301	0,873
NPV, R million, 25 years, @ 0% discount :	794,0	118,4
@ 3% discount :	290,8	77,5
@ 5% discount :	91,9	61,1
Maximum Exposure, escalated, R million :	1 287,3	83,2
Maximum Exposure, base date, R million :	832,2	46,6
Payback Period, years, escalated money :	11,3	0,6
Payback Period, years, base date money :	15,2	1,0

The above expected result for Real IRR after 25 years of 6,30% is 0,55% less than the conventional result of 6,85%. This amount could be considered to be the risk discount rate to be applied over and above a "normal" hurdle rate for an NPV analysis.

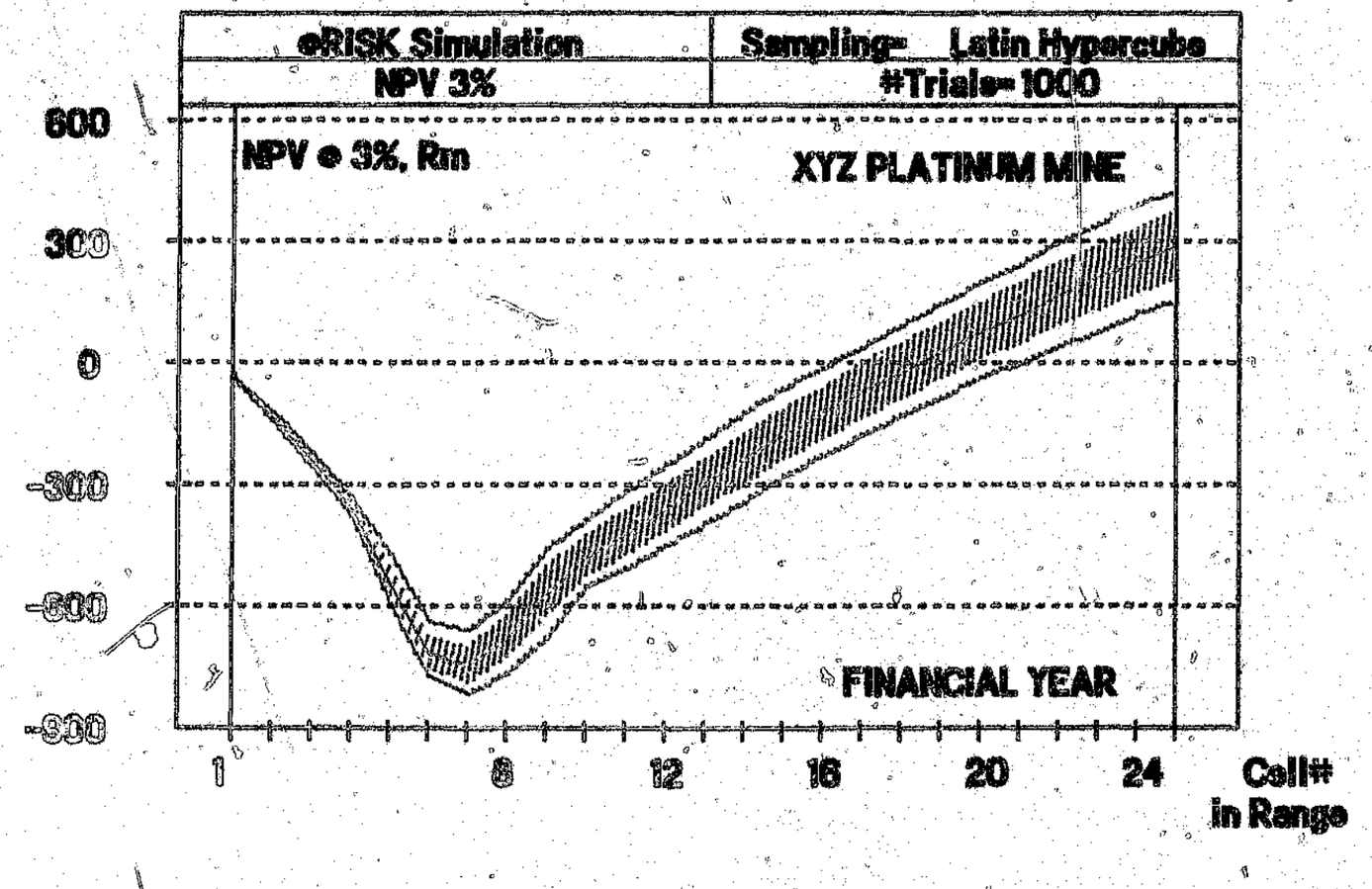
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



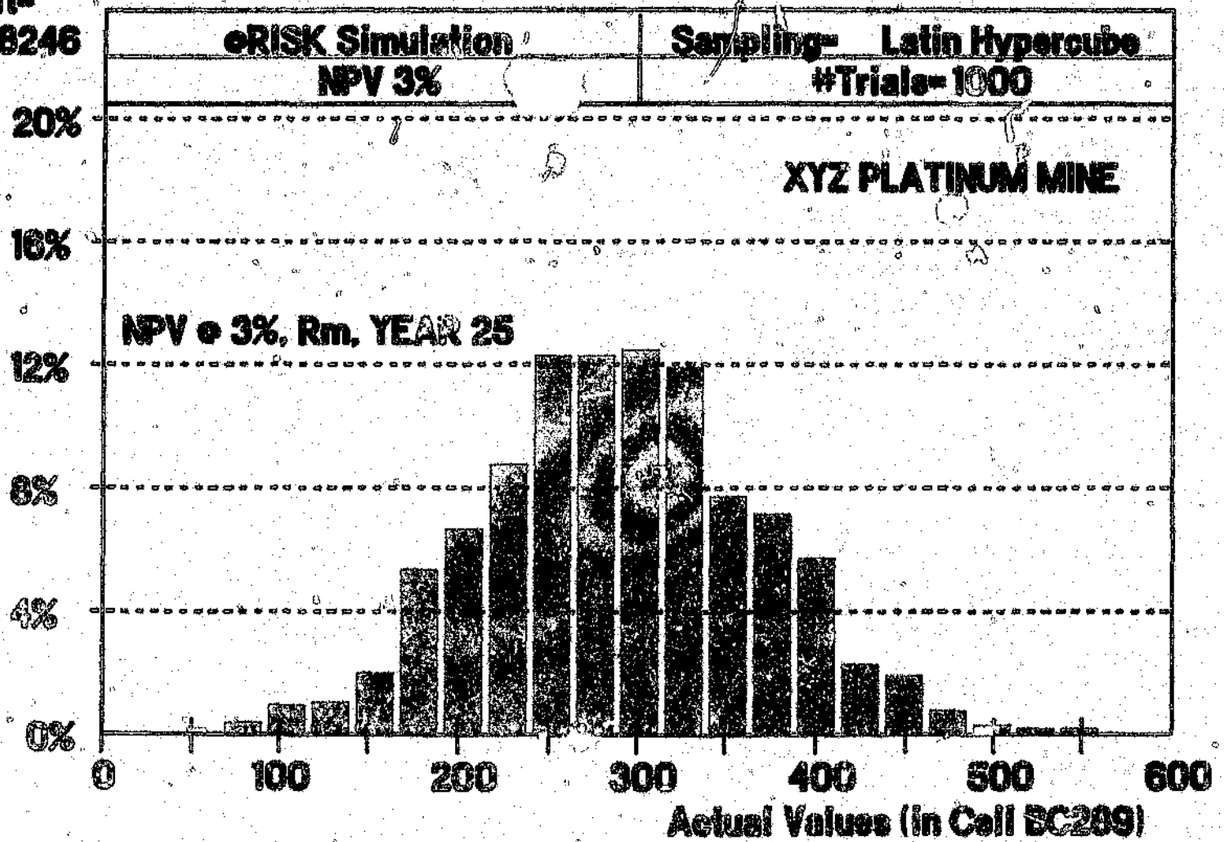
Expected Result= 793.9803



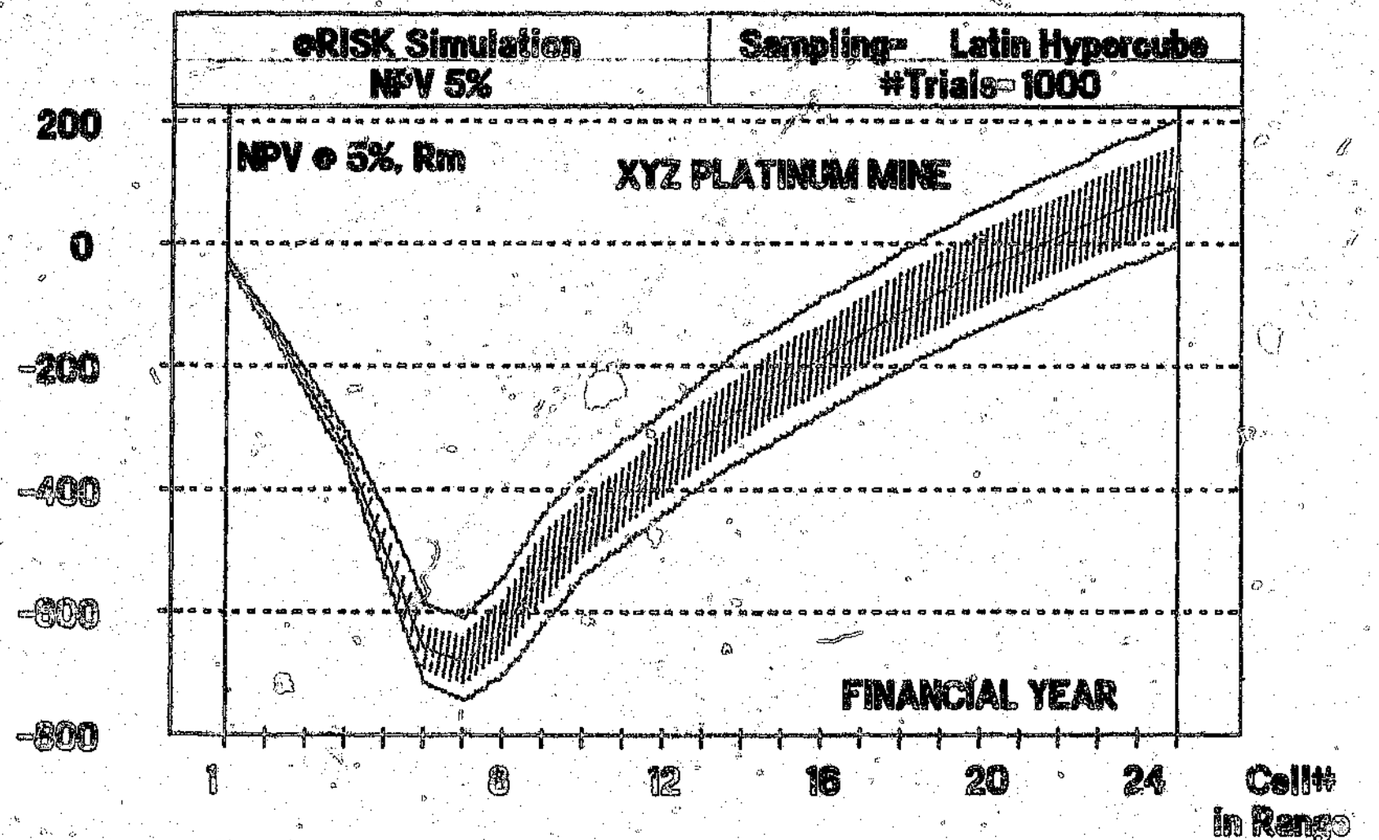
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



