

THE DEVELOPMENT OF AN IMPROVED LABOUR PLANNING MODEL FOR MINES

Bertie Meyer

Thesis submitted in partial fulfilment of the requirements for the degree of Master of Engineering in the Faculty of Engineering at the North-West University, Potchefstroom Campus.

Promoter: Dr M Kleingeld

2004

Potchefstroom

ABSTRACT

The mining industry is the largest source of foreign income for South Africa. It is also the main source of employment in the country, for example Anglo Platinum employs approximately 40 000 employees and contractors. As a result labour cost in South African mines makes up nearly 50% of total mine costs.

The focus of this study was to investigate the current underground labour planning models used in the platinum mining industry and to design a mine labour planning model to optimise the labour – Anglo Platinum specific. This would minimise all of the mining-related risks in a direct or indirect manner.

Financial modelling showed an annual improvement of R38 million for Rustenburg Platinum Mines. If this new approach could be extended to the rest of Anglo Platinum, a saving of R151 million could be realised by increasing revenue and a decreasing labour cost.

The optimum labour output level of underground mines was determined from a mining, services and engineering perspective and the GAP (or production output potential compared to the current output levels) was established.

One of the main objectives was the determination of the existing labour supply GAP, and thus the requirements to fill this GAP. For this purpose, specific checklists were designed to capture all the relevant information. Site personnel were involved throughout the entire process to ensure ownership of the new model. This buy-in was achieved through planning workshops, interactive presentations and discussions.

Between the different operations the GAP ranged between an oversupply of labour by 5%, and a 5% undersupply below the optimum potential. The improved frequency of daily blasts validated the correct amount and mix of the labour force.

Reef deposits are not replaceable and it is in the interest of all stakeholders to extract every portion in the most efficient manner. Mines require vast amounts of capital and with risks, like fluctuating metal prices, exchange rates, rising costs, labour unrest and geological uncertainties, it is important to have optimum labour planning model and labour management systems in place.

The new model has been successfully implemented in RPM with the benefits described above.

SAMEVATTING

Die doel van hierdie studie was om die huidige produksie- en arbeidsbeplanning, en arbeidsbestuur vir ondergrondse mynbousisteme, soos tans in gebruik in die platinum mynbou-nywerheid, te ondersoek. Die ondersoek het hoofsaaklik gehandel rondom die ontwerp van 'n arbeidsbeplanningsstelsel om sodoende die arbeid in Anglo Platinum te kan optimeer.

Na suksesvolle implementering is 'n finansiële evaluasie gedoen en dit is bevind dat die inkomste na die ondersoek met R38 miljoen per jaar verbeter het vir Rustenburg Platinum myne. As die studie vir die hele Anglo Platinum gedoen word, word beraam dat tot R151 miljoen ekstra inkomste gegenereer kan word.

Hierdie werk is tesame met die personeel op elke myn gedoen om die bevindinge te verifieer. Om almal in die proses te kon betrek, is verskeie samekomste gebruik met, onder andere, sessies waar die gehoor die voorbeelde vir modellering kon voorstel. Wysigings is aangebring en die resultate is gedebateer. Die wyse, eenvoud en resultate van die stelsel word deur verskeie dissiplines ondersteun, onder andere mynontwerpspesialiste asook mannekragbestuurders.

Die mynindustrie is die grootste bron van buitelandse valuta vir Suid-Afrika en dit is ook die hoofbron van werkverskaffing met Anglo Platinum wat ongeveer 40 000 mense direk en indirek in diens het. Arbeidskoste beslaan ongeveer 50% van die totale koste op 'n myn.

Ertsreserwes is onvervangbaar en dit is in almal se belang om dit optimaal te benut. Myne benodig enorme hoeveelhede kapitaal en met risiko's, soos wisselende metaalpryse, stygende kostes, arbeidsonrus en geologiese onsekerhede, is optimale beplanning- en bestuursisteme uiters noodsaaklik.

ACKNOWLEDGEMENTS

I would like to express my gratitude towards the management of Anglo Platinum for allowing me the opportunity to perform this study. I consider myself honoured for having Alan Field as my mentor.

The following people have also made invaluable contributions throughout the course of this study and I am sincerely grateful for their assistance and guidance:

- Riaan Vermeulen for motivating and supporting me throughout the course of this study.
- The mine managers of Anglo Platinum, with Sean O'Connor and Rudi Rudolph being the first two to formally apply the LP system to do production planning on their mines.
- Production managers, with particular reference to Fred Ungerer for supporting the LP system in various ways since inception.
- Marius Kleingeld from CRCED for his drive, guidance and persistence as my study leader.
- Eddie Mathews from CRCED for his dedication, patience and guidance throughout the two-year course of this study.

SPECIAL CIRCUMSTANCES

Due to the extreme competition in the mining industry, confidentiality agreements between the company and the author as well as for ethical reasons, most of the results may not be disclosed without written approval from the author and an Executive from Anglo Platinum.

NOMENCLATURE

Build-up head grade: The total 4E grams produced from the concentrating process from concentrate, metallics (where applicable) and tailings divided by the total tons milled.

Capital expenditure: Total capital expenditure on mining and non-mining property, plant and equipment, and capital work-in progress.

Chairlift decline: An excavation parallel to the reef plane, equipped with a chairlift for conveying people (endless rope with chairs attached).

Conveyor belt incline: Inclined excavation normally parallel to the reef plane, equipped with conveyor belts for rock handling. Some mines have man-riding conveyor belts that convey men and rock.

Development: Any tunnelling operation that has for its object either exploration or exploitation, or both.

Dilution: The dilution refers to the lowering of the reef grade due to the addition of rock with a lower grade or the loss of content through various possible mechanisms.

Dyke: A sheet that cuts across the structural planes of the country rocks.

Equipping: The preparation of a ledged-out area to allow the extraction of the remaining reef area through a process called stoping.

Fault: A "break" in the reef plane with displacement.

GAP: The difference between the planned targets and the actually achieved targets.

Geological losses: Normally expressed as a percentage of the total ore reserve lost due to faults, dykes, potholes, slumps and certain reef replacements (i.e. iron replacement).

g/t: Grams per ton, unit of measurement of grade. One gram per ton is one part per million.

Labour, At Work: The number of employees who are at the mine ready to perform duties, which excludes sick, accidents, special leave and absenteeism.

Labour, On Strength: The number of employees who are at the mine ready to perform duties. This excludes employees on annual leave and at the training centre.

Labour, In-service: The total number of employees on the mine books.

Ledging: The widening of tunnels (normally in the reef plane) to install equipment necessary for reef extraction (stoping).

Material incline: Inclined excavation normally parallel below the reef plane, equipped with a winding or hoisting device and tracks. Material, rock, men and equipment may be conveyed through this excavation.

Milling: A process to reduce broken ore to a size at which concentrating can be undertaken.

Ongoing capital development: The ongoing capital development is the excavations required to replace levels.

Ore: A natural mineral-bearing substance of economic interest.

Pay limit: That value at which it is estimated that ore can be mined without profit or loss.

PGM: Platinum group metal; six element metals of the platinum group nearly always found in association with one another. These metals are platinum, palladium, rhodium, ruthenium, iridium and osmium.

Pothole: Common to igneous reef planes – it can be explained as a load upon the reef plane (whilst in liquid state) thus displacing reef resulting in a narrower reef width in the area where the load occurred. Potholes vary in size and some may be kilometers in diameter. In some cases it is possible to mine the reef below the pothole.

Primary development: The initial development carried out in any portion of a mining area.

Reclamation: In this activity all the useful material is reclaimed for use in other areas, which includes pipes, winches, electric cables, etc.

Reef plane: A reef plane (or part thereof) in space is described by the following:

- **True dip:** This is the steepest average angle at which the reef plane is inclined relative to the horizontal plane (normally at its origin closest to the earth's surface). It ranges from 0° to 90° and is represented by an arrow pointing from the origin, parallel to the steepest inclined line in the plane. The direction of this arrow is also defined relative to a standard survey system.

- **Strike:** This refers to a line that can be drawn inside the reef plane that lies parallel to the horizontal plane and 90° relative to true dip direction.
- **Reef width:** The width of the reef is measured at 90° relative to the reef plane – the minimum thickness measurable.
- **Stoping width:** The width of the excavation made during stoping operations.

At this point it is important to understand that, for mining purposes, the reef plane is defined in terms of true dip, width and position relative to a grid on the surface of the earth (and a specific survey system).

Reef width: The sum of the widths of the individual reef bands within the reef body.

Secondary development: The development carried out within the area delineated by primary development.

Stoping: Operations directly associated with the extraction of reef.

Sweepings: The clean up of residual broken ore in stopes.

UG 2: A chromite reef in the Bushveld sequence often containing economic values of PGMs.

Vamping: The final clean up of track ballast and/or accumulations in gullies and along transportation routes⁴².

Winch: A winch in the underground sense is an electrical winding device with normally two steel rope drums rotating in opposite directions enabling the linear movement of a scraping device. (Appendix 9)

4 E: four elements. The grade that is always measured as the combined content of the four most valuable precious metals: platinum, palladium, rhodium and gold.

TABLE OF CONTENTS

ABSTRACT	II
SAMEVATTING	III
ACKNOWLEDGEMENTS	IV
SPECIAL CIRCUMSTANCES	V
NOMENCLATURE	VI
LIST OF TABLES	XII
LIST OF FIGURES	XIII
CHAPTER 1: INTRODUCTION	1
1.1 Background to Platinum Mines in South Africa.....	2
1.2 Conventional Mine Production Planning – Background.....	3
1.3 Highest Costs: Labour.....	4
1.4 Review of Labour Planning from Literature	6
1.5 Need for Improved Labour Planning.....	9
1.6 Objectives of this Study	9
1.7 Brief Overview of Dissertation.....	10
CHAPTER 2: HUMAN RESOURCE PROBLEMS DUE TO CURRENT PRACTICES	11
2.1 Problems	11
2.2 Background.....	11
2.3 Blasting Efficiency.....	13
2.4 Production Planning.....	13
2.5 Labour Planning	15
2.6 Annual Leave	16
2.7 Absenteeism	18
2.8 Summary of Current Shortcomings.....	20
2.9 The Way Forward	20
CHAPTER 3: DEVELOPMENT OF THE IMPROVED LABOUR PLANNING MODEL	21
3.1 Background.....	21
3.2 Description	21
3.3 Half-level Planning.....	23
3.4 Production Planning.....	24
3.5 Labour Planning	25
3.6 Duties of Personnel.....	26

3.7	Summary	26
CHAPTER 4: DETAILED LP SYSTEM IMPLEMENTATION		28
4.1	Introduction	28
4.2	Production Requirements	28
4.3	Labour	34
4.4	Leave Planning	39
4.5	Financial Benefits	40
4.6	Summary	41
CHAPTER 5: APPLICATION OF THE NEW SYSTEM – STRATEGIC		42
5.1	Mine Scenario Analysis	42
5.2	Monthly Production Planning	42
5.3	Long-term Production Planning	42
5.4	Layout Optimisation	43
5.5	Production Impact on Revenue	43
5.6	Simplified Management Approach	43
5.7	Leave Planning	43
CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS		44
6.1	Summary of Results	44
6.2	Expected Impact of Results	44
6.3	Conclusion	45
6.4	Recommendations for Future Work	45

LIST OF REFERENCES	47
APPENDIX A: FINANCIAL SUMMARY – OLD SYSTEM.....	50
APPENDIX B: TECHNICAL SHEET.....	51
APPENDIX C: MINING EQUIPMENT: LOCOMOTIVE.....	52
APPENDIX D: MINING EQUIPMENT: WINCH	53
APPENDIX E: LAYOUT	54
APPENDIX F: PARAMETERS.....	55
APPENDIX G: SHAFT LABOUR.....	57
APPENDIX H: TRAMMING LABOUR	58
APPENDIX I: GENERAL STOPPING LABOUR.....	59
APPENDIX J: FINANCIAL CALCULATIONS – NEW SYSTEM.....	60
APPENDIX K: DEVELOPMENT TARGETS.....	61
APPENDIX L: SKILLED LABOUR.....	62
APPENDIX M: TOTAL LABOUR.....	63
APPENDIX N: DIP AND STRIKE OF A PLANE ⁴³.....	64