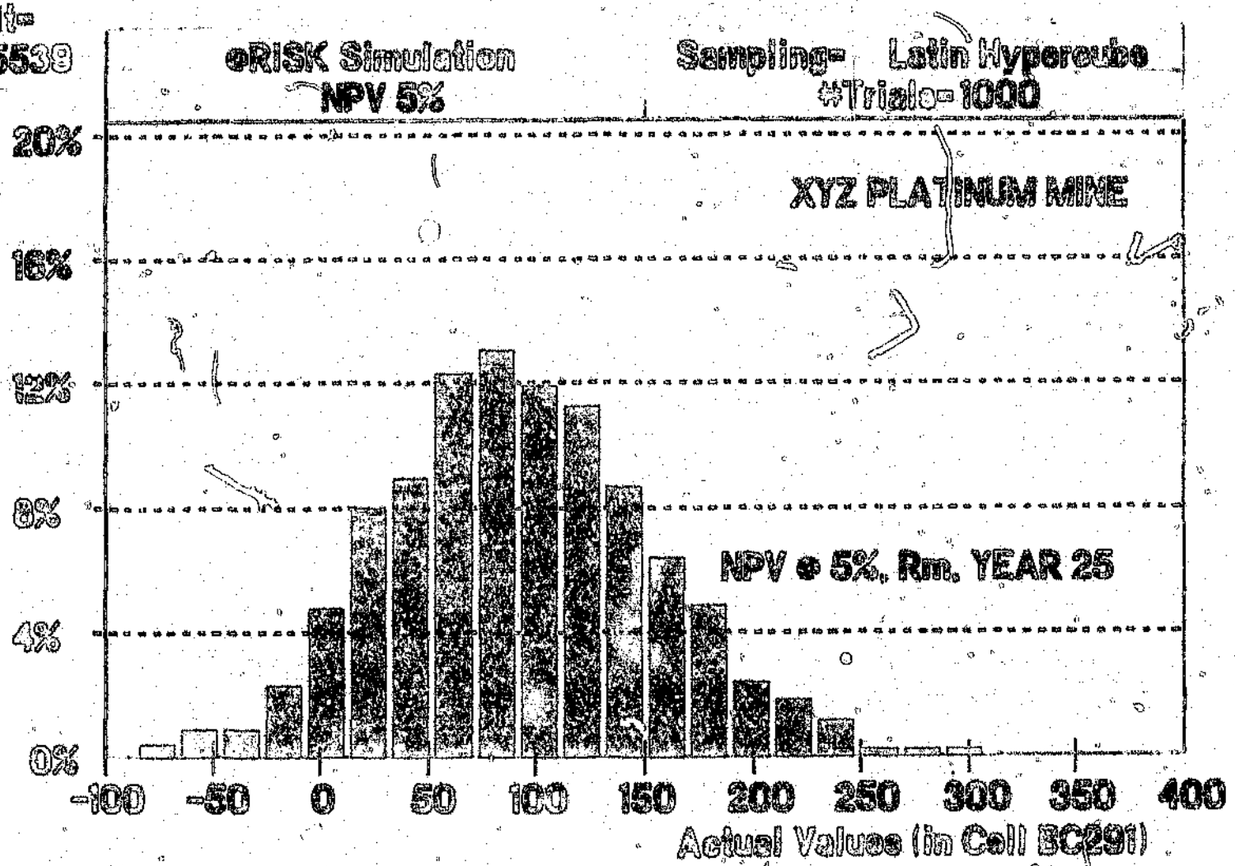
Expected Result= 290.8246



**Trend in Mean,
1 Std.Dev.,
5/95 Perc.**

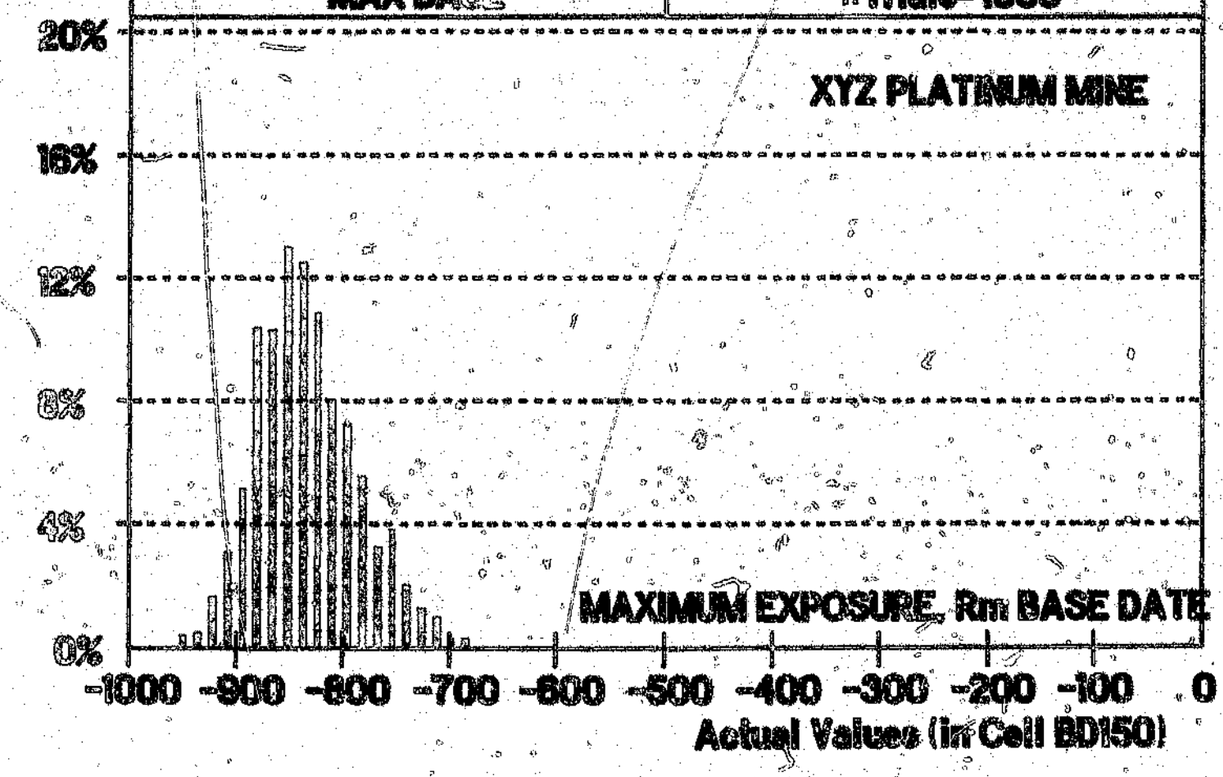


Expected
Result=
91.85538

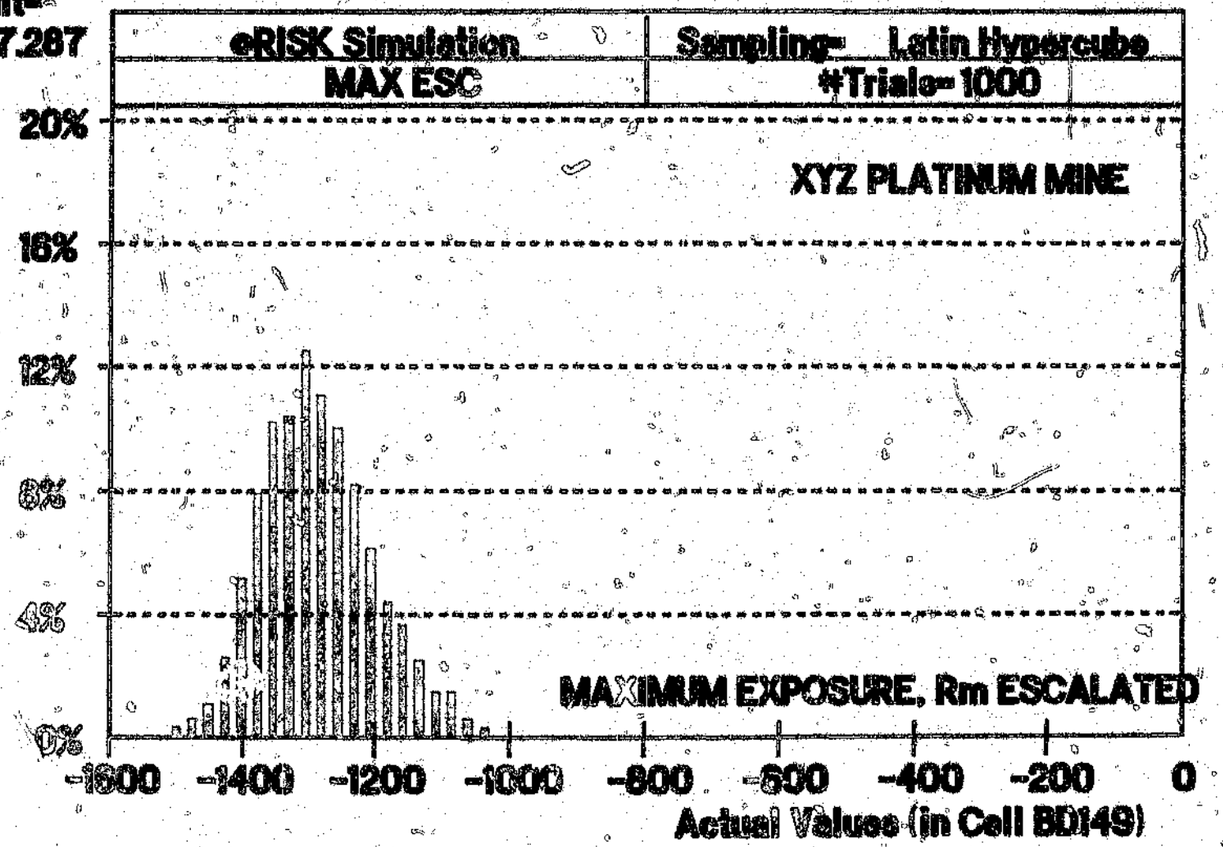


Expected Result= -832.1716

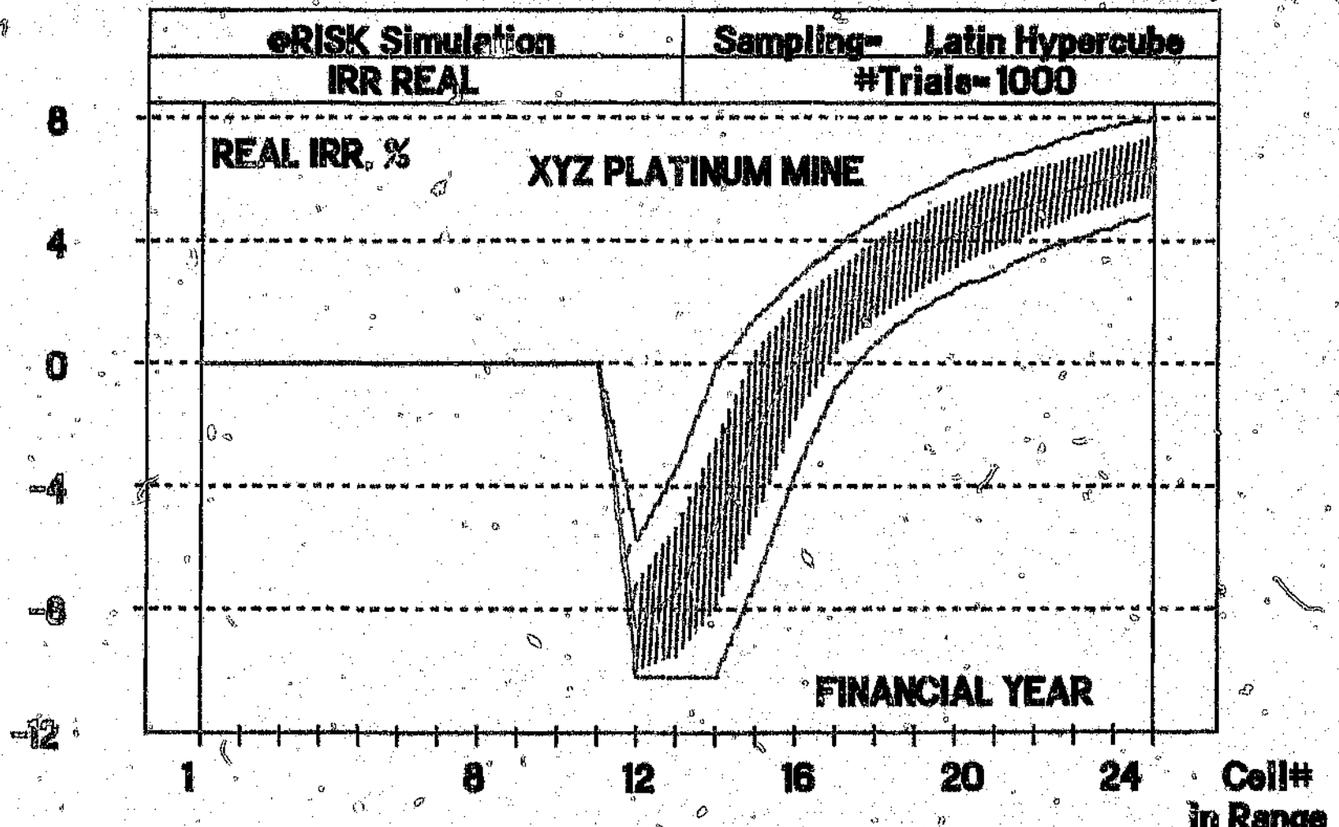
eRISK Simulation	Sampling= Latin Hypercube
MAX BASE	#Trials= 1000