LIST OF TABLES

TABLE 2.1:	BLAST EFFICIENCY.....	13
TABLE 3.2:	DUTIES OF PERSONNEL	26
TABLE 4.1:	FACTORS FOR LABOUR PLANNING PER HALF LEVEL	29
TABLE 4.2:	DAILY TONS	29
TABLE 4.3:	BLASTING SHIFTS FOR THE YEAR	30
TABLE 4.4:	DAILY DEVELOPMENT METERS PER END TYPE	31
TABLE 4.5:	DAILY DEVELOPMENT ENDS	31
TABLE 4.6:	STOPPING TARGETS.....	32
TABLE 4.7:	TRAMMING PARAMETERS	32
TABLE 4.8:	STOPPING GENERAL PARAMETER.....	33
TABLE 4.9:	SHAFT PARAMETERS.....	33
TABLE 4.10:	SERVICE PARAMETERS.....	34
TABLE 4.11:	DEVELOPMENT LABOUR REQUIRED PER END	35
TABLE 4.12:	STOPPING LABOUR PARAMETERS	35
TABLE 4.13:	TRAMMING LABOUR.....	36
TABLE 4.14:	GENERAL LABOUR.....	36
TABLE 4.15:	SHAFT LABOUR.....	37
TABLE 4.16:	SERVICE LABOUR.....	38
TABLE 4.17:	TOTAL LABOUR.....	38
TABLE 4.18:	IDEAL LEAVE PROFILE	39
TABLE 4.19:	ANTICIPATED COST AND REVENUE BENEFITS	40

LIST OF FIGURES

FIGURE 1.1:	BUSHVELD IGNEOUS COMPLEX: MAP OF THE ANGLO PLATINUM MINES AND LEASE AREAS.....	2
FIGURE 1.2:	MINING CYCLE	5
FIGURE 1.3:	REASONS FOR LOST BLASTS	6
FIGURE 2.1:	THE PROBLEMS AND CAUSES OF THE CURRENT PROCESS.....	12
FIGURE 2.2:	DAILY SQUARE METER PLANNING PER MONTH.....	14
FIGURE 2.3:	DAILY LABOUR PLANNING PER MONTH.....	15
FIGURE 2.4:	LEAVE PROFILE	17
FIGURE 2.5:	DAILY ABSENTEEISM	18
FIGURE 2.6:	ABSENTEEISM OF EMPLOYEES	19
FIGURE 3.1:	PLAN VIEW OF THE HALF-LEVEL SUITE	23
FIGURE 3.2:	OLD/NEW DAILY SQUARE METER PLANNING	24
FIGURE 3.3:	OLD/NEW EMPLOYEE PLAN.....	25

CHAPTER 1: INTRODUCTION

Preface

Several labour planning software packages were released during the past thirty years and systems, like *Cads mine*¹ and *Data mine*², are widely used. These are however specialist fields and are not totally user-friendly to the untrained. They are also not simple for optimisation and scenario planning in the sense needed by Managers for quick decision-making.

However, if these systems are properly used, very powerful and accurate information can be generated and it is not the intention of this document to suggest that current labour planning models should be replaced.

The new labour planning (LP) model should rather be run in parallel with the formal planning model focusing on the longer-term issues. One model can also verify the accuracy of the other to achieve higher levels of confidence.

The LP model requires basic Microsoft Excel knowledge, as well as some understanding of the relationships between the various underground activities – shaft operations (vertical and inclines) development, ledging, equipping, stoping, sweeping, vamping, reclamation, logistics and services.

1.1 Background to Platinum Mines in South Africa

South Africa is rich in mineral resources and contains the largest known platinum reserves in the world situated in the Bushveld Igneous Complex. Anglo Platinum is the world's largest platinum producer with most of its reserves in the form of an underground narrow tabular ore body dipping (inclination relative to horizontal) from 9 to 22° with an average stoping width of less than 1 m. There are two main mineral zones, namely the Merensky Reef and the UG2 (Upper Group 2) Reef horizons. (There is another variation in the Potgietersrust area called Plat Reef, but this is currently being mined by open-pit mining methods and will not form part of this study.)

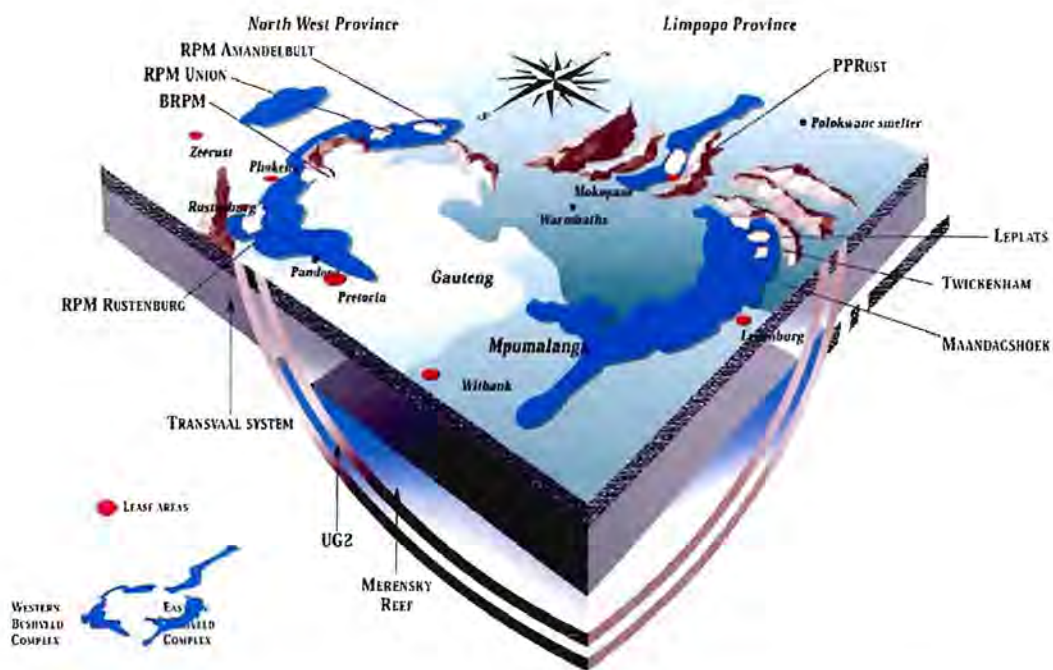


Figure 1.1: Bushveld Igneous Complex: Map of the Anglo Platinum mines and lease areas

Two commonly used terms in the mining world are "green fields" and "brown fields" operations. The former refers to new or virgin areas and the latter to existing operations. In an expanding business world, most of the attention and focus is enjoyed by the green fields operations due to the large amounts of initial capital required.

The true potential of brown fields is often overlooked because of annual comparisons to historical business plans that may not be optimised in the first instance. The contents of this document will focus on determining the optimum quality and quantity (OQ²) from existing and new operations by using the labour planning model.

It mainly addresses technical design aspects and human resources – but the financial issues cannot be isolated from the optimisation process and may thus be referred to from time to time (Appendix A).

Narrow reef conventional underground platinum mine design parameters will be used throughout the document. Narrow reef in this document refers to the ore body not exceeding 2 meters in reef width.

The underground mining methods have not really changed since inception, but the introduction of rock drills; locomotives (Appendix C), winches (Appendix D) and conveyor belts, etc., have caused noticeable labour efficiency improvements. The fear exists that the different mining layouts have now reached efficiency limits, with serious safety implications if labour numbers were to be reduced any further.

There is a constant productivity improvement drive that results in less people producing at higher levels from the same environments as in the past. It reduces the exposure risk, but shortcuts are often taken, thus resulting in unsafe work. Additional pressure is added by metal price variations, inflation, exchange rate fluctuations, labour relations and the vast amounts of capital involved. Capital for a typical 200 000 tons of ore per month operation (mining and concentrating) amounts to R4 billion in year 2003 financial terms⁴.

For the purpose of this exercise, the emphasis will be on the interrelationship between the main activities and some aspects surrounding it, i.e., the services, equipment and infrastructure inputs supporting the main activities to arrive at the optimum output levels.

1.2 Conventional Mine Production Planning – Background

Conventional mine production planning, in general, is done based on the past experience of the production personnel. Historical output levels are used as a basis for future plans and mining layout changes are made at the discretion of management^{1,5,6,7}.

Building on previous inefficiencies often occurs, resulting in crisis management conditions. Where the management turnover is high, one often finds that layouts change constantly, depending on the preferences of the different managers, thus causing mines never to reach steady-state (layout-optimum) production levels.

This is extremely costly/inefficient as it could take more than two years to reach full production for most known layouts. Ore reserve management becomes virtually impossible and flexibility

suffers constantly. If better systems were in place, this would reduce the negative impact on the ore reserves.

The direction of mining relative to the true dip of the ore body (reef plane) is normally the deciding factor when describing the specific conventional extraction method (Appendix E). Two main alternatives exist:

- **Strike mining:** Strike refers to a main extraction direction 90° on true dip or parallel to the zero inclination line inside the ore body. The most commonly known strike mining layouts are scattered breast and long wall mining where extraction takes place in a strike direction with the advancing front being parallel or slightly off parallel to the true dip line. Well-known strike mining variations are scattered breast, long-wall, overhand, underhand and breast-retreat layouts.
- **Dip mining:** When the advancing face progresses in a direction generally parallel to the dip direction, it is referred to as dip mining. Down-dip is when mining takes place in the direction of dip, and up-dip mining is when the extraction takes place 180° against the dip direction – in other words, mining from the bottom upwards. Well-known dip-mining variations are down-dip and up-dip.

These main mining activities⁵ can be broken down into development, ledging, equipping, stoping, sweepings, vamping and reclamation.

The use of graphical mine planning models/tools, for example *Data mine* and *Cads mine*, have become more popular, but require specialist skills. The person responsible for the production can thus not do his own planning without the assistance of a specialist.

Some mines make use of manually calculated parameters that form part of their mine standards and procedures documents, but this seldom caters for all possible layouts and conditions.

1.3 Highest Costs: Labour

The labour cost is the highest single item cost on a mine. The labour cost in South African mines equates to up 50%^{10,11,12,13} of total on-mine costs.

In the mines, a daily cycle⁴² (see Figure 1.2) has to be completed to achieve the targets. This cycle consists of the following activities: cleaning, drilling of blast holes, charging-up of explosives and the installation of support. A specific number of employees are assigned to this cycle. Every employee is trained to do a specific task in this mining cycle.

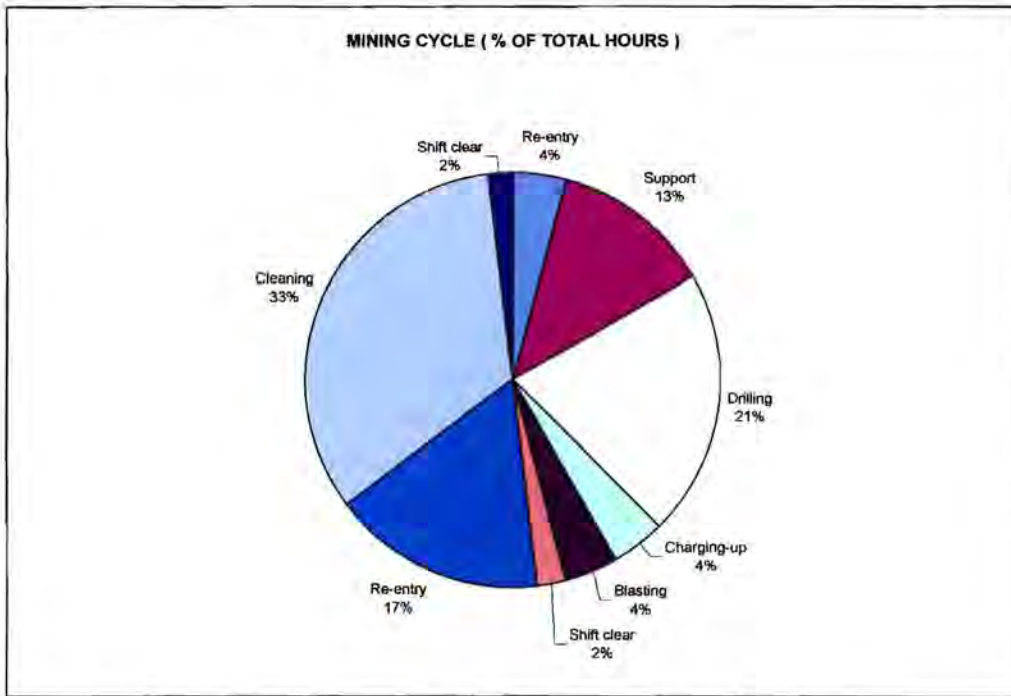


Figure 1.2: Mining cycle

When any employee is not on the job to perform a task in the cycle, the cycle cannot be completed. It can only be done if that specific employee is back on the job. Another employee of the same job category can also complete that specific task. Every time a cycle is not completed, there is a loss in revenue, but the cost is incurred.

Only the correct number of labourers on the stope panel will ensure a quality blast. The revenue will also increase due to more panels being blasted. If there is a shortage of labourers, the mine cannot achieve a daily blast. Figure 1.3¹⁴ shows that labour shortage is by far the highest contributor to lost blasts namely 47%.

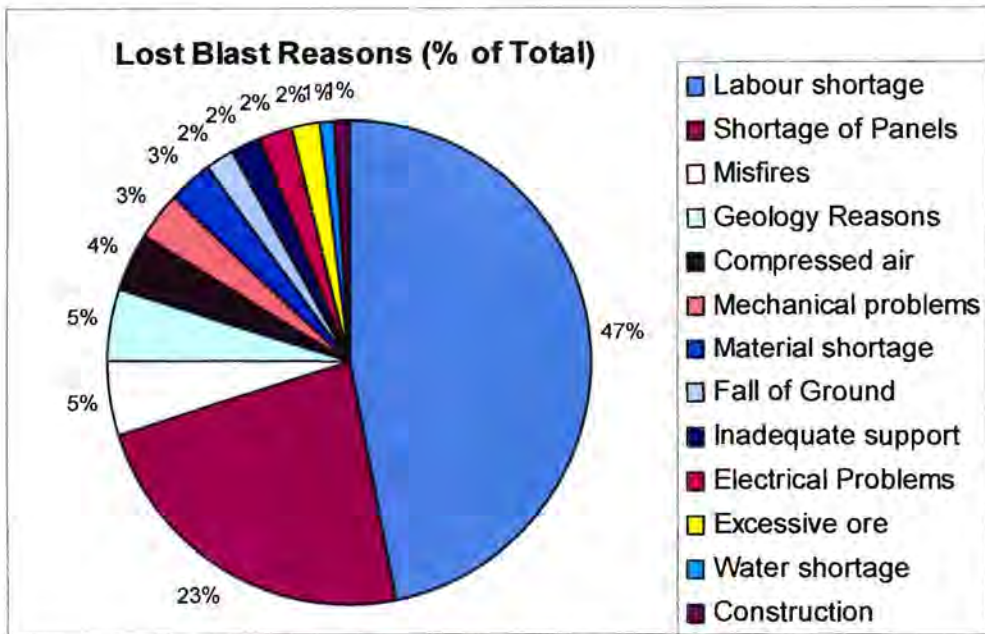


Figure 1.3: Reasons for lost blasts

Lost blasts are the primary reason for a loss in revenue, and for an increase in the *GAP*.

1.4 Review of Labour Planning from Literature

The approach towards the investigation of published literature and available practices was conducted through different avenues, namely personal communication, a study of various mine planning systems and mine standards, and international electronic searches.

No mine labour planning system similar to the LP model could be found through the following means:

- Communication with experts in the industry.
- Study of various mine labour planning systems.
- Study of mine labour planning standards, and
- International electronic search.

After personal communication with mine management⁵ – Christo Naude (General Manger), Rudi Rudolph (Mine Manager), Fred Ungerer (Production Manager), Vis Kruger and Freddie Huyser of the survey department meetings with their supervisory teams, the various technical teams, Luke Zindi and Anton van Zyl of the planning department, human resource personnel and employee representatives – a detailed study of the current labour planning systems was conducted. Discussion and feedback sessions were held on a weekly basis during the study.

The following problems were identified during the meetings between the various role players mentioned above:

- Different production targets – due to no formal planning systems on the mine. Each shaft got its own planning techniques. When the shaft personnel completed the yearly and monthly planning, the plan of each shaft was sent to the central planning department. The central planning department added all the shaft plans to get a mine plan. When the plans on the shafts are not done correctly the mine plan will also be wrong.
- Non-existence of leave planning, because there are different labour requirements on a monthly basis. Because the labour plan is erratic, it is difficult to get a workable leave plan.
- High absenteeism amongst the employees, due to the insensitive treatment the employees get which causes a low morale amongst them. In the mining environment and working conditions absentees will occur because of the interpretation that absenteeism means an employee is not at work to perform his duties. If the absence without permission and abusing of sick leave can be reduced, the absentee rate will be halved, which will be acceptable.
- No parameters for the support teams, because the planning of support teams is done haphazardly, which results in the over- or underplanning of these departments. When there is an underplanning in these departments, it may cause unsafe acts, which may lead to serious incidents.

To gain more information on relevance of the labour planning system in the international mining world, an Internet search was conducted. Some of the websites that did contain relevant information are listed as references, but limited information, applicable to labour planning in the massive reef hard rock environments, seems to be published.

Several graphical planning systems are described and most of these can be used to do planning on a half-level basis. Anglo Platinum is constantly investigating new planning systems and is currently investigating a system called *Mine24D*. No conclusions can be published yet but the system works on the same basis as Cads mine that is investigated and compared to the LP model.

The following list contains some of the keywords used for the electronic search process:

underground+mining, mine+planning, mine+level, mine+optimize, mine+production+optimize, deep+mine, hard+rock+mine, South+Africa+plan, planning+system, cads mine, data mine, mine24d, mine+schedule, plan+software, mine+software.

Search results were intensified by focusing on the narrow reef underground mine planning systems through using related secondary search keywords.

Copernic.com was the main Internet search engine used due to the fact that it utilises a host of independent websites, like Yahoo and MSN, to assist in the search. The Sciencedirect website didn't contain any information relevant to this study.

The most relevant websites were the following:

<http://www.surpac.com>

<http://www.minemodel.com>

<http://www.runge.com>

<http://www.minenet.com>

Some discussions around the planning ability of Miningtek were mentioned, but no additional information as to whether it could be done on the LP basis could be found on their website. After visiting the Runge website, a local mine planning representative was made available for a planning discussion – again, no LP model was used and additional detailed information would be costly.

Data mine, *Cads mine* and *Vulcan* are all available graphical software packages but web information made no mention of the specific planning approach. All these systems can however be aligned to follow the LP approach.

Other websites, for instance <http://www.mines.edu>, refer to information relevant to the Colorado School of Mines as an educational organisation – no detailed information on published documentation regarding the relevant mine planning systems could be found.

The above-mentioned researches revealed the following:

- Summary of the article²⁰ **“Mine Plant Design and Evaluation”**: To design and evaluate a mine in a given geological, technical, economic and operating environment on a strategic basis, but the more detailed production – and labour planning – on a daily basis are not discussed.
- The article¹⁹ **“What Do Mining Engineers Do?”** discusses *mine operations and management*, but states that they must ensure that the right amount of mineral is

produced at the right quality and at the right time in a safe and cost-effective manner in accordance with mining approval conditions. However, no detail is given as to how to go about achieving the production requirements or labour requirements.

- The article¹⁷ “**Performance Management Overview**” states: In an effective organisation, work is planned out in advance. Planning means setting performance expectations and goals for groups and individuals to channel their efforts toward achieving organizational objectives. Getting people involved in the planning process will help them understand the goals of the organization, what needs to be done, why it needs to be done, and how well it should be done. By involving the workers in the planning process create an environment of trust and cooperation.

1.5 Need for Improved Labour Planning

The result of the literature studies and interviews with mine management, clearly indicate that there is a need for an improved labour planning system.

The problem with the current system is that because the monthly targets are determined by one-twelfth of the annual target, the daily targets differ from month to month.

This results in the following problems:

- Daily targets differ every month.
- The labour numbers varying because the labour numbers are calculated on these monthly targets.
- Due to this varying labour number in some months, there is an oversupply or undersupply of labour.
- The inconsistent labour requirement results in a low morale among workers.
- This syndrome also expresses itself in a high rate of absenteeism and abusing of sick leave.

1.6 Objectives of this Study

In any operation there is a difference between what production should be possible to achieve with specific ore reserves and mine planning, and what has actually and practically been achieved. In Anglo Platinum this difference is defined as the *GAP*.

The objectives of this study are:

- To determine the production GAP in the existing Anglo Platinum operations due to the shortage of employees
- To create a system or methodology that can assist mine management with the following:
 - Monthly labour planning
 - Long-term labour planningin order to reduce this gap.
- To determine the impact on revenue by this proposed methodology.

1.7 Brief Overview of Dissertation

Chapter 1 contains general as well as Anglo Platinum-specific mining information. The majority of the platinum produced is from labour-intensive conventional underground sources. Some risks the mining industry is exposed to are discussed. The main conventional mining activities are identified and explained. The problem statement, objectives and the needs of this study are defined.

Chapter 2 is a discussion of current human resource management in terms of labour planning, leave planning and absenteeism.

Chapter 3 covers two important terms, production planning and the labour planning. The LP model's basic operating procedure is summarised. A detailed step-by-step LP assessment exercise with relative input and output example tables is then completed and explained.

Chapter 4 contains the results and findings of this study. Reference is made to all the objectives of this study.

Chapter 5 contains a strategic approach on the results and findings of this study that can be used for the life of a mine plan.

Chapter 6 is the conclusion and suggests possible future work.

CHAPTER 2: HUMAN RESOURCE PROBLEMS DUE TO CURRENT PRACTICES

2.1 Problems

The following observations were made during the study:

- There is a lack of standards in the up-front plan (see Figure 2.1); this results in different planned monthly production outputs.
- This in turn results in excess staff and forced leave, which results in staff changes, absenteeism and leave variations.
- The final impact is on the bottom line through a less than optimum labour utilisation and unnecessarily high labour costs.

2.2 Background

The yearly production targets are divided by the number of months in the year, i.e. 12, which results in equal monthly targets. There are, however, different numbers of blasting shifts in the month.

The monthly targets are divided into the blasting shifts for the specific month to give a daily target. Because there are different shifts in the months, the daily target differs every month. Sometimes the daily targets are high or low.

To determine the labour requirement for the mine, factors based on the production planning are used to determine the labour numbers. Because the monthly targets are different, the labour numbers also differ.

This change in numbers makes it impossible for the supervisors and Human Resource department to manage the employees optimally. In Figure 2.1 the labour process cycle shows the consequences of the change in production targets; sometimes there is an excess of staff and during some months a shortage of staff.

When there is an excess of staff, the employees are forced to go on unplanned leave. When there is a shortage, however, the production targets are not met and the employees are not allowed to take annual leave. Six weeks are required to recruit and train employees, but when

they are ready to commence work, the targets have frequently changed and there may be a surplus again.