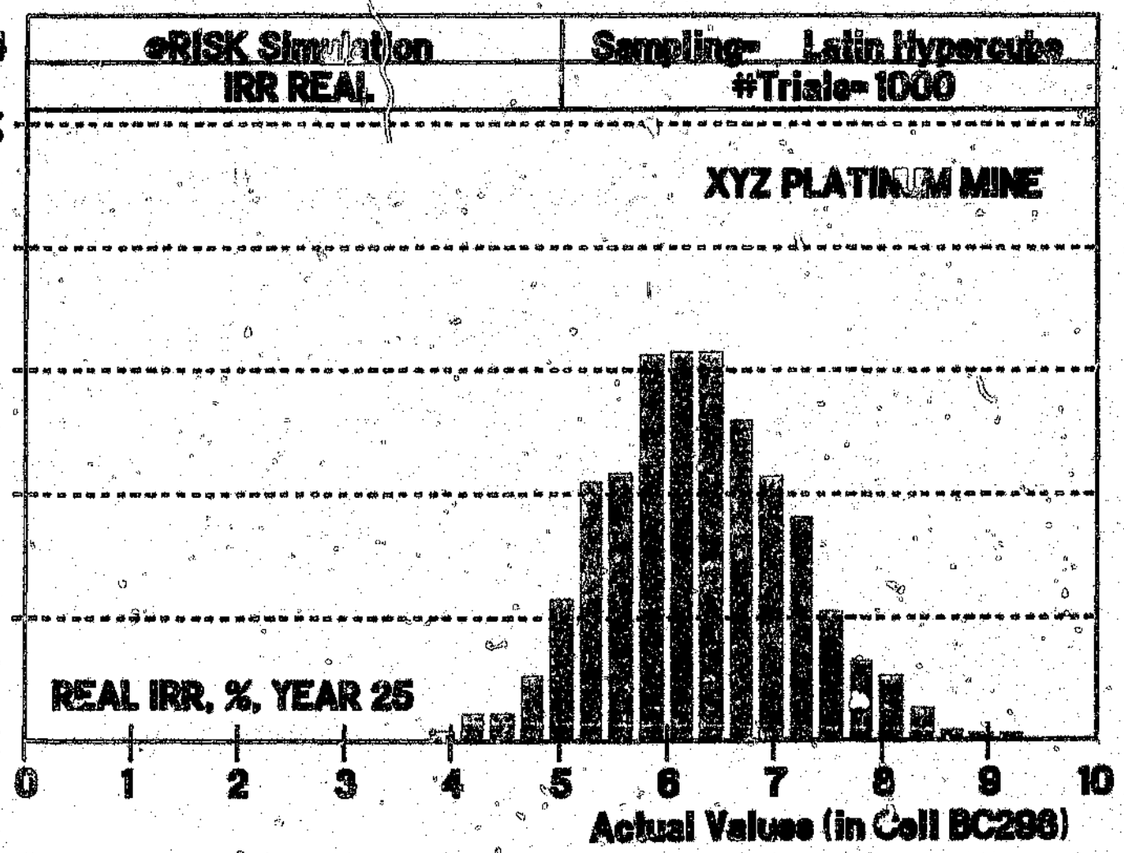
Expected Result= -1287.287



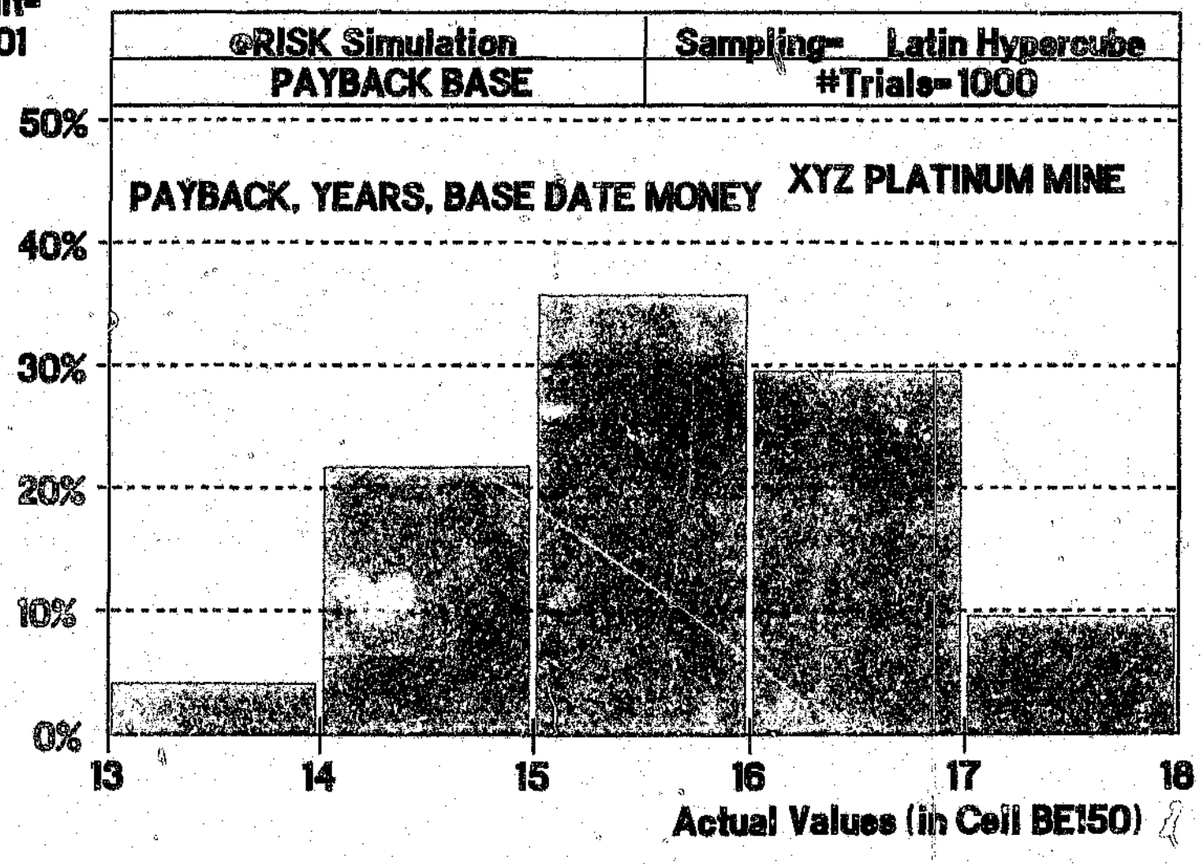
**Trend in Mean,
1 Std.Dev.,
5/95 Perc.**