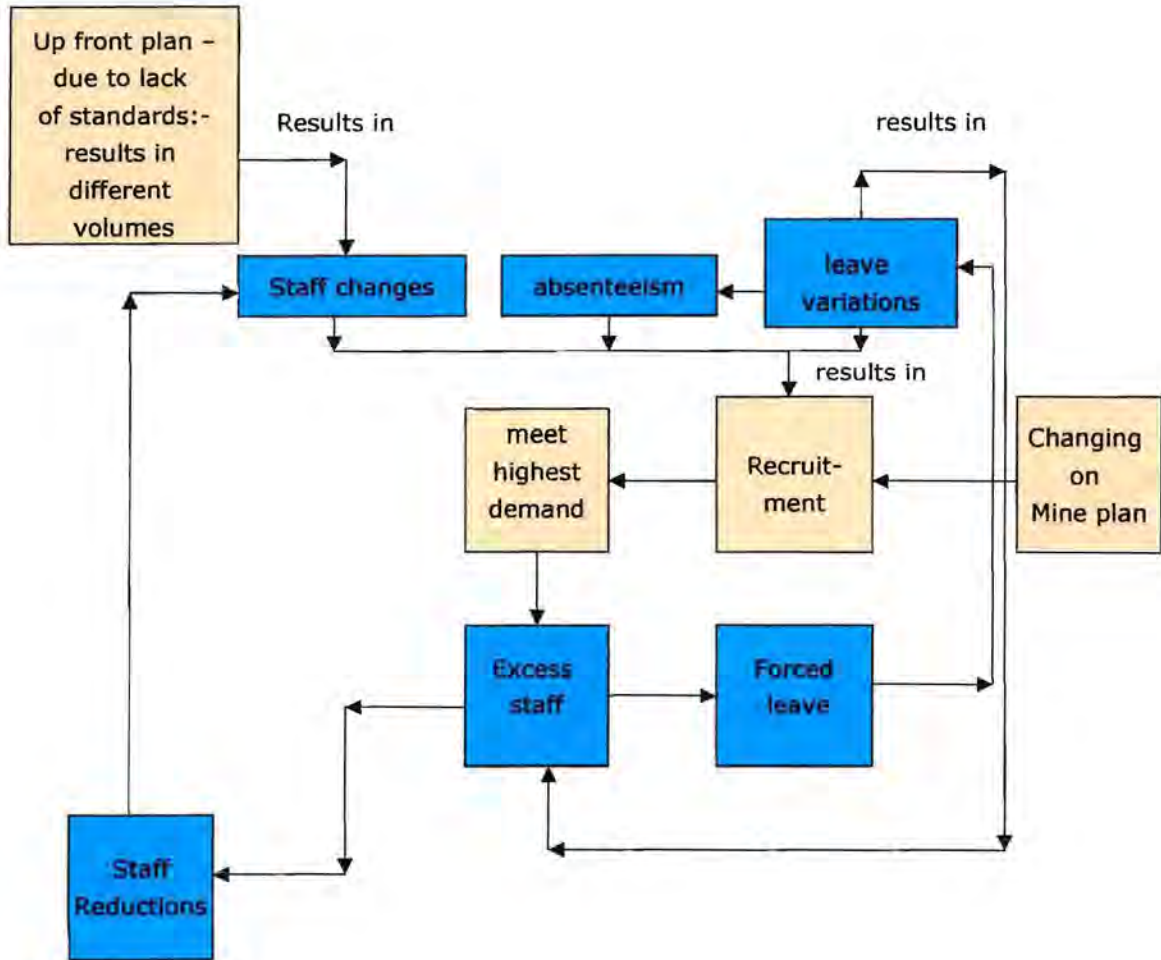


Figure 2.1: The problems and causes of the current process

The current practice results in a low level of morale due to human resource problems. There is no proper labour planning system in operation which supplies an inconsistent number of employees to the operations. Sometimes there is a shortage of employees and sometimes an oversupply. This syndrome also expresses itself in a high rate of absenteeism on the mine.

When there is a shortage of employees, few or none of the production targets are met. When targets are not met, the employees do not get any bonuses.

When there are too many employees on the job, they informally arrange to take turns to be absent and to share the bonus in the event of reaching the target. However, bonuses are often lost due to low efficiency³¹.

This situation demoralises the employees. An attitude of carelessness is common because they feel that the supervisors do not care about their well-being. This results in high absenteeism and abuse of sick leave.

2.3 Blasting Efficiency

Blast efficiency refers to the blast frequency (actual blasts/possible blasts) multiplied by the advance efficiency (actual advance per blast/maximum possible advance per blast).

Because the old planning system did not take the blasting efficiencies in the development ends and stopping panels into consideration, the production plan was overstated and impossible to achieve.

The blasting efficiency is also taken into account when determining the maximum possible advance per end per month. A development end that has the capability to be advanced at a rate of 46 meters per month is downgraded to 39 meters per month due to a blast efficiency of 86%.

Table 2.1: Blast efficiency

	Development	Stoping
Shifts in month	23	23
Blast frequency %	92	87
Advance efficiency %	93	85
Blast efficiency %	86%	74%

During January 2003 to August 2004 an exercise was conducted at Anglo Platinum to determine the actual blasting efficiency that was actually achieved. This was found to be 74% for stoping and 86% for development (see Table 2.1). These figures were then used as an input into the LP system.

2.4 Production Planning

The current production planning method is not formalised for the Anglo Platinum group as a whole – each mine uses different methods and parameters. Even here, there are only planning

parameters for stoping and development – not for other work required (mining services) such as engineering, human resources, shafts and general support departments.

Production planning volumes form the basis of any labour planning system. Production targets are determined annually during budget planning, which starts four months before the new financial year.

For budgeting, this annual figure is divided into 12 intervals. These monthly figures become the monthly production targets. Because months consist of a different number of production shifts, it follows that the daily production targets differ from month to month.

Figure 2.2 shows a typical variation of production targets over a year.

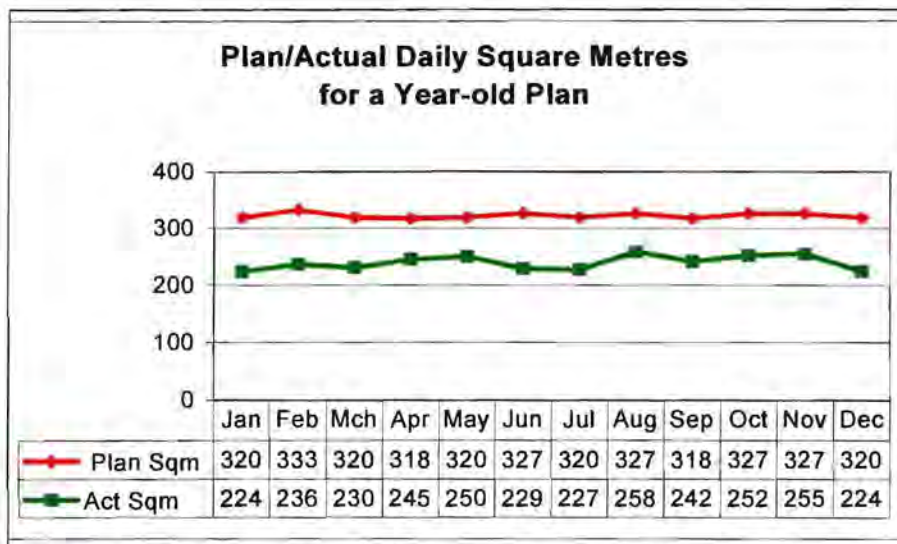


Figure 2.2: Daily square metre planning per month

Production planning is done according to a mine master plan. *The previous year's results are not taken into consideration, because lost blasts and poor advance per blast, which are expressed as blast efficiency, are not used when the planning is done.* This plan is done with the knowledge that the targets cannot be met.

This is a major reason that the *GAP* is so big in Anglo Platinum; the blast efficiency was 74% for stoping and 86% for development at the shaft where the study had been done. This means that 74% of the production plan was achieved, but the planned cost spent.

2.5 Labour Planning

Labour planning is also not consistent. A different amount of labour is required on a monthly basis due to incorrect production planning and no provision is made for service labour planning (Figure 2.3). This results in an imbalance between employees on production and in service departments. The ratio between production employees and non-production employees is currently 40:60.

A factor of 40 m² per employee is used to calculate the number of stoping employees required. A factor of 6 m per employee is used to calculate the required development employees. The required labour differs monthly because of the different shifts in the month.



Figure 2.3: Daily labour planning per month

The calculations of the number of employees required are based on the daily production targets. When the daily production targets are not constant for the year, the different daily employee targets make the management of labour difficult. This means that one month there are too many employees and the next month too few employees.

The time to interview, sign-on and train an employee takes six weeks³². However, the demand for employees differs on a monthly basis. The supply and demand of labour is therefore out of sync. This leads to the situation that during some months there is an oversupply of employees and at other times an undersupply of employees.

Labour planning optimisation revolves around sustaining the optimum blasting frequency for the life of the mine. This implies getting the most possible blasts at the best possible advance

per blast from the appropriate ends (blast attack fronts). In addressing these improvements, the following questions exist:

- Is the equipment adequate and can the services support all the mining activities in the production area?
- Is the capital replacement rate synchronised with the ore extraction rate?
- Is there a simple planning system in place that can assist the operations to supply answers to all of the above questions?
- Is the required labour force at the work?

2.6 Annual Leave

As a general rule, no leave planning is done on the mines. Employees are normally told only a day before their leave commences that he has to go on leave, without any prior arrangements with him. Then the employees still have to wait up to three days before they get their leave pay.

On returning from leave he has to wait for a vacancy in his job category before he can be signed back on the mine. This takes between three and fourteen days.

The ex-leave employee goes to the training centre between four and fourteen days before commencing work. During this period there is a *labour shortage* in the operations and the employees in the operations can't catch up the lost production.

As a result of the different amount of labour required on a monthly basis, there is no leave planning (Figure 2.4). People are sent on leave according to a weekly actual-labour figure. This means that the workers are forced to take leave at a day's notice. The employees are penalised if leave is taken before the leave cycle is completed and only receive a pro-rata leave bonus.

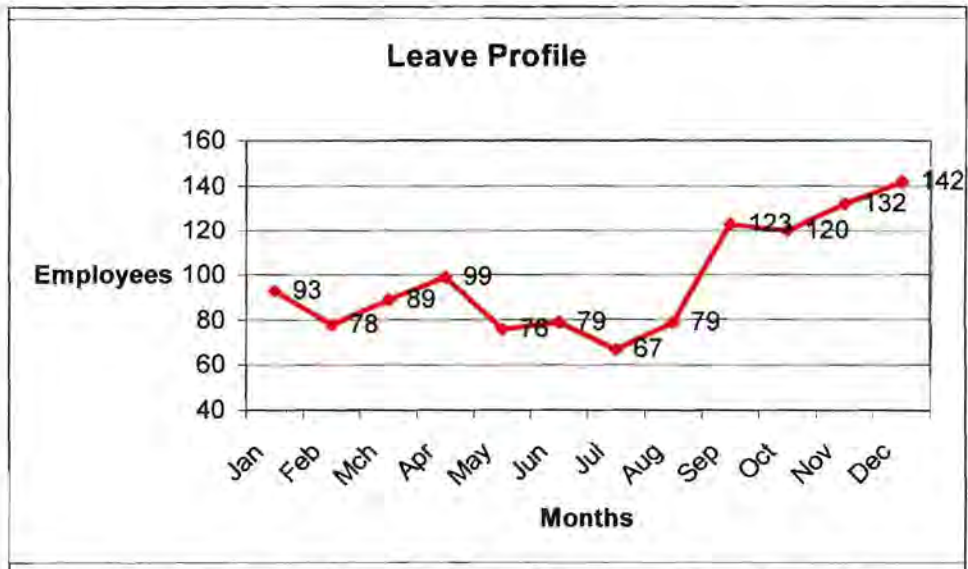


Figure 2.4: Leave profile

Employees are allowed to take 23 days paid leave, 6 days unpaid leave and 6 days for ex-leave training a year. There are 277 working shifts in a year. The employee is not at work for 35 days a year or 12.5% of the year.

To ensure an adequate supply of employees to the mine, an additional labour force of 12.5% above the daily employee requirement is needed.

The current supervisor controlling a team is not involved in the management and granting of annual leave for these teams. This has the following effect:

- Leave due dates are not taken into account when planning.
- Staff returning from leave has to effectively sign on again.
- Staff is forced to go on leave before due dates.
- Policies and procedures with regard to leave are inconsistent – labour treated as contract workers.

Leave profiles change during the year and it is found that too many employees are on leave at any time some times during the year as shown in Figure 2.4.

The skills mix of the employees on leave is also skewed. This phenomenon causes an erratic supply of employees to the operations. Leave planning will ensure that this phenomenon is corrected (red line shows correct planning).

The due dates for an employee are calculated when he has been working for exactly one year, that is 287 shifts on the mine. He is then entitled to take 21 days of paid leave and 6 days of unpaid leave during the cycle.

Employees commence duties at different times during the year; therefore the starting date for leave is different for each employee. The law prescribes that employees are not allowed to overstay their leave due dates by more than 3 months, but in some cases the employees overstay their leave by a year.

2.7 Absenteeism

Absenteeism refers to time that an employee is not on the job during scheduled working hours, except for granted leave of absence or holiday time.

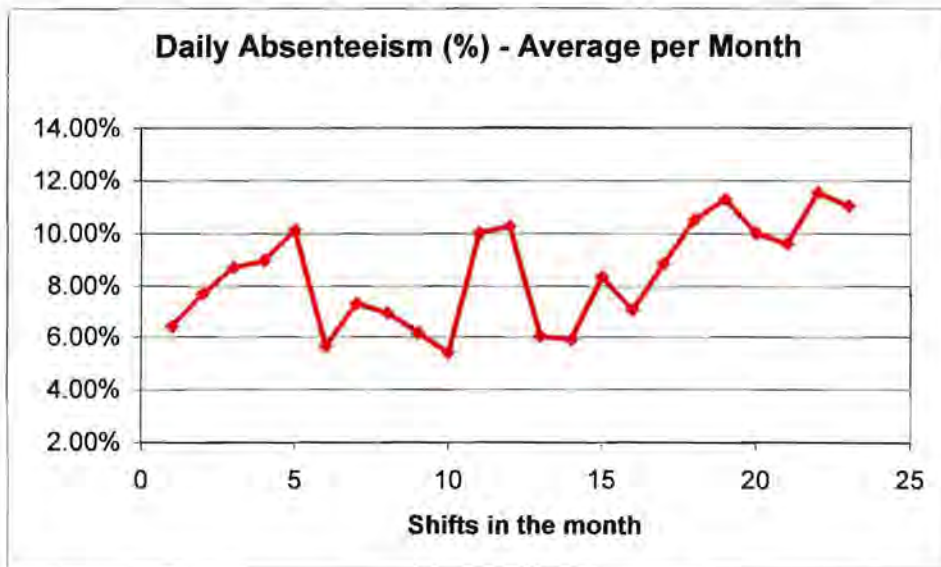


Fig 2.5: Daily absenteeism

The bottom axis represents the consecutive shift average of that day of the month.

Figure 2.5 shows the number of employees that are not at work on a daily basis. This syndrome has a very negative effect on achieving the daily production targets. This absenteeism pattern is constant throughout the year, with absenteeism peaking before long weekends and paydays.

Absenteeism in mines affects the running of the mine and seriously compromises the quality and quantity of the product to be delivered.

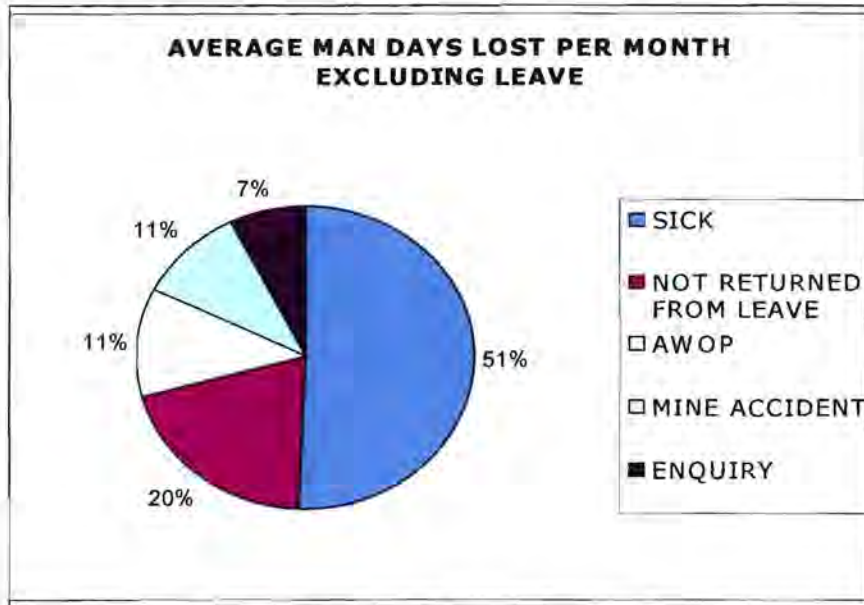


Figure 2.6: Absenteeism of employees

The reasons for daily absenteeism are broken down in Figure 2.6, and it can be observed that 51% of the absenteeism is as a result of sick leave.

Clearly there are many legitimate reasons for taking sick or other types of leave. It is often debatable how much sick leave is "reasonable". It often depends on the pattern and circumstances rather than the actual total amount of sick leave that an individual takes.

Managers have a responsibility to balance the rights and needs of employees with the needs of the mine. High levels of absenteeism, either on the part of individuals or in the whole mine, are often symptomatic of underlying problems. Addressing these issues can result in lower absenteeism levels that benefit staff, managers and clients.

Absenteeism and sick leave can seriously affect a company's productivity. Employees are allowed to 10 days sick leave a year. As a result of this rule, the employees believe they are entitled to this even when they are not sick. They will take all sick leave allowed during a calendar year for fear of losing the days.

This practice is also due to low morale and a poor relationship with management.

- The absenteeism process has many loopholes where absence is not recorded.
- No flexibility to cope with ad hoc absenteeism.
- Disciplinary procedures are the cause of many shifts being missed.

The mining activities require hard physical work due to confined space, the change in barometric pressure and the heat. Employees are selected on their physical abilities and heat tolerance. The effect of HIV/Aids is believed to have a negative effect on the physical abilities of the employees and they tend to be more absent from work than a few years ago^{39,40,41}. Up to now the effect was not closely monitored but will be monitored in the future.

2.8 Summary of Current Shortcomings

- When the target for the new year is determined the previous years actual achievements are not taken into consideration.
- Alternating production planning.
- A different labour plan each month.
- No leave planning.

2.9 The Way Forward

The path of building the new system:

- To design a new LP system that will adequately address the problems of the current practices.
- To test this against a current operating mine and
- To draw conclusions and make recommendations.

An improved labour planning model will ensure success the following criteria:

- Constant production planning
- Proper leave planning
- Management and reduction in absenteeism
- Reduce the GAP.

The experience of expert personnel will be drawn to get to ideal plans, which are easy to understand and to implement. This improved labour planning model will be built on fixed planning parameters and stoping panels to be mined.

CHAPTER 3: DEVELOPMENT OF THE IMPROVED LABOUR PLANNING MODEL

3.1 Background

It was shown in paragraph 2.3 that the blasting efficiency for stoping is 74% and 86% for development. These results have now been brought into consideration in the labour planning.

By setting the targets at $100/74=135\%$ rather than 100%, it can be predicted with relative certainty that 100% of the stoping target can be reached. Similarly, the development target in the new plan at 116% of the production should be achieved.

In addition, the ratio of production to non-production employees of 40:60, as discussed in paragraph 2.3, has been changed to 50:50. This means that to achieve the additional production, the total number of employees will increase slightly. Some of the non-production employees will be trained and transferred to production.

It was found that the relative reduction of non-production employees did not detrimentally influence the services department.

The GAP in the old system was 26% ($100-74$) for stoping. By increasing the target to 135% in order to achieve the actual target of 100%, it appears that the GAP has increased to 35%. This, however, was done in order to achieve the required production targets.

The GAP of 35% can now be addressed by management and reduced through better utilisation in accordance with the new labour system.

3.2 Description

The fundamental difference between the old and the new approach is that, instead of dividing the annual production target by 12 to obtain the monthly production targets (from which the daily targets are then derived), the annual target is divided by the total number of shifts in the year to obtain these daily targets.

This will give a constant production target per shift and a constant labour force. The most common planning system used for modelling underground tabular mining practice in South Africa is Cads mine. This system is used on all the Anglo Platinum underground mines. This

system was used as the most important benchmark for the LP model. A testing procedure where common parameters were agreed upon was drawn up.

The parameters were based on the new input requirements of the LP model and contained inter alia the following:

- Half-level planning³⁰
- Monthly advance rates of the various excavations⁵
- Relevant dependencies – scheduling of the different development ends relative to each other⁵.
- The findings were compared in terms based on quality, quantity and timing. In all cases the correlation was within 10%.

The improved labour planning system will give the following:

- A fixed daily production plan for the year.
- The type of development end is specified and a daily target for each end is calculated to ensure replacements are raised on time.
- Calculate the panels to be blasted on a daily basis. To achieve these targets, the lost blasts and poor advance per blast are taken into consideration. These two factors are combined and are called blast efficiency.
- The labour planning will be done on constant daily production.
- This labour provision will eliminate the daily over-/undersupply of labour.

Stope panels to be blasted and development ends to be blasted will be calculated. A team of employees will be allocated to each panel and each type of development end. This method will ensure a constant labour plan and this will assist in labour control and leave management.

Presentations on the LP model methodology and certain findings generated by the LP model were presented to senior mine managers at central forums held on a monthly basis. Although the current mine managers in Anglo Platinum have gold mine experience as well, the labour planning concept, as illustrated to them, proved to be different to their historical or current planning systems.

3.3 Half-level Planning

Figure 3.1 describes the half-level suite of a typical breast-mining layout. Note that each level is divided into two half levels by the "shaft" (east and west). Each half level contains all the mining activities mentioned before (development, ledging, equipping, stoping, vamping and reclamation) and is independent from any other half level. It is thus the smallest self-sufficient unit encompassing all mining activities.

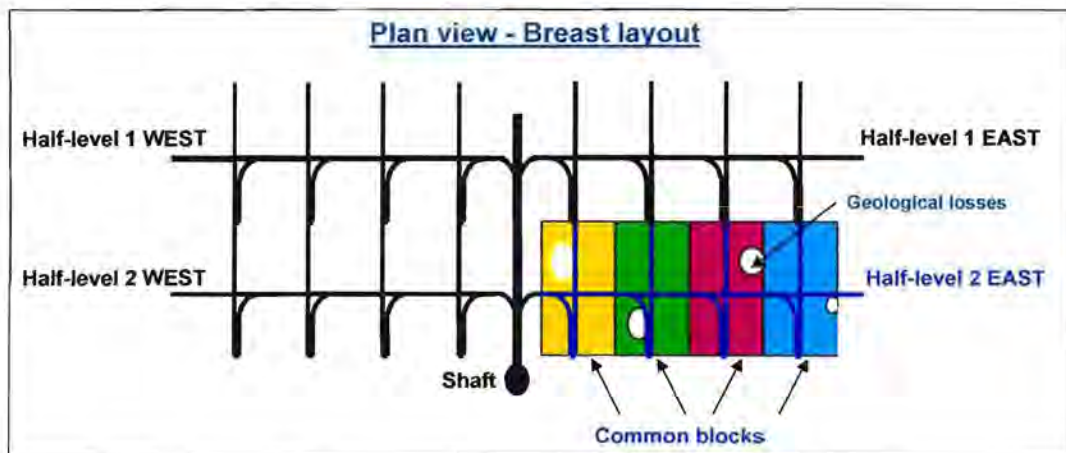


Figure 3.1: Plan view of the half-level suite

Contrary to previous practices, the LP system uses the Half-level Planning Model³⁰ Technical Sheet (Appendix B) as an input. The LP system will be used to standardise the planning system on a mine, a fixed list of mining parameters that have been derived from on-mine studies are used for inputs (Appendix F).

These standards fix the outputs per half-level per shift after which the development requirements can be calculated by using a replacement factor as supplied in the specific mine standard. This is a very rigid approach but will be supported if the variance between underground mining methods proves to be limited, which apparently is in the case at Anglo Platinum.

The LP system is built-up by using production targets and production parameters. In the old planning system there were only parameters for development and stoping operations, but nothing for mining services.