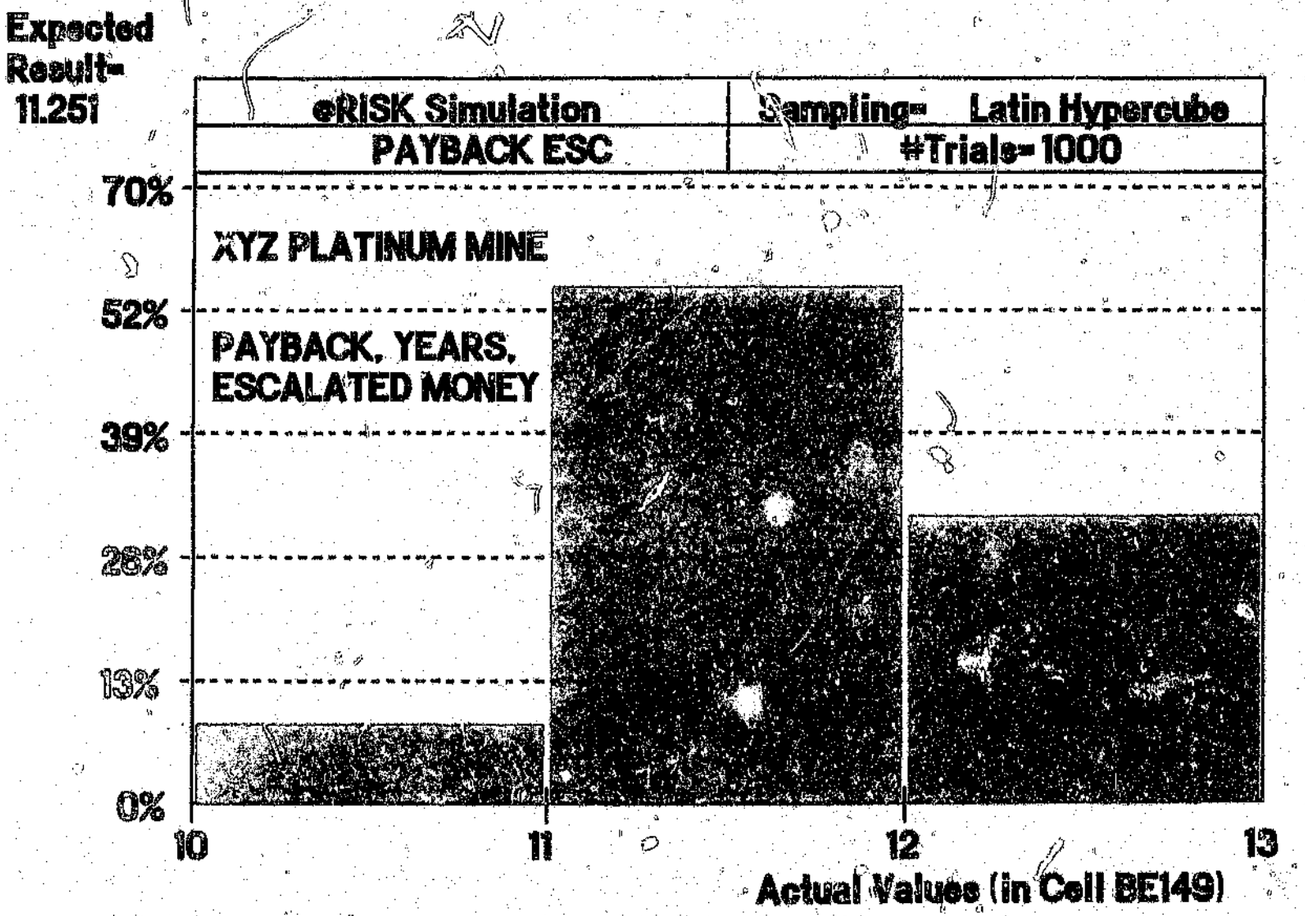


Expected Result= 6.300794

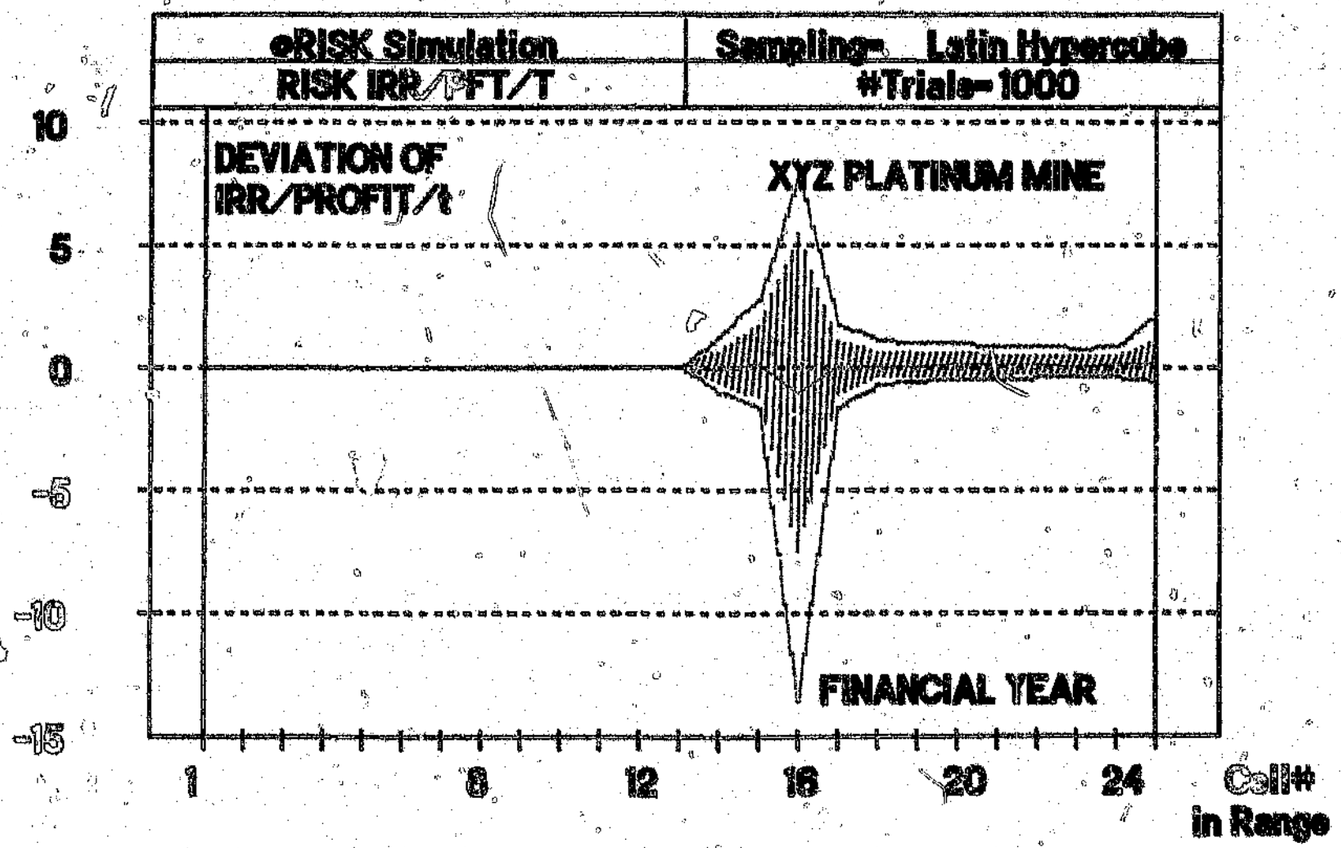


Expected Result= 15.201

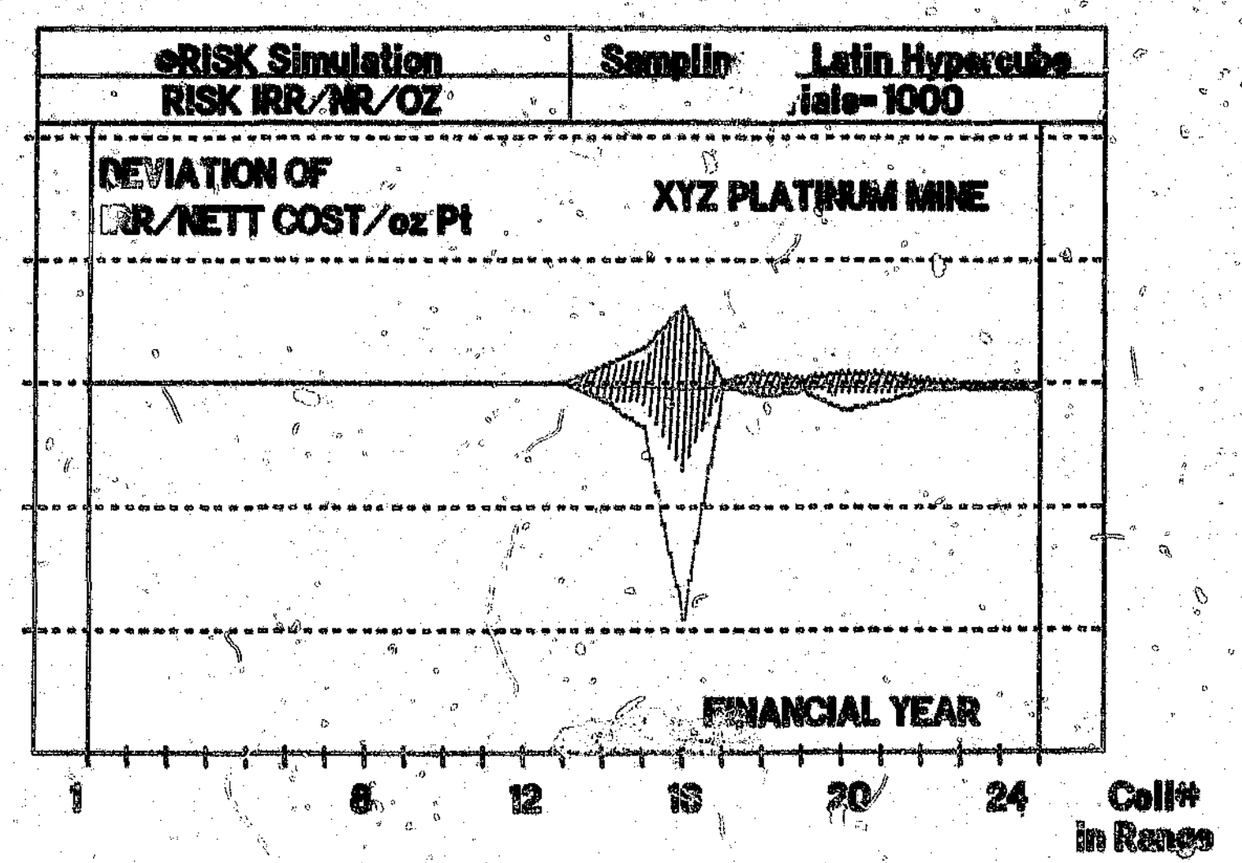



Expected
Result=
11.251
eRISK Simulation
PAYBACK ESC
Sampling= Latin Hypercube
#Trials= 1000
70%
XYZ PLATINUM MINE
52%
PAYBACK, YEARS,
ESCALATED MONEY
39%
26%
13%
0%
10
11
12
13
Actual Values (in Cell BE149)

Trend in Mean, 1 Std.Dev., 5/95 Perc.



**Trend in Mean,
1 Std Dev.,
5/95 Perc.**



5.4 ROBUSTNESS CRITERIA

As mentioned in section 3.4, the objective is to find the variable, V, with an expected result closest to zero and with the smallest standard deviation.

The following results were produced (see pages 108 to 119 for graphical representations of these results), where E is the expected result and SD is the standard deviation for V for that year :-

RESULTS FOR x/y = REAL IRR DIVIDED BY ROBUSTNESS CRITERIA 1 TO 6

Robustness Criterion	1 Net Cost (R/t)		2 Net Cost (R/ce Pt)		3 Profit (R/t)		4 Profit (R/ce Pt)		5 Cut-off Headgrade (g P/t)		6 Cash Margin (%)	
Financial Year	E	SD	E	SD	E	SD	E	SD	E	SD	E	SD
14	(0,759)	12,563	(0,743)	12,276	(0,053)	0,656	(0,053)	0,655	(0,147)	0,435	(0,092)	0,542
15	(0,714)	17,836	(0,721)	17,694	0,162	1,436	0,161	1,430	(0,046)	1,075	0,085	1,202
16	(3,093)	64,831	(3,151)	65,243	(1,015)	6,341	(1,018)	6,318	(0,575)	5,243	(0,585)	5,819
17	(0,825)	2,358	(0,821)	2,414	0,017	1,040	0,018	1,036	0,045	0,909	0,017	0,952
18	(1,065)	7,557	(1,000)	7,563	0,075	0,567	0,075	0,564	0,041	0,510	0,053	0,494
19	(0,875)	3,260	(0,876)	3,240	0,080	0,462	0,079	0,453	0,030	0,331	0,053	0,373
20	(1,033)	9,305	(1,031)	9,137	0,090	0,445	0,089	0,433	0,024	0,312	0,057	0,327
21	(0,998)	[illegible]	(0,998)	8,754	0,083	0,401	0,082	0,397	0,020	0,271	0,052	0,284
22	(0,985)	3,039	(0,985)	3,054	0,032	0,391	0,031	0,384	0,011	0,241	0,052	0,272
23	(1,020)	1,658	(1,019)	1,660	0,077	0,356	0,076	0,350	0,017	0,228	0,043	0,241
24	(1,075)	1,803	(1,077)	1,851	[illegible]03	0,375	0,082	0,363	0,016	0,217	0,051	0,245
25	(0,904)	2,609	(0,903)	2,632	0,142	0,822	0,132	0,801	0,008	0,107	0,053	0,479
OVERALL	(1,106)	11,309	(1,109)	11,293	(0,015)	1,108	(0,016)	1,100	(0,043)	0,835	(0,035)	0,941

5.4 ROBUSTNESS CRITERIA

As mentioned in section 3.4, the objective is to find the variable, V, with an expected result closest to zero and with the smallest standard deviation.

The following results were produced (see pages 108 to 119 for graphical representations of these results), where E is the expected result and SD is the standard deviation for V for that year :-

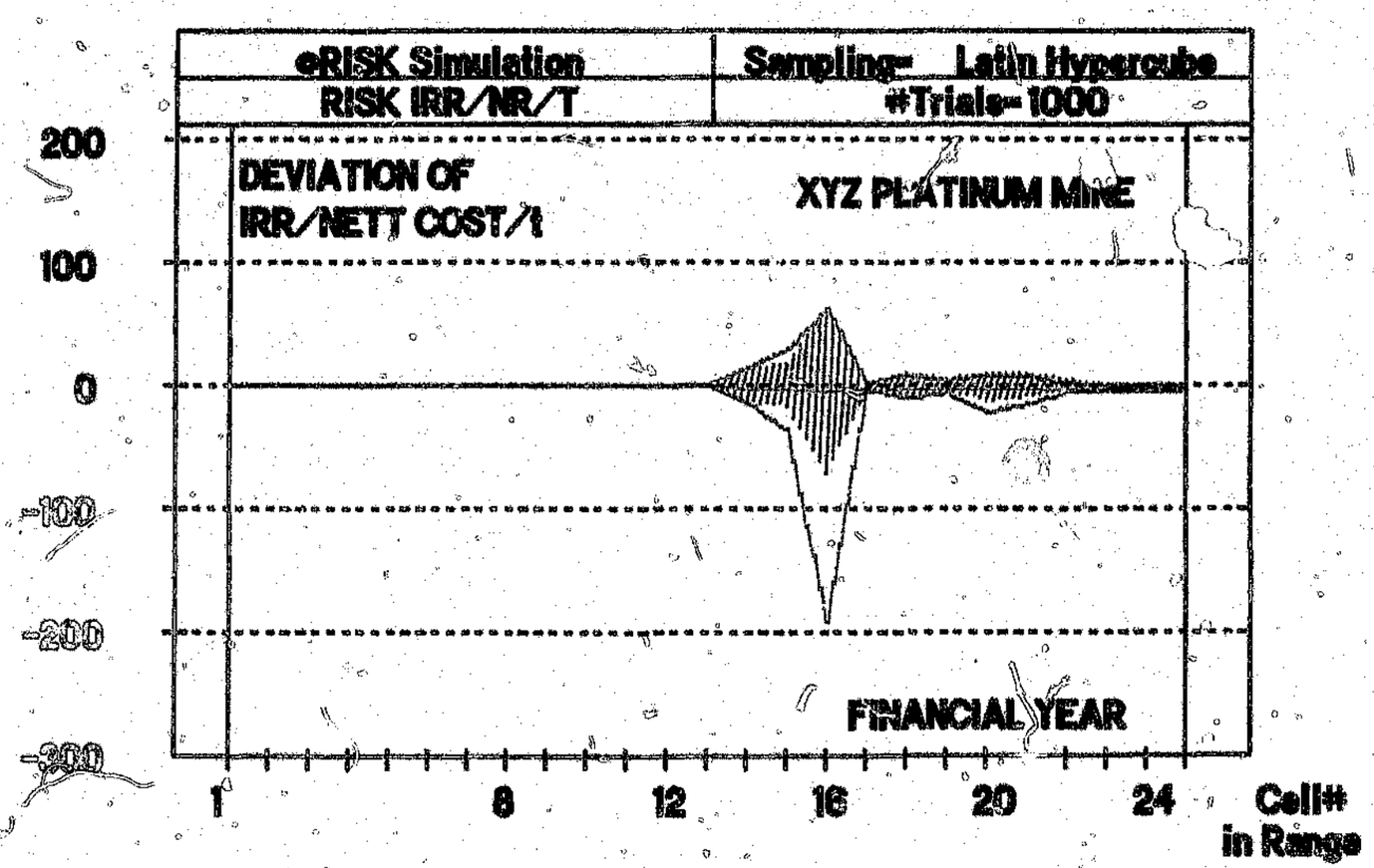
RESULTS FOR x/y = REAL IRR DIVIDED BY ROBUSTNESS CRITERIA 1 TO 6