This LP system gives constant production targets on a daily basis, which includes blasting efficiencies, for the calendar year. The development ends and required meters, that have to be blasted on a daily basis, are calculated to ensure that enough stope panels are available for

stopping. The panels that have to be blasted on a daily basis are also calculated. This gives management a simple method of managing the daily production by comparing the daily panels to be blasted and the actual panels that have been blasted. Corrective can be taken immediately.

3.4 Production Planning

The new stopping target is divided into the stope panel lengths to obtain the number of stope panels and development ends that have to be blasted.

Production planning optimisation revolves around sustaining the optimum blasting frequency for the life of the mine. This implies getting the most possible blasts at the best possible advance per blast from the appropriate ends (blast attack fronts). In addressing these improvements, the following questions exist:

- Is the equipment adequate and can the services support all the mining activities in the production area?
- Is the capital replacement rate synchronised with the ore extraction rate?
- Is there a simple planning system in place that can assist the operations to supply answers to all of the above questions?
- Is the required labour force at work?

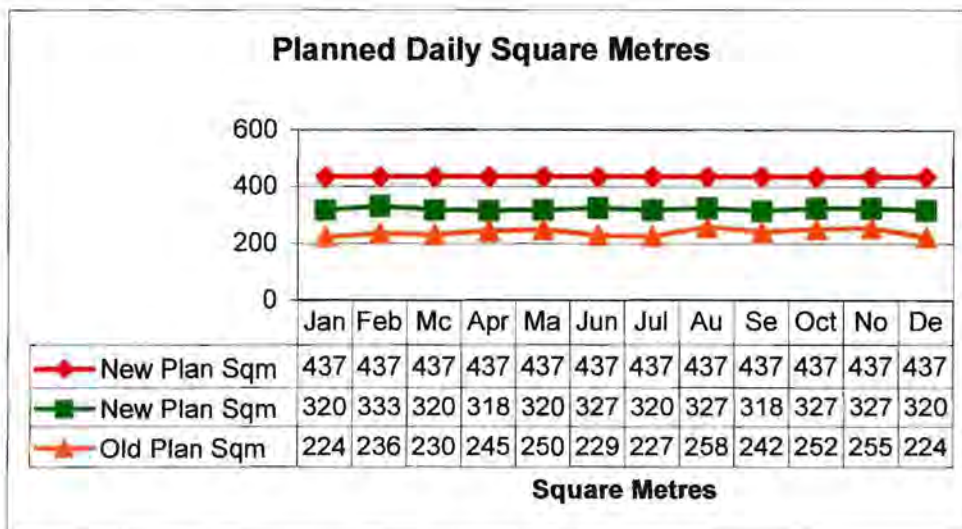


Figure 3.2: Old/new daily square metre planning

Figure 3.2 shows that in the old plan, a figure of 323 m² per day was intended; however, in the view of the 74% achieved stopping targets, the actual figure achieved was 239 m² per day.

According to the new plan, in order to achieve 323 m² per day, a new target of 436 m² per day must be set. This will mean that even if the efficiency is not reduced, the desired production target of 323 m² per day will be met.

3.5 Labour Planning

The improved LP system determines the exact number of employees that are required on a daily basis on a full production shaft. By using this system, the labour figure for the entire mine is obtained on a daily basis.

When employees return from leave, they have to spend about 4 to 12 days in the training centre. The LP system includes this requirement to ensure that there is no labour shortage on the working faces. The additional planned employees will be the equivalent of employees going on leave on a weekly basis.

Because the LP system is now based on a constant production target for the year, labour requirements do not vary from month to month as in the past. When production targets change during the year, the Human Resource Department is informed three months in advance so that the necessary arrangements can be made.

A constant labour requirement for the calendar year will eliminate the confusion between production personnel and human resources. This will give all role players the ability to concentrate on the core business and not to waste their time and effort on soft issues.

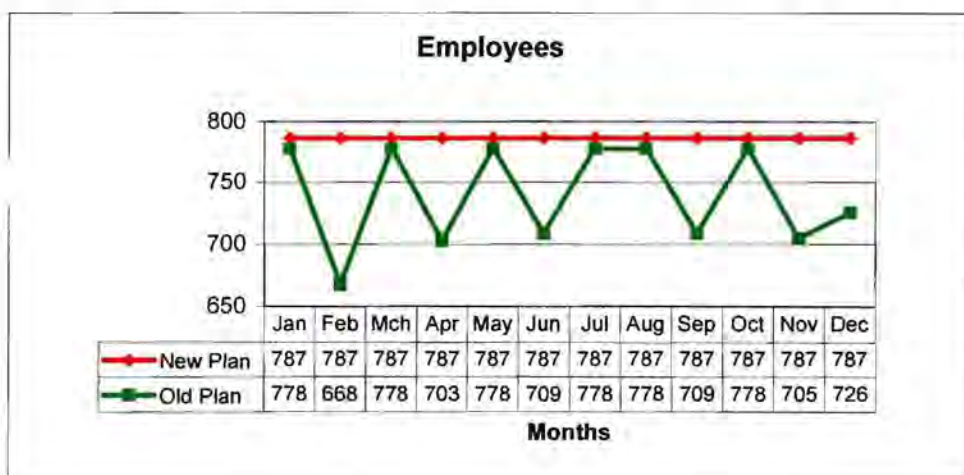


Figure 3.3: Old/new employee plan

Figure 3.3 shows the constant labour plan for the year from the new plan and that, on average, 17 more employees are necessary to achieve the increased production rate.

3.6 Duties of Personnel

The duties of all personnel are described in Table 3.2, key issues are defined and responsibility is allocated.

Table 3.2: Duties of Personnel

Key Issues	Description	Responsibility
Better informed business decision-making process	The what-if scenario can be used to test the best options.	Production Manager Surveyor Planning Officer
Improved productivity by increased blasting frequency	Ensure a full complement of workers on a daily basis.	Production Manager HR Manager
A constant labour requirement for the calendar year, which will eliminate confusion between production personnel and HR	Keep the production planning constant throughout the financial year and keep the labour requirements according to the guidelines.	Production Manager Surveyor BA Planning Officer
Improve the utilisation of resources	The correct number and mix of categories of employees will be at the working places on a daily basis.	Production Manager HR Manager
Calculate the primary development ends to be blasted	Use the replacement factor to calculate the primary development meters to ensure the constant replacement of the ore reserves.	Production Manager Surveyor Planning Officer
Monthly production plans to be constant on a daily basis for the entire calendar year	Keep the daily production targets constant for the entire calendar year.	Production Manager Surveyor Planning Officer
Logistics planning to be integrated with the business plan for the shaft	Use the production parameters based on tons, panels and end to calculate the logistics requirements.	Production Manager Surveyor Logistics Manager Planning Officer

3.7 Summary

The LP system is user-friendly and focuses management's attention towards optimising Anglo Platinum from the smallest independent production unit, namely the half level. Attention is directed towards individual development ends, instead of on the total mine planned development rate, thus eliminating more difficult development ends from being neglected.

The focus is also directed towards revenue awareness. Layouts can be optimised on a technical as well as financial basis without expert assistance.

It was already shown in Figure 1.3 that 47% of the lost blasts are due to labour shortages. These shortages can be the result of incorrect labour planning, absenteeism, sickness or simply a short supply of labour.

By applying the new LP planning system, the GAP between the planned production and the actual production achieved will be reduced.

CHAPTER 4: DETAILED LP SYSTEM IMPLEMENTATION

4.1 Introduction

The improved LP system was tested during January 2003 and April 2004 on a shaft in the Rustenburg Mines. The test system is set out below.

The improved LP system uses production parameters, which were established during the study, to formalise the labour planning for underground mines. These production parameters may differ from mine to mine and the plan can be changed to cater for the differences.

The system was demonstrated to the entire mine management team of Anglo Platinum and a decision to use it for the next 5-year planning session was made within three months after the demonstration.

The model has the flexibility to build mine-specific requirements into it and is constantly developed further with mine involvement. It also has the potential for further development into an operating cost/profitability planning model that will make it a total business profitability-planning tool.

This chapter describes a typical application of the model and methodology in detail.

4.2 Production Requirements

To build the improved labour model, a set of rules must be followed to calculate the labour requirements, starting with the technical sheet and ending with the labour required.

A technical sheet (Appendix B) is drafted to establish production requirements for a specific mining layout. The half-level planning exercise and the factors as per Table 4.1 are used for the labour planning.

The following parameters per half level were established during the investigation and are now used as standard in the LP model:

Table 4.1: Factors for labour planning per half level

Development monthly m	71
Development m/shift	3
Monthly m²	2 500
m²/shift	109
Monthly revenue	R 5,108,343
Monthly tons to reef	14,655
Monthly tons to waste	608
Head grade – 4E	4.36 g/t 4e

Table 4.1 indicates the basic factors necessary for commencing the LP model.

After the technical sheet has been drafted, it is used to establish the following parameters, which are detailed below:

- Ore tons
- Working shifts
- Half levels
- Development
- Stopping
- Logistics
- Stopping general
- Shaft logistics
- Services
- Skilled labour

4.2.1 Ore Tons

The amount of broken tons per day is required as input into the Labour Planning Model.

Table 4.2: Daily tons

Calculations	
Total reef tons required per month	55,000
Reef tons per day	2,300
Waste tons per day	95

Total tons per day	2,395
Tons milled per day	1,970

Table 4.2 indicates that a total of 55,000 tons is required for this specific month. When this amount is divided by the amount of shifts for the month, the daily reef tons required is 2,300 tons. Because there are more milling shifts in a month and the milling operation is a continuous operation, the daily reef tons to be milled are less than the reef tons mined.

4.2.2 Working Shifts

The total number of blasting shifts for the calendar year is determined by adding all the monthly blasting shifts.

The total annual production target is divided into the total number of shifts in the year to obtain a daily factor for a calendar year.

Table 4.3: Blasting shifts for the year

Month	Shifts
January	25
February	23
March	24
April	23
May	24
June	23
July	25
August	25
September	24
October	25
November	23
December	23
Total	287

Table 4.3 indicates that there are 287 blasting shifts in this specific year. In some years these blasting shifts may differ by one or two days more or less.

4.2.3 Half Levels

The number of half levels to be worked is calculated by dividing the monthly tons planned of 55,000 tons by the tons per half level by the planned monthly ton. In this exercise *4 half levels* have to be worked to give 10,979 reef tons per day.

4.2.4 Development

The total development meters to be blasted are calculated in the Technical sheet (Appendix B). Table 4.4 indicates the development metres to be blasted on a daily basis for the year.

Table 4.4: Daily development metres per end type

Development – Daily	Meters
Haulage	2.84
Cross-cut	2.84
Box 1	0.64
Box 2	0.50
Box3	0.36
Funk hole	0.11
Step-over	0.11
T/way	0.28
Raise	2.84
Sub-development – all ends in block	0.94
Total	8.33

To open ore reserves efficiently, the development ends indicated in Table 4.5 have to be blasted.

Table 4.5: Daily development ends

Development	Ends
Haulage	2
Cross-cut	2
Box 1	1
Box 2	1
Box3	1
Funk hole	1
Step-over	1
T/way	1
Raise	2
Subdevelopment – all ends in block	1
Total daily ends	11

The development ends are drilled with different lengths of drill steel and this gives different advance rates. Table 4.5 shows that 11 development ends have to be blasted in order to achieve a perfect replacement for the stoping operations. This will reduce the shortage of panels, as indicated in Figure 1.3.

4.2.5 Stoping

The total number of square metres required for the year is used to calculate the daily square meter target; this is obtained by dividing the total number of square metres by the total number of shifts for the year.

Table 4.6: Stoping targets

	Jan-06	Feb-06	Year
m ² (calendar)	10,925	10,051	125,419
m ² per day	437	437	
Panels to be blasted – daily	19	19	

Table 4.6 shows the square metres for the year as 125,419 and daily square metres of 437, *which is constant for the entire year*. The monthly square metres are calculated by multiplying the daily square metres with the number of shifts in that specific month and 19 panels to be blasted on a daily basis to obtain the stoping target.

4.2.6 Logistics

There are no parameters for calculating service labour figures on the mine and this differs from shaft to shaft. Table 4.7 indicates the parameters that have been drawn up and can be used to calculate the service department's labour requirements.