Robustness Criterion	1 Net Cost (R/t)		2 Net Cost (R/ex Pt)		3 Profit (R/t)		4 Profit (R/ex Pt)		5 Cut-off Headgrade (g PGM/t)		6 Cash Margin (%)	
Financial Year	E	SD	E	SD	E	SD	E	SD	E	SD	E	SD
14	(0,739)	12,563	(0,748)	12,276	(0,053)	0,656	(0,053)	0,655	(0,147)	0,435	(0,092)	0,542
15	(0,714)	17,836	(0,721)	17,624	0,162	1,436	0,161	1,430	(0,046)	1,075	0,036	1,262
16	(3,090)	64,051	(3,131)	65,243	(1,015)	6,341	(1,018)	6,318	(0,576)	5,243	(0,885)	5,819
17	(0,315)	2,393	(0,321)	2,414	0,017	1,040	0,016	1,036	0,046	0,909	0,017	0,952
18	(1,[illegible])	7,557	(1,000)	7,563	0,075	0,562	0,075	0,564	0,041	0,310	0,053	0,454
19	(0,875)	3,260	(0,876)	3,240	0,050	0,462	0,079	0,458	0,030	0,381	0,053	0,370
20	(1,033)	9,365	(1,031)	9,137	0,090	0,445	0,089	0,438	0,024	0,317	0,057	0,327
21	(0,998)	8,779	(0,999)	8,754	0,033	0,401	0,032	0,397	.20	0,271	0,052	0,284
22	(0,035)	3,039	(0,505)	3,054	0,032	0,391	0,001	0,234	0,017	0,241	0,052	0,272
23	(1,020)	1,658	(1,019)	1,658	0,077	0,356	0,076	0,350	0,017	0,228	0,043	0,241
24	(1,075)	1,500	(1,077)	1,531	0,033	0,375	0,032	0,362	0,016	0,212	0,051	0,245
25	(0,904)	2,909	(0,903)	2,632	0,142	0,822	0,132	0,201	0,005	0,107	0,028	0,475
OVERALL	(1,106)	11,309	(1,109)	11,273	(0,015)	1,100	(0,016)	1,100	(0,040)	0,835	(0,035)	0,941

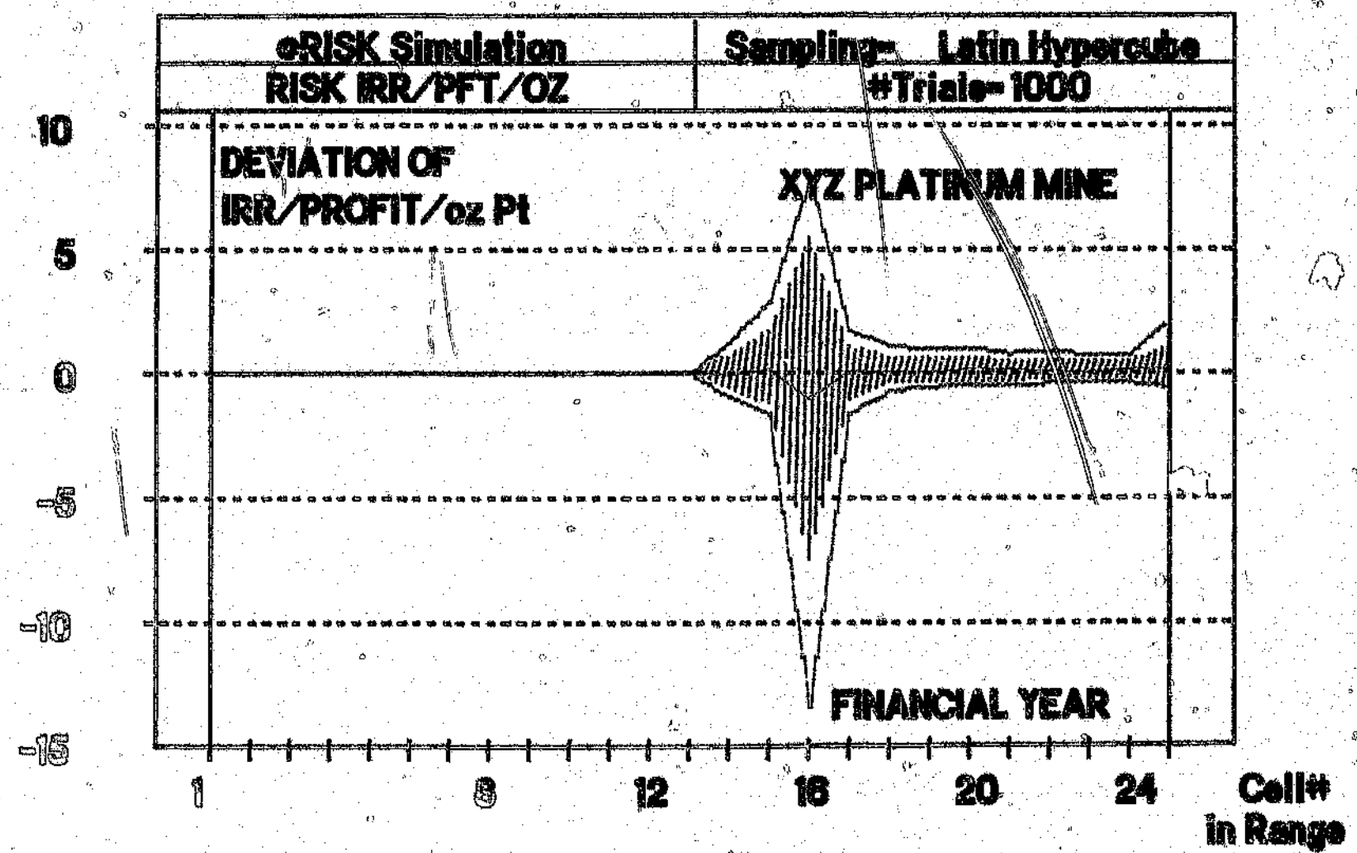
RESULTS FOR x/y = NPV @ 0% DISCOUNT DIVIDED BY ROBUSTNESS CRITERIA 1 TO 6

Robustness Criterion	1 Net Cost (R/t)		2 Net Cost (R/oz Pt)		3 Profit (R/t)		4 Profit (R/oz Pt)		5 Dutoit Headgrade (g PGM/t)		6 Cash Margin (R)	
Financial Year	E	SD	E	SD	E	SD	E	SD	E	SD	E	SD
6	0,031	0,284	0,031	0,287	0,929	22,609	0,911	26,370	(0,021)	0,116	0,678	31,913
7	(0,231)	60,036	(0,231)	59,704	0,131	0,343	0,131	0,342	(0,019)	0,108	0,079	0,363
8	(0,555)	14,397	(0,533)	14,455	0,113	0,491	0,111	0,403	(0,019)	0,102	0,064	0,326
9	(0,900)	2,723	(0,009)	2,685	0,091	0,446	0,090	0,446	(0,018)	0,114	0,043	0,298
10	(0,892)	3,142	(0,892)	3,132	0,057	0,413	0,055	0,407	(0,043)	0,128	0,014	0,271
11	(0,970)	2,571	(0,732)	2,569	0,053	0,423	0,051	0,418	(0,046)	0,139	0,017	0,289
12	(0,575)	6,510	(0,566)	6,606	0,053	0,482	0,052	0,476	(0,054)	0,201	0,008	0,339
13	(0,921)	5,845	(0,920)	5,811	0,046	0,503	0,044	0,538	(0,066)	0,293	0,000	0,414
14	(0,906)	3,955	(0,003)	3,938	0,033	0,723	0,031	0,719	(0,091)	0,483	(0,010)	0,604
15	(0,665)	15,629	(0,676)	15,514	0,015	1,459	0,013	1,458	(0,195)	1,243	(0,057)	1,345
16	(2,375)	85,187	(2,293)	82,210	0,106	4,290	0,111	4,275	0,497	3,956	0,214	4,049
17	(4,367)	83,455	(4,341)	83,296	0,073	0,837	0,072	0,885	0,091	0,606	0,065	0,832
18	(1,025)	4,560	(1,026)	4,531	0,031	0,613	0,029	0,606	0,038	0,516	0,056	0,519
19	(1,356)	10,366	(1,369)	10,705	0,071	0,465	0,070	0,462	0,025	0,399	0,044	0,373
20	(1,154)	4,025	(1,151)	4,042	0,068	0,424	0,067	0,418	0,014	0,321	0,040	0,319
21	(1,003)	1,420	(1,004)	1,414	0,062	0,394	0,062	0,38	0,012	0,293	0,034	0,279
22	(0,953)	3,267	(0,953)	3,245	0,060	0,256	0,059	0,351	0,006	0,264	0,032	0,249
23	(1,212)	6,816	(1,204)	6,784	0,064	0,369	0,063	0,362	0,003	0,244	0,034	0,247
24	(1,005)	2,039	(1,004)	2,035	0,061	0,354	0,061	0,350	0,004	0,235	0,032	0,291
25	(1,330)	10,346	(1,330)	10,315	0,068	0,353	0,079	0,3	(0,002)	0,220	0,047	0,226
OVERALL	(1,113)	16,359	(1,110)	16,190	0,113	1,835	0,111	2,015	0,009	0,514	0,071	1,674

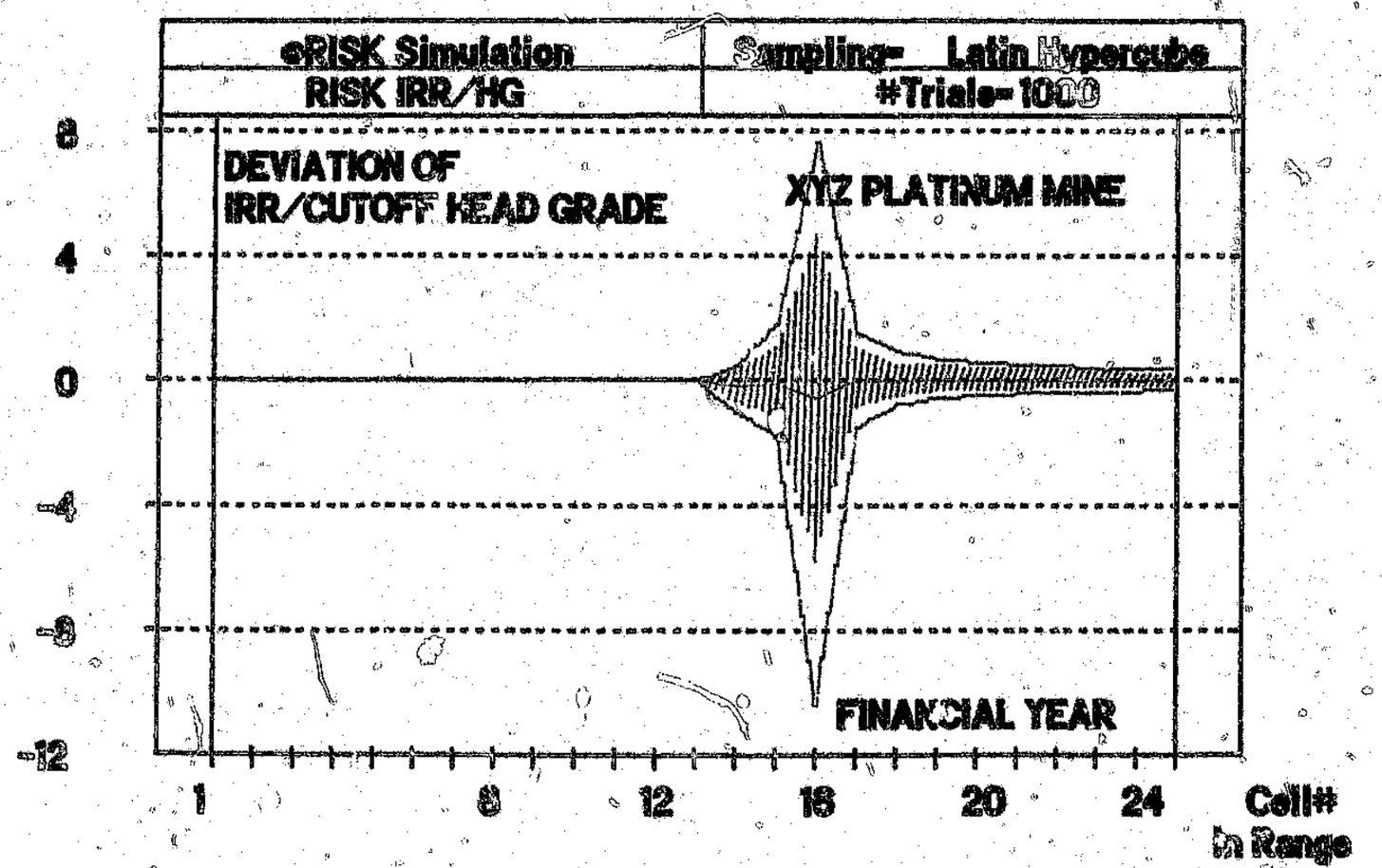
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



Trend in Mean.
1 StdDev.
5/95 Perc.



Trend in Mean,
1 Std.Dev.,
5/95 Perc.



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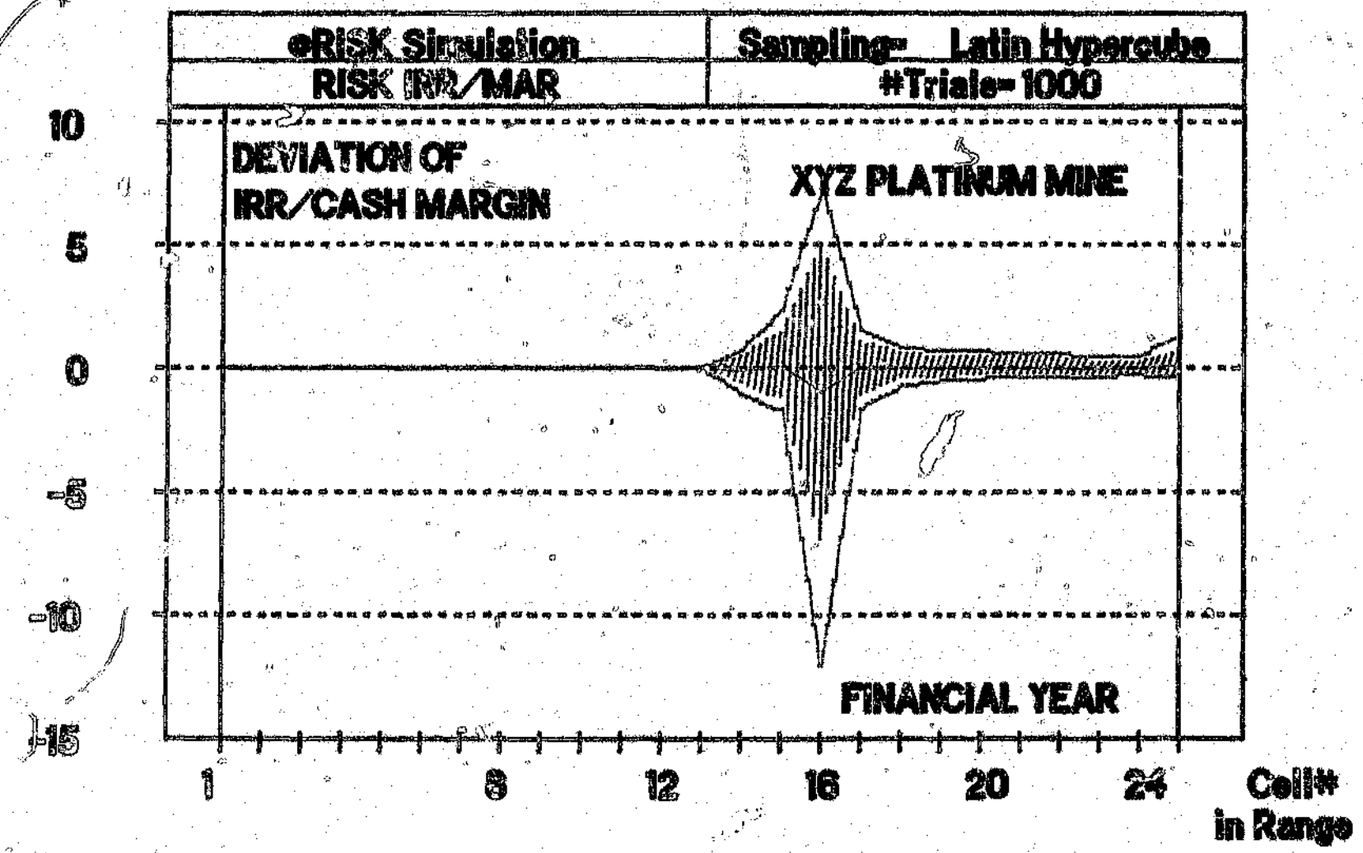

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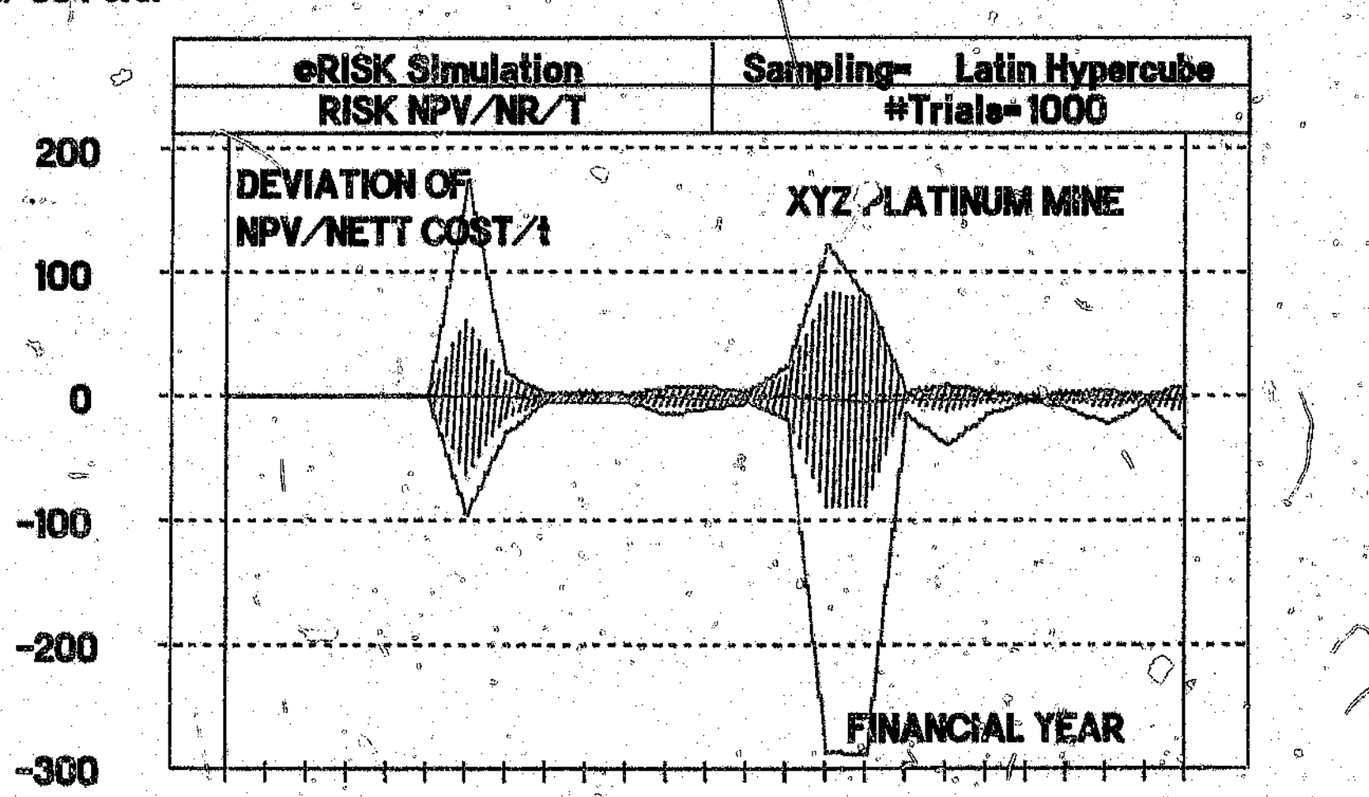

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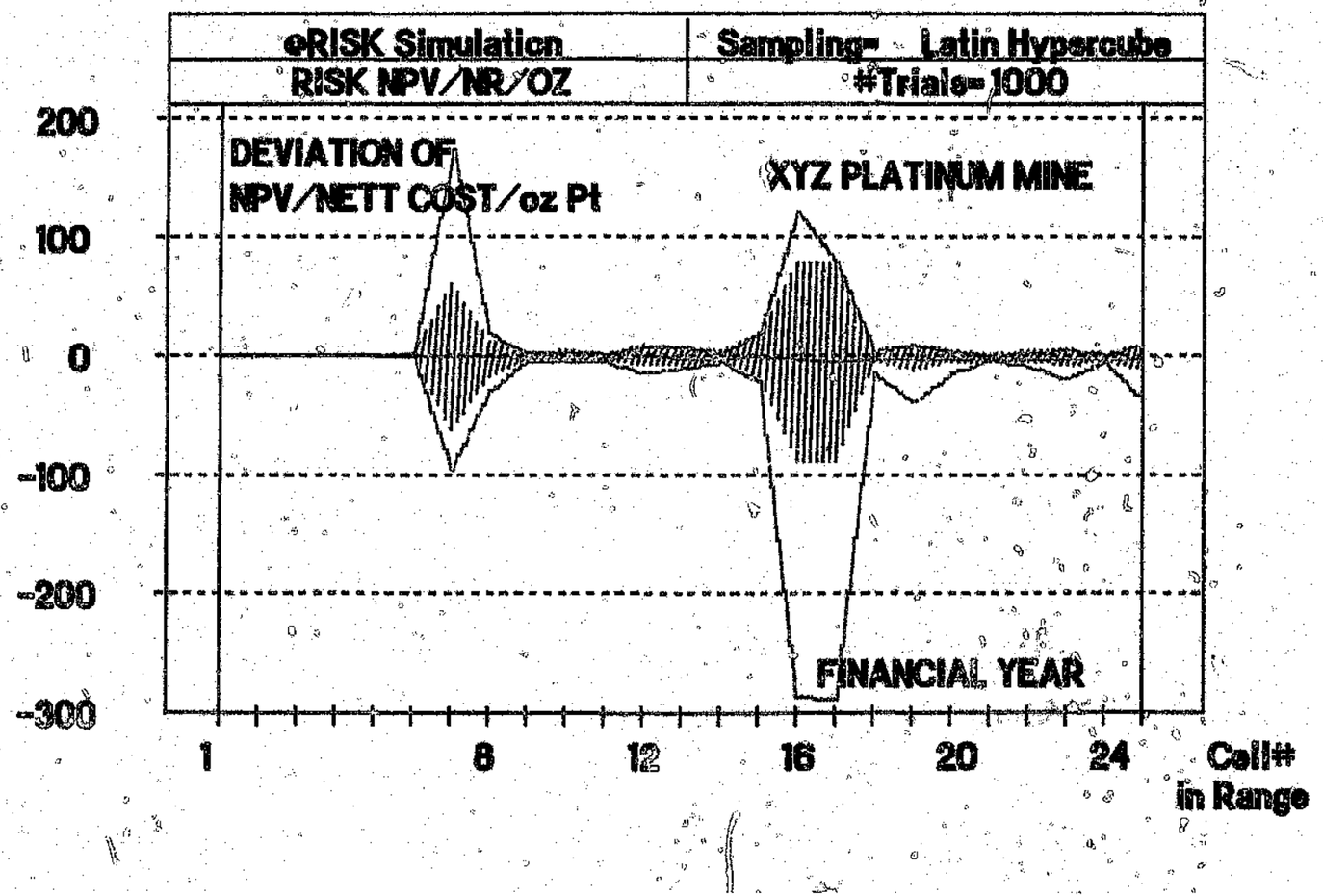

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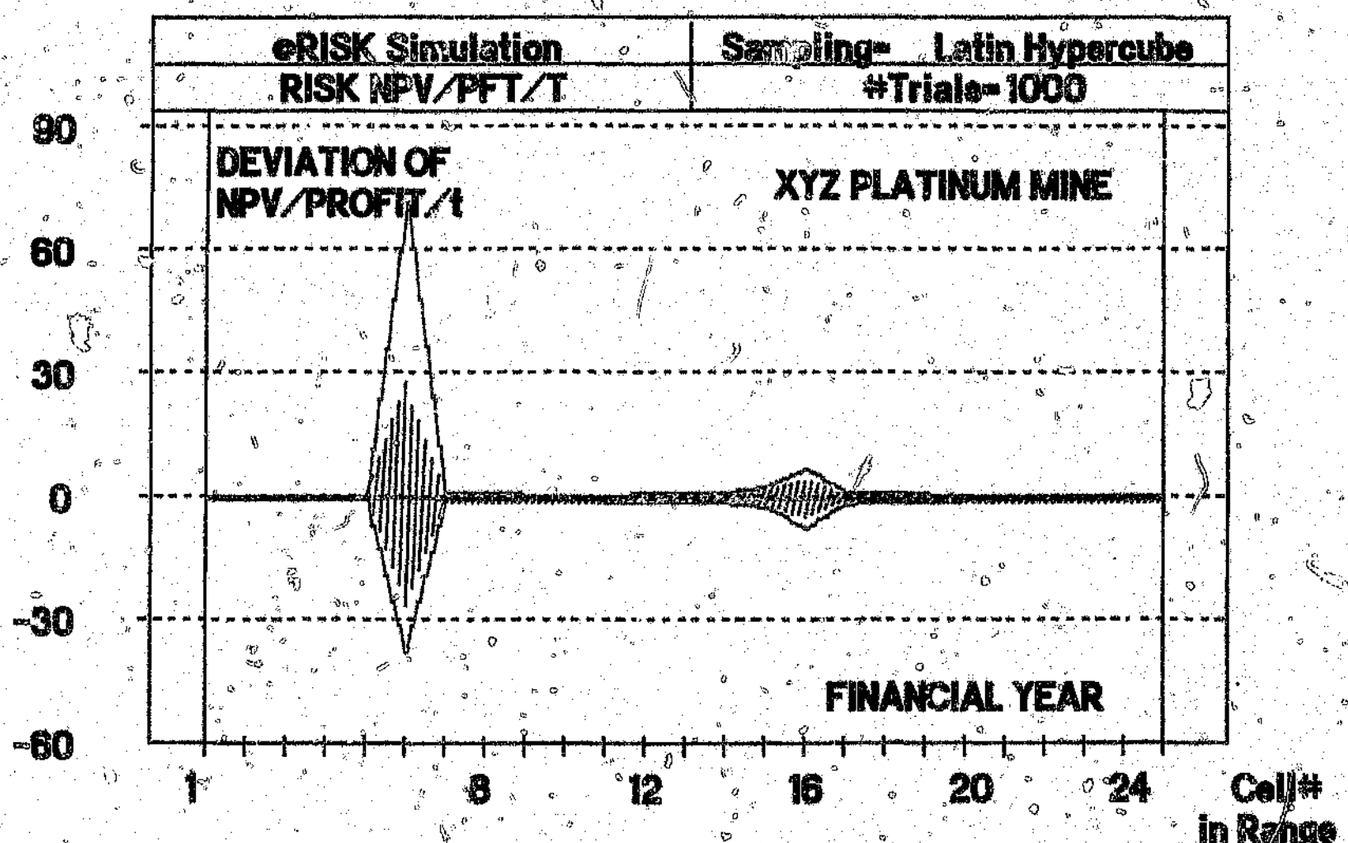