The tramming parameters are determined after consultation with the supervisors and employees. The parameters are not rigid but can be used as a guideline when doing the planning for a specific shaft.

The average tramming distance in kilometer is the distance between the tipping point and the furthest draw point. The standard tons kilometer per locomotive is the locomotive's capability over a 24-hour period.

Table 4.7: Tramming parameters

Average tramming distances	1.72
Standard tons km per loco	180

Tramming crew per loco	2.2
------------------------	------------

The tramming crew consists of a driver and a guard per locomotive and a supervisor for each 5 locomotives on a level (see Table 4.7).

4.2.7 Stope General

The stope general employees are the additional workers that carry out the services for the stoping operations.

Table 4.8: Stopping general parameter

Stope-equipping crew per panel	0.25
Stope-equipping employee per crew	4
Winch-erecting crew per panel	0.25
Winch-erecting employee per crew	3
Reclamation crew per panel	0.1
Reclamation employee per crew	3
Transport levels on shaft	4
Transport crew per loco	3
Stope-transporting crew per panel	0.15
Stope-transporting employee per crew	2

All the activities and parameters are listed in Table 4.8 and these general parameters are used in the model when the labour requirements are calculated.

4.2.8 Shaft Logistics

The shaft logistics are the activities carried out in and around a mineshaft. The main activities are to raise and lower employees, material and broken rock. The shaft parameters were determined for a specific type of shaft and is a guideline in determining the labour required for those operations.

Table 4.9: Shaft parameters

Tons hoisted per haulage maintenance crew	115
Tons hoisted per hoisting crew	6 000
Tons hoisted per hoisting maintenance crew	10 000
Tons hoisted per belt crew	270
Tons hoisted per incline hoisting crew	10 000
Tons hoisted per belt maintenance crew	500

None of these parameters were previously available on the mines. The shaft parameters indicated in Table 4.9 were established through consultation with the mine personnel and calculations. The correct number of employees can now be planned in order to prevent under- or oversupply of shaft employees. (Oversupply leads to wastage and undersupply could lead to serious mine incidents.)

4.2.9 Services

Services are classified as the employees who are doing the maintenance, administration and managing of the labour force. The service departments are engineering, ventilation, survey and manpower (Table 4.10).

Table 4.10: Service parameters

	Percentage
Services	5 %
Engineering	5 %
Leave	12.5 %
Training	2 %

The factors in Table 4.10 are used in the LP model to ensure a constant labour supply to the operations.

4.2.10 Skilled Labour

The skilled labour is calculated by using parameters determined during the investigating phase of this study and are summarised in Appendix L. All these parameters have been quantified during the study and are now used in the LP system.

4.3 Labour

The labour is built up by adding the development labour, stoping labour, logistics, general, shafts, services and skilled labour.

4.3.1 Development Labour

The amount of development labour is calculated by multiplying the number of ends with the employees for that specific end. The total is obtained by adding up.

Table 4.11: Development labour required per end

	Jan-06	Feb-06
Haulage	71	65
Cross-cut	71	65
Box 1	16	15
Box 2	12	11
Box 3	9	8
Funk hole	3	3
Step-over	3	3
T/way	7	7
Raise	71	65
Sub development	16	15
Total meters	279	257
Total W/C development MDPs	61	61

The labour planning model summarises the development as indicated in Table 4.11. The constant labour requirement for the entire year can be noted. The mining personnel use these figures for monthly planning and the manpower personnel labour requirement remains constant for the entire year.

4.3.2 Stopping Labour

The following parameters are to be used when calculating the stopping labour required:

Table 4.12: Stopping labour parameters

	Jan-06	Feb-06	Year
m ² (calendar)	10,925	10,051	125,419
m ² per day	437	437	
Panels to be blasted	19	19	
Total stopping MDPs required	251	251	

4.3.3 Logistics Labour

The required number of employees for tramming is calculated by the labour planning model and indicated in Table 4.13.

Table 4.13: Tramming labour

Base data	Jan-06	Feb-06
Broken tons for tramming per month	59,877	55,087
Blasting shifts	25	23
Broken tons for tramming per day	2,395	2,395
Average tramming distance	1.7	1.7
Tons kilometer	4,120	4,120
Standard tons kilometer per locomotive	180	180
Number of locomotives required	23	23
Workers per crew	2.2	2.2
Tramming workers	50	50

4.3.4 Stoping General Labour

The labour requirements for general stoping are determined and listed in Table 4.14.

Table 4.14: General labour

Stope-equipping crew per panel	0.25	0.25
Crews required	5	5
Workers per crew	4.0	4.0
Stope-equipping workers required	19	19
Winch-erecting crew per panel	0.25	0.25
Crews required	5	5
Workers per crew	3.0	3.0
Winch-erecting workers required	14	14
Reclamation crew per panel	0.1	0.1
Crews required	2	2
Workers per crew	3.0	3.0
Reclamation workers required	6	6
Transport levels on shaft	4.0	4.0
Crews required	4	4
Workers per crew	3.0	3.0
Transport workers required	12	12
Stope transport crew per level	0.15	0.15
Crews required	3	3
Workers per crew	2.0	2.0
Stope transport workers required	6	6
Tons hoisted	2,395	2,395
Tons per worker	115	115
Haulage maintenance workers required	21	21
Total mining commons	129	129

4.3.5 Shaft Labour

The labour requirements are determined by using the parameters and production targets, and the requirements are listed in Table 4.15 on a daily basis. The monthly shaft labour is listed in Appendix G; the labour requirement is constant for the year.

Table 4.15: Shaft labour

Base Data	Jan-06	Feb-06
Tons Hoisted	1,299	1,299
Tons per Worker	300	300
Hoisting workers required	4	4
Tons Hoisted	1,299	1,299
Tons per Worker	500	500
Shaft Maintenance workers required	3	3
Tons Hoisted	1,299	1,299
Tons per Worker	300	300
Incline Shaft hoisting workers required	4	4
Tons Hoisted	1,299	1,299
Tons per Worker	270	270
Belt workers required	5	5
Tons Hoisted	1,299	1,299
Tons per Worker	500	500
Belt maintenance workers required	3	3
Cementation	10	10
Supervision	5	5
Sanitation	2	2
First-Aide	3	3
Dams&drains	6	6
Tribal Rep	3	3
Electr Loco Crew	4	4
Jumper Checker	4	4
Chair lift	7	7
Total Shaft Logistics	63	63

4.3.6 Services Labour

The number of service employees is calculated by multiplying the specified % with the total underground employees. The employees required are indicated in Table 4.16.

Table 4.16: Service labour

Services	26
Engineering	26
Leave	80
Training	13

4.3.7 Total Labour

The total labour required to operate a shaft is summarised in Table 4.17 and Appendix M. The constant labour requirement for the year is the ideal situation and creates no confusion between all the role players.

Table 4.17: Total labour

	Jan-06	Feb-06
UMO	89	89
MDP (stoping)	251	251
MDP (stoping commons)	129	129
MO general gang	5	5
Vamping gang	5	5
Stope construction	5	5
Total mining commons	143	143
MDP (WC development)	61	61
MDP (WC dev commons)	10	10
MDP (shafts)	63	63
ARM and HR	26	26
Eng working costs	26	26
Total underground employees	670	670
Training	13	13
Leave (underground)	80	80
MDP (surface) strength	20	20
MDP (surface) service	22	22
Total employees (on strength)	703	703
Total employees (on leave)	83	83
Total employees (in service)	786	786

It can be seen in Table 4.17 that the total number of employees of 786 "in service" is constant for the year on a daily basis.

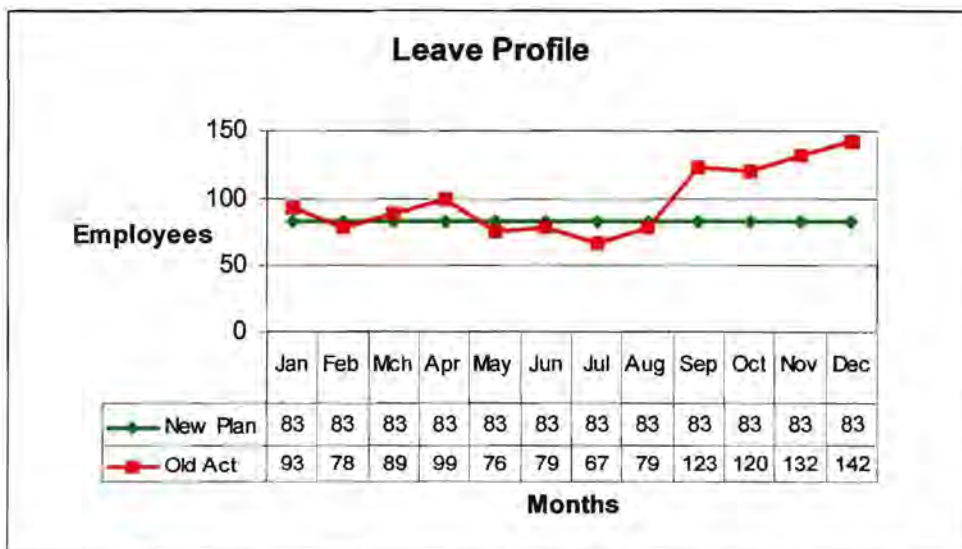
4.4 Leave Planning

Leave planning is now done on an annual basis. The team of employees in a work team will be consulted when leave planning is done. The supervisors know when each of the employees is due to go on leave. The allowance to carry the additional 12,5% of employees ("in service") gives a specific number of employees. In this exercise it is 83 employees per month as indicated in Table 4.16.

Employees are sent on leave on a weekly basis to ensure no overcrowding in the hospital during their exit interviews or take-on medical examinations, and at the training centre. The number of employees to go on leave is determined by dividing the additional employees by the number of weeks in a month. When this cycle is in operation, a natural flow of employees will occur and the same number of employees going on leave, in the training centre and coming back from leave will be equal. All the employees are scheduled for leave to proceed on leave on the same day and return on the same day.

This procedure will ensure a constant labour flow which will ensure a balance between the employees proceeding on leave and those returning from leave as indicated by the green line in Table 4.18.

Table 4.18: Ideal leave profile



The following results are obtained:

- No overlapping of leave
- Eliminate shortage/over compliments on strength
- Sufficient training time to cover all legal requirements
- Understandable system
- Improved employee morale
- Improved control (even flow)
- Improved training (sufficient training time)
- No waiting time before take-on (eliminate legal liability)
- Constant availability of labour at the workplace.

4.5 Financial Benefits

The cost of not completing the cycle for the day leads to a loss in revenue of R53,397 per panel¹⁰. The total on mine costs is R38,826, which is fixed costs on a mine¹⁰.

The revenue is calculated by making use of an equivalent value per 4e gram delivered to surface. To thus arrive at a value per shaft head 4e gram, the total revenue (after all concentrating and refining losses) has to be divided by the assayed shaft head grams. In the example a R100 per 4e gram was used for all revenue calculations.

Appendix A and J indicate the anticipated revenue, cost and profit for this study.

The following benefits were calculated in terms of improved revenue and reduced costs:

Table 4.19: Anticipated cost and revenue benefits

NEW	Revenue	R19 171 141
	Cost	R11 444 000
	Profit	R7 731 141
OLD	Revenue	R14 186 644
	Cost	R9 900 000
	Profit	R4 286 644
DIFFERENCE (Shaft)	Revenue	R4 984 497
	Cost	R1 544 000
	Profit	R3 444 497
BENEFIT (Mine)	Profit	R37 576 327
BENEFIT (Group)	Profit	R 151 151 677

Table 4.19 shows an improvement in revenue of R37.6 million for the Rustenburg Mine and R151 million for the group. This is an estimate and a detailed financial run will be done at the end of the 2004 financial run to calculate the real improvements.

4.6 Summary

The improved labour planning and leave planning will reduce the absenteeism on the mine, due to the improved morale, because the employees will know that the management team cares about them.

There will be enough employees for each one to do his/her daily tasks and no employees will have to stand in for their colleagues. More employees are planned by bringing the production efficiency into consideration.