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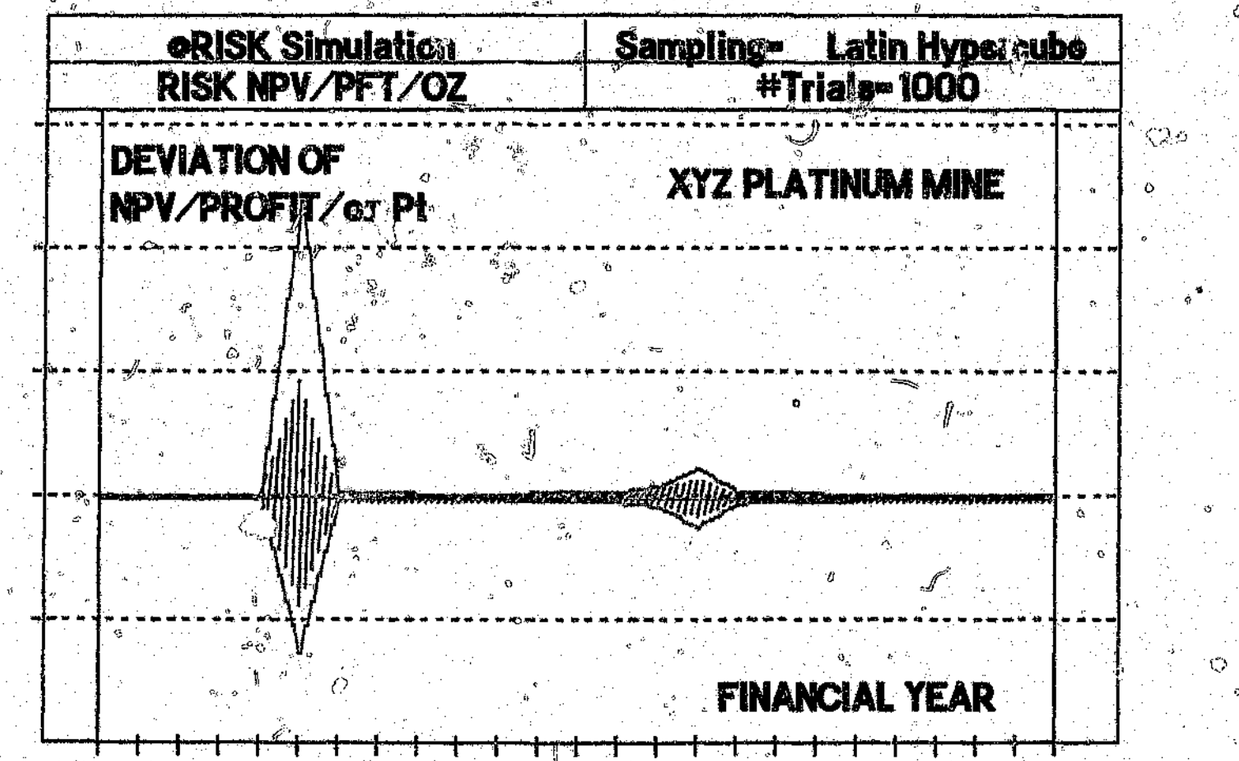

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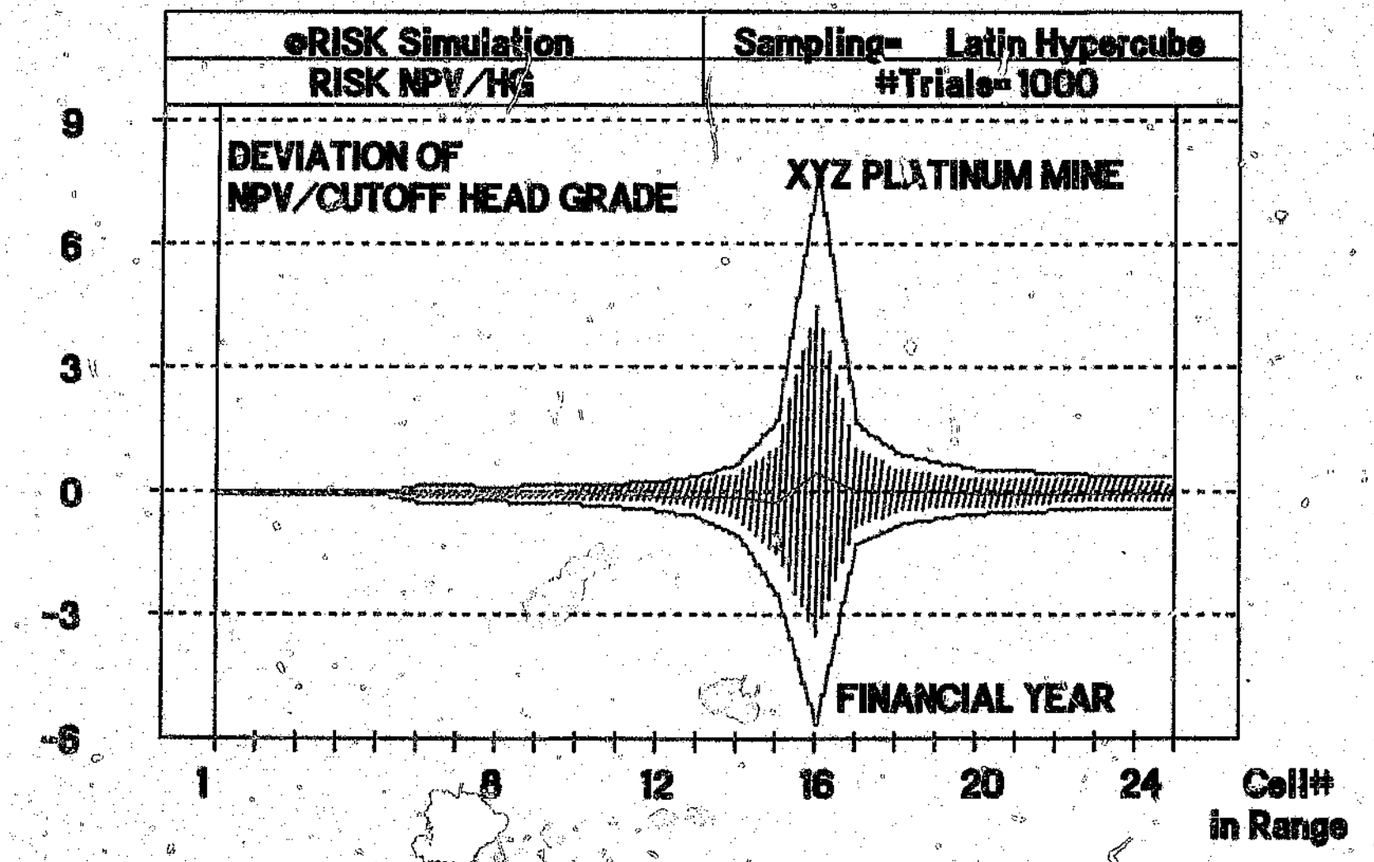

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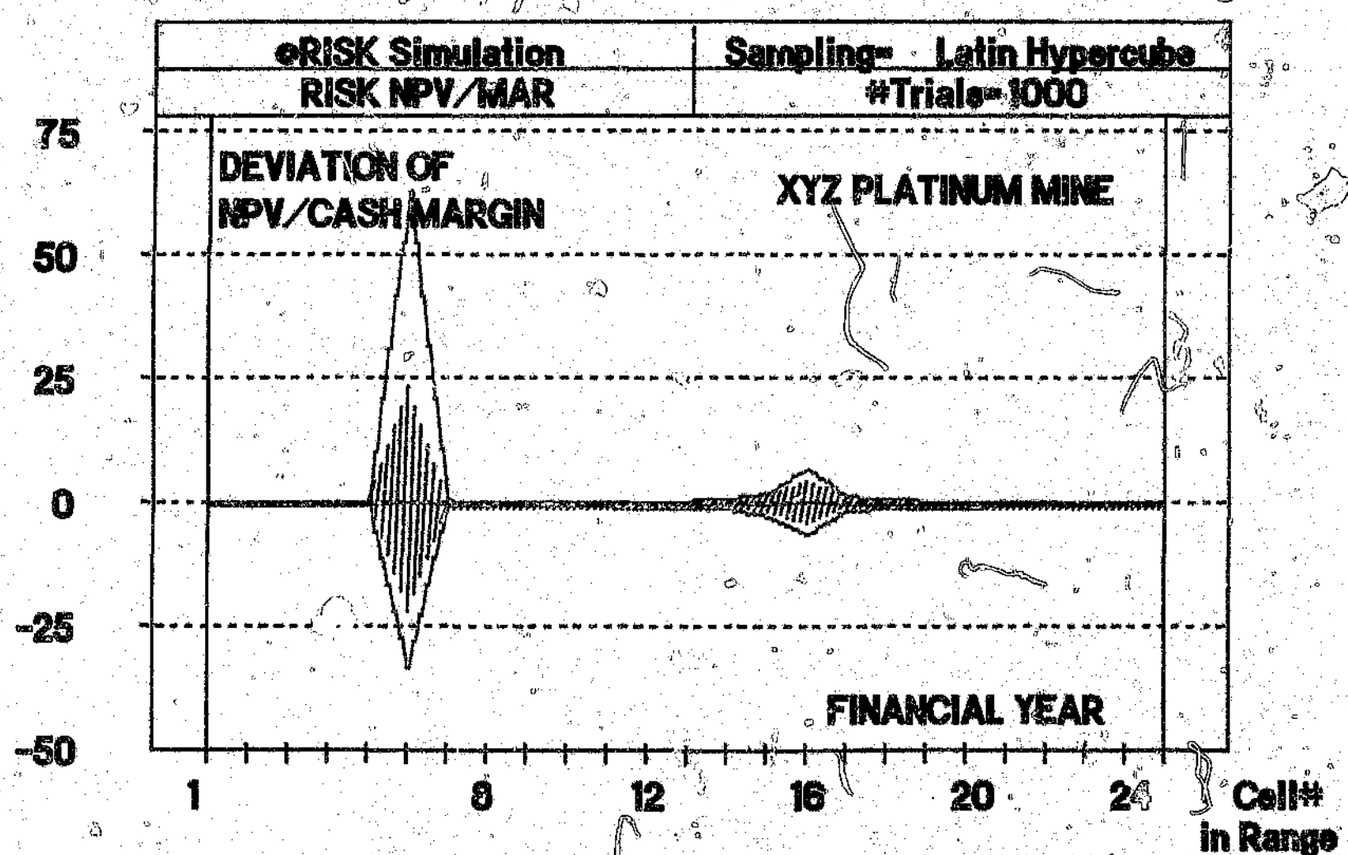


The underlined numbers on pages 106 and 107 are the lowest SD figures or the E figures closest to zero for each particular year and overall. The following notes can be made :-

(i) the Net R/t and Net R/oz Pt criteria produce the worst SD and E results of the ones considered. Net R/oz Pt is slightly worse that Net R/t.

(ii) Although the actual numbers are different, criteria 3 to 6 show similar patterns over time for SD and E. This is probably to be expected since all of these are related to profit.

(iii) Cut-off head grade, however, stands out as producing the lowest SD for V, especially in years 6 and 15 - 17.

(iv) The Profit/t, Cash Margin and Cut-Off Head Grade criteria stand out as producing values for E closest to zero.

(v) Years 6 and 15 - 17 are the periods when (1) production starts and (2) Real IRR and NPV @ 0% discount first become positive, respectively.

6. COMPARISON OF RESULTS

If one were to compare the conventional results for Hartley and XYZ, from a potential investor's point of view, the following would emerge :-

	Hartley	XYZ
Real IRR, %, 25 years :	11,36	6,85
NPV, R million, 25 years, @ 0% discount :	993	928
@ 3% discount :	530	363
@ 5% discount :	333	139
Maximum Exposure, escalated, R million :	595	1 305
Maximum Exposure, base date, R million :	518	851
Payback Period, years, escalated money :	6	11
Payback Period, years, base date money :	9	15

Clearly, without taking strategy or risk analysis into account, the Hartley project stands out as having better financial results in all cases than XYZ. The difference in production between the two projects is not great enough for this to make them uncomparable.

Risk analysis helps to add quantitative results for the perceived uncertainties for both projects. The following results comparison is thus produced :-

	HARTLEY		XYZ	
	E	SD	E	SD
Real IRR, %, 25 years	3,825	1,010	6,301	0,873
NPV, R million, 25 years, @ 0% discount	725,9	84,5	794,0	118,4
@ 3% discount	351,8	58,0	290,8	77,5
@ 5% discount	191,6	48,0	91,9	61,1
Maximum Exposure, escalated, R million	639,8	38,8	1 287,3	83,2
Maximum Exposure, base date, R million	553,8	31,3	832,2	46,6
Payback Period, years, escalated money	7,0	0,8	11,3	0,6
Payback Period, years, base date money	10,4	1,1	15,2	1,0

This comparison is now different from the one that the conventional results presents. Hartley is shown to suffer more as a result of the risk quantification than XYZ does. In fact, XYZ's expected NPV @ 0% discount is now higher than Hartley's and XYZ's maximum exposure has decreased whilst that for Hartley has increased. In effect, the conventional results have now been discounted for risk for both projects. For example, the risk discount rate for Hartley is 2,55%, compared to XYZ's 0,55%.

However, this exercise is not meant to reflect a diligent analysis of either Hartley or any South African PGM operation, but the above results do illustrate the usefulness of risk analysis in looking beyond conventional results, especially when two potential projects are situated within different uncertainty and risk environments.

What is important is that the following are common to both projects with regard to the robustness criteria studied :-

(i) Net cost/t and net cost/oz Pt are both inefficient and inaccurate measurements of robustness when conducting sensitivity and risk analyses, compared to other available criteria which produce lower values of SD and values of E closer to

zero in the foregoing analysis. The reason that these are inefficient robustness criteria is that variations in metal prices both for platinum and for other PGMs and base metals can affect these criteria without necessarily affecting profitability. For example, a reduction in net cost/oz Pt could also be accompanied by a reduction in revenue/oz Pt.

(ii) Cut-off head grade is the most efficient of the robustness criteria, producing an average standard deviation of between 0,545 and 0,835 for the V-factor $(z+\Delta z)/z - 1$ when Real IRR is divided by it and of between 0,430 and 0,514 for V when NPV @ 0% discount is divided by it.

(iii) Cut-off head grade has an expected result for V of between (0,140) and (0,046) when Real IRR is divided by it and of between (0,049) and 0,009 when NPV @ 0% discount is divided by it.

(iv) Cash margin has a slightly better expected result for V when Real IRR is divided by it ((0,066) - (0,035)) and also is relatively accurate when NPV @ 0% discount is divided by it ((0,035) - 0,071).

(v) Cut-off head grade is a better robustness criterion during the critical periods of (1) start of production, (2) when a positive Real IRR and NPV @ 0% discount are first made and (3) when a fresh capital programme is embarked on, producing lower deviations and expected results closer to zero for V than the other criteria in the foregoing analysis.

Cash margin is equal to profit divided by revenue expressed as a percentage. Cut-off head grade is equal to 100% less this cash margin multiplied by the actual mined head grade. It can be concluded, therefore, that cut-off head grade is a more accurate reflection of a project's robustness when sensitivity and risk analyses are run because it relates both the financial and technical soundness of the project in one parameter.

If this is the case, then presumably one could take it a step further by calculating the cut-off recovered grade and thus covering all the possible technical variations. To do this, one would have to let individual metal recoveries have an input variability, but this is not done in the model. This variability would probably be very difficult to define.

A problem lies in trying to determine why the cut-off head grade criterion should vary less than the cash margin criterion when the two are so closely related. One can normally determine the one if one knows the other.

The answer lies in the effect that changes in head grade have over time. Because of the pipeline effect, which is built into the model, a change in head grade will be manifest by a change in production not only in the year in which the head grade changes but also in the subsequent year. This, in turn, spreads the changed revenue over those two years and thus dilutes the effect on cash margin for the first year. The cut-off head grade, however, is determined by multiplying the full head grade by a factor related to cash margin.

As an example, assume that, in one particular year, head grade changes by x%. Furthermore, the pipeline effect is only y% for that year and (1 - y) % for the subsequent year. The original cash margin is :-

$$M = \frac{(R - C)}{R}, \text{ where } R = \text{revenue and } C = \text{costs}$$

The new cash margin for that year will thus be :-

$$M^1 = \frac{(R(1+xy) - C)}{R(1+xy)}$$

$$\therefore \frac{M^1}{M} = \frac{(R(1+xy) - C)R}{R(1+xy)(R-C)} = \frac{R(1+xy) - C}{R(1+xy) - C(1+xy)}$$

Similary, the original cut-off head grade is :-

$CO = \frac{C}{R} \cdot HG$, where HG is head grade

The new cut-off head grade will thus be :-

$$CO^1 = \frac{C}{R(1+xy)} \cdot HG(1+x)$$

$$\therefore \frac{CO^1}{CO} = \frac{C \cdot HG(1+x)R}{R(1+xy)\,C \cdot HG}$$

$$= \frac{(1+x)}{(1+xy)}$$

Let us assume that :-

$$\frac{CO^1}{CO} > \frac{M^1}{M}$$

Therefore :-

$$\frac{(1+x)}{(1+xy)} > \frac{R(1+xy) - C}{R(1+xy) - C(1+xy)}$$

$$\therefore (1+x)(R(1+xy) - C(1+xy)) > (1+xy)(R(1+xy) - C)$$

$$\therefore (1+x)R(1+xy) - C(1+x)(1+xy) > C(1+xy)^2 R - C(1+xy)$$

$\therefore R(1+x) - C(1+x) > R(1+xy) - C$

$\therefore R(1+x-1-xy) > C(1+x-1)$

$\therefore R(x-xy) > Cx$

$\therefore Rx(1-y) > Cx$

$\therefore R(1-y) > C$

$\therefore R(1-y) - C > 0$

which means that revenue must be greater than costs by a factor of (1-y), or 100% less the pipeline percentage applicable for each year, for the effect of a variation in head grade to be greater on cut-off head grade than on cash margin.

The important point here is that cut-off head grade does vary differently than cash margin and that it varies less when used as a robustness criterion for Real IRR or NPV @ 0% discount. During production build-up, when this difference is marked, (R-C) is not large, and may even be negative, and thus R(1-y) - C will probably be less than zero, which, from the calculation above, means that the effect of a change in head grade is greater on cash margin than on cut-off head grade, resulting in the distortions in SD for V produced by the cash margin criterion during the relevant periods shown by this study.

Costs are relevant as a major barometer of robustness. It is a simple fact that low cost producers will survive longer than high cost producers. However, high revenue producers will also survive longer than low revenue producers. The net cost criteria do not take both sides of this equation into account. The other criteria (profit and margin-related) do take both sides into account, but this study shows that margin-related criteria are more efficient indicators of robustness than profit criteria.

In practical applications, however, it may be easier to refer to cash margin as a robustness criterion rather than to calculate the cash margin from the cut-off head grade. This choice needs to be made by the person conducting the evaluation.

7. CONCLUSIONS

It is concluded that, since the cash margin criterion produces a value of E closest to zero, it is expected to be a more accurate measure of project robustness than the other criteria considered. However, when running sensitivity or risk analyses, cut-off head grade will be a better indicator of project robustness because its SD is lower in the foregoing analysis.

The following steps are thus suggested when evaluating a potential PGM project :-

a) Run the PGM project results conventionally, predicting Real IRR, NPVs and other financial indicators.

b) If these results are acceptable and could possibly fit into corporate strategic aims, compare them against alternatives available to the corporation.

c) Run similar conventional analyses for all competitors or potential competitors.

d) Rank these results in descending order on the basis of cash margin.

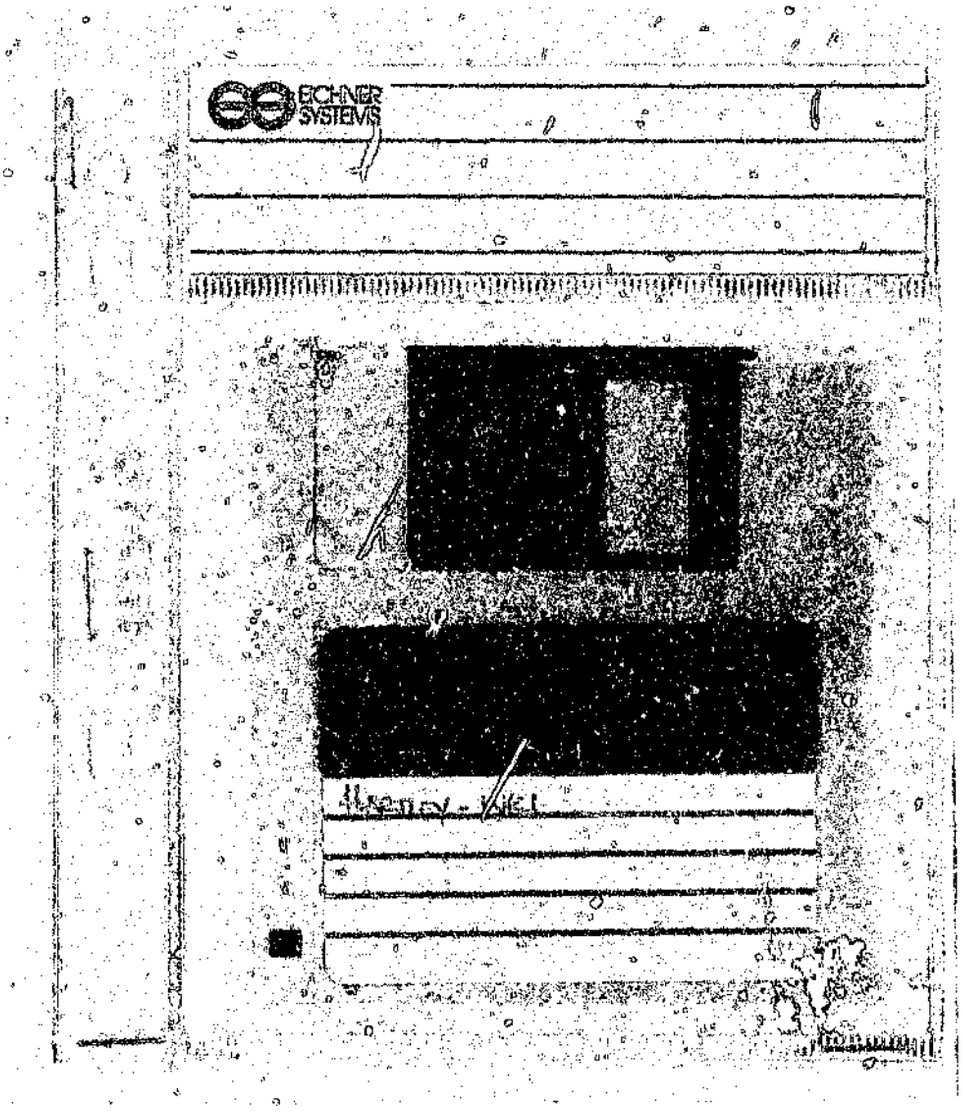
e) Run sensitivity/risk analyses for all the above PGM producers.

f) Rank them again, but this time on the basis of the expected difference between head grade and cut-off head grade, expressed as a percentage of head grade.

g) The position of the project in the above rankings will determine the project's robustness and thus provide decision-makers with the necessary information to assess the riskiness involved.

The assessment of the potential upward and downward potential of each input parameter for each producer is essential to this kind of evaluation and requires in-depth knowledge and information. This kind of competitiveness analysis should form an essential part of any executive summary of a PGM project evaluation. A brief outline of a potential PGM project's robustness would probably be of greater value to executive decision-makers than a miriad of financial data with no reference to competitiveness.

8. COMPUTER DISK WITH MODEL



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