This has an effect on the bottom line of the mine to the value of approximately R38 million.

CHAPTER 5: APPLICATION OF THE NEW SYSTEM – STRATEGIC

5.1 Mine Scenario Analysis

The LP model was successfully applied to analyse various mining scenarios within Anglo Platinum. The effect of layout changes on various outputs was correctly quantified and correlated with manual calculations and mine simulation programmes, like *Cads mine*. Stope width changes immediately impact on the grade and the revenue. Waste and reef quantities vary with any alteration to the mining layout, blast efficiency, etc., and logistical requirements can be assessed immediately. Some shafts changed their mining systems and production plans after investigating the outcome of the LP model's results.

5.2 Monthly Production Planning

In its current state, the LP model supports monthly or longer period planning. The annual targets are obtainable from the strategic plan. Dividing the annual plan by the number of shifts available gives the daily production planning. The daily targets are multiplied by the monthly blasting shifts for each calendar month. A detailed labour plan can be built from this information on an annual basis and this can continue for long periods.

Most mines produce at lower than optimum production levels. The LP model doesn't only indicate where problems are experienced, but it also gives management direction towards bottleneck identification and solutions. Sub-optimum stope face lengths or stoping widths are in place thus causing underutilisation of current labour and equipment.

5.3 Long-term Production Planning

The LP model has a built-in production planning facility that can be used on an annual basis. The user is given the option to build flexibility into this plan by defining the number of idle or spare panels per half level. This plan contains every possible output required and is divided into two sections, namely the annual progressive section and the average monthly production section.

The LP model was used to assist with the 5-year production plan for 2003 to 2007. Accurate shaft 5-year plans have been compiled in less than a week after starting the process whilst conventional systems took as long as three months. This was achieved due to less confusion,

because the guidelines indicated in this thesis were used. There were no different interpretations between the mining department, the planning department and management regarding the basis of the exercise. The exercise is done on a Microsoft Excel spread sheet and is simple to use.

5.4 Layout Optimisation

Once the preferred layout has been selected, additional enhancements can be modeled. In many cases common block widths are not optimised and the LP model allows the user to make effortless changes. It is important to ensure that the scheduling is still correct after any dimension changes. When block dimensions are increased, immediate output increases and development efficiencies can be observed.

Decreasing stoping widths and/or increasing panel lengths will show the effect on dilution and thus revenue per total ton broken. In most cases the capability of the people, equipment and the infrastructure must be known before attempting any optimisation exercise, for example the maximum pull distance of a winch or the minimum stope width people can work in.

5.5 Production Impact on Revenue

The LP model uses a fixed value per 4e gram and any changes to the reef production rate will be expressed in a rand-based revenue value. The cost per ton of production is inserted and profitability calculations can thus be performed (Appendix J).

5.6 Simplified Management Approach

The approach followed throughout this study may be used as a management approach. Dividing the mine into manageable independent units and then optimising these will lead to optimised shaft systems and ultimately an optimised Anglo Platinum.

5.7 Leave Planning

Employees now know when they will go on leave a year in advance and they will no longer be forced to go on leave a day before the leave starts. The family will know when the employee will go on leave and more social planning can be done. This will ensure a happy work force.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of Results

A summary of these results is:

- The LP model was successfully applied to analyse various mining scenarios within Anglo Platinum.
- Monthly planning is the smallest planning unit supported by the LP model.
- The LP model was successfully used to do long-term production planning and periods of up to seven years can be summarised.
- The LP model was successfully used to guide management towards optimising the current production levels.
- The half-level concept was applied to indicate the importance of ongoing capital replacement development as part of optimising the mine.
- A layout comparison was efficiently done and selections can now be made based on the area's specific requirements.
- The LP model has proved its capability to assist in optimising layouts by allowing the user to see the output effect after making relevant alterations.
- The LP model expresses any change by the user in a monthly revenue format thus sensitizing the stakeholders to the financial implications of their decisions.
- The LP model has a component that accurately calculates the needs around major ore handling equipment requirements directly aligned with the production levels.
- Managing a mine on the half-level concept with or without the LP model is broadly discussed.
- The LP model is selected by a group of senior managers within Anglo Platinum to form the basis for approving any new mining project.

6.2 Expected Impact of Results

The LP model indicated that Anglo Platinum can increase its current production per half level from around 2 000 to more than 3 000 m² per month. However, this does not necessarily imply that the output may be increased by 50%, but current operating half levels may rather be

reduced to allow better resource utilisation. Mines can now be divided into more manageable units to ultimately optimise overall efficiencies. Layouts may be assessed on a scientific and financial basis instead of personal preference basis. Development of both working cost and capital types will be managed on a just-in-time basis.

Capital allowances can be made according to the true infrastructure requirements and making use of the LP revenues as well as available working cost databases may optimise cash flow profiles.

6.3 Conclusion

The improved labour planning system meeting all the requirements of the set objectives has been designed, developed and tested. This labour planning system has been evaluated against existing software packages and acceptable correlation levels with more complex mine planning systems within 10%¹⁵.

The LP system has been accepted as a norm for mine planning and mining project evaluation by senior mine management throughout Anglo Platinum within less than a year since the initial introduction. It is user friendly and it focuses management's attention towards optimising Anglo Platinum. The focus is also directed towards revenue awareness (Appendix B) on a technical as well as a financial basis without expert assistance.

Capital as well as ore reserve optimisation forms an integral part of mine planning and the importance of replacement capital is highlighted. A total mine's long-term plan requires one person and it may be completed accurately in less than one week.

The standardisation of planning methods will ensure a constant daily labour plan. The leave management will ensure that labourers can negotiate for own leave, thus they will not be forced to go on leave.

6.4 Recommendations for Future Work

Based on the results of this thesis, the following improvements and developments can be identified and their development is recommended:

- The design of a labour-planning module linked to a *cost* model. This entails a complete zero-based exercise of all activities. The costing is done on previous years' expenditure and a percentage is added to compensate for the next year's inflation rise. If, however,

zero-based costing is used that is built up from basic principles, a better handle on the cost will be achieved.

- The development of a profitability model after the labour module is completed. This system is planned to manage profits and profitability from half level up to shaft level.
- The effect of HIV/Aids on the performance of the employees. The employees' body strength decreases and more employees are required to perform a specific task, which will result in labour costs.

Policies regarding sick leave due to HIV/Aids must be firmed up.

LIST OF REFERENCES

1. The Data Mine. (27 November 2002). Available from <http://www.the-data-mine.com/>.
2. Cads Mine. (27 November 2002). Available from <http://www.cadsmine.com>.
3. Lurie Jos. (1977). Chapters 6, 9 and 12 in *South African Geology*. McGraw-Hill Book Company.
4. Anglo American Platinum Limited. (2003). *BRPM North and South Shafts Second Phase Summary p4 to p5 – PCE*. 55 Marshall St, Marshalltown.
5. Rustenburg Platinum Mine. (2003). *2003 Business Plan*. RPM, PO Box 65, Klipfontein. Conversations with Mine Manager Rudi Rudolph and Economic Research Manager Luke Zindi. RPM, PO Box 65, Klipfontein.
6. Vermeulen. A. (2003). "*Lay-out selection*" *Mining Optimisation*. Internal memo. 55 Marshall St, Marshalltown, 2107.
7. Storrar, C.D. (1987). *South African Mining Evaluation*. Chamber of Mines. p 8 and p 9.
8. Anglo American Platinum Limited. *LE 12 2002*. 55 Marshall St, Marshalltown, 2107. p 8 and p 9.
9. Anglo American Platinum Limited. (2003). *Annual Report 2002*. 55 Marshall St, Marshalltown, 2107. p 67 and p 69.
10. Anglo American Platinum Corporation Limited. (2004). *Annual Report 2001*. Johannesburg: 55 Marshall St, Marshalltown, 2107. p 40.
11. Anglo American Platinum Corporation Limited. (2002). *Annual Report 2003*. Johannesburg: 55 Marshall St, Marshalltown, 2107;
12. Anglo American Platinum Corporation Limited. (2004). *Annual Report 2003*. Johannesburg: 55 Marshall St, Marshalltown, 2107. p 95 and p 99.
13. Vermeulen, A. (2003). *Anglo Platinum MINECO presentation. Anglo American Platinum Corporation Limited Budget Report 2002 to 2006*. Johannesburg; 55 Marshall St, Marshalltown, 2107. p 29 and p 33.
14. Becker, J.G.P. (October 2003). *Anglo Platinum Cads Mine Designer*. Personal Communication.
15. Turffontein Shaft Planning Team and Anglo Platinum Cads Mine Designer. (June 2002 and October 2002). Personal Communication.
16. US Bureau of Mines. (23 November 2002). *Office of Personnel Management, Performance management Overview*. Available from <http://imcg.wr.usgs.gov/usbmak/thisis.html>.
17. *Colorado School of Mines*. (23 November 2002). Available from <http://www.mines.edu/group/>.
18. *Mine Net*. (23 November 2002). Available from <http://www.minenet.com/>.
19. *What mining engineers do?* (24 June 2003). Available from http://www.mines.unsw.edu.au/whatis/whatis_whatdomedo.htm.
20. Mine 4810 – *Mine Plant Design and Valuation*. (24 June 2003). Available from <http://www.dal.ca/~zoudh/mine4810.htm>.
21. *Labour and labour welfare*. Available from <http://www.planningcommission.nic.in/plans/planrel/fiveyr/8th/vol2/8v2ch7.htm>.

22. SRK. (24 June 2003). *Underground Mine Evaluation, Design & Planning*. Available from <http://srk.co.uk?serv/mineeval/undergrnd.html>.
23. *Northams Operational Review*. (24 June 2003). Available from [http://www.northam.co.za/annual report/2001/review of ops.html](http://www.northam.co.za/annual%20report/2001/review%20of%20ops.html).
24. Prodrak, A. (2003). *Ore body Evaluation*.
25. Harmony. (24 June 2003). *Large rise in Gold production*. Available from <http://www.prodtrak.com/Orebody.htm>. and <http://www.btimes.co.za/00/0130/comp/comp07.htm>.
26. Collins Holton, M. (2003). *South Africa: Optimal planning systems for large underground mining corporations*. *Mine Planning*. Available from <http://apcom2003.co.za/pages/techprog5.html>. (Accessed 24 June 2003).
27. Arnessen, M. (2003). *South Africa: Knowledge in – Money out, redefining mine planning and scheduling standards to improve and stabilise business performance*. *Mine Planning*. <http://apcom2003.co.za/pages/techprog5.html>.
28. Vieira, F. (2003). *South Africa: Utility based framework for optimal mine layout selection, subject to multi-attribute*: *Mine Planning*. Available from <http://apcom2003.co.za/pages/techprog5.html>. (Accessed 24 June 2003).
29. Benecke, K.J. Dr. Ing. (June 1984). Replacement of trucks by conveyors. *World on criteria*.
30. Mitchell, J.J. and Dilbertson, W.A. (6 June 2003). *High angle conveyor offers mine haulage savings*. Available at <http://www.saimh.co.za/beltcon/beltcon3/paper37.html>.
31. Vermeulen, A. (2002). *Methods to Optimise Underground Mine Production*. M thesis. Potchefstroom: Potchefstroomse Universiteit vir Christelike Hoër Onderwys.
32. *American Economic Review*. 90(2): 410. (May 2000). Available from <http://search.eb.com/search/magazine?query=power+reasoning>.
33. Rustenburg Platinum Mine. (2003). *Training Manual*. RPM, PO Box 65, Klipfontein.
34. Bobbin, T. (August 1999). *Absenteeism – Causes and Cures*. Available from http://www.findarticles.com/cf_dls/m3638/12_40/59521650/print.jhtml.
35. Kwik Skwiz. (June 2003). *How to monitor and address absenteeism in district hospitals*. Available from <http://www.hst.org.za/isds/kwikskz/kwik25.htm>.
36. *USA Today* (Magazine). (26 June 2003). Putting the brakes on employee absenteeism. Available from http://www.findarticles.com/cf_dls/m1272/2659_128/61586737/print.jhtml.
37. *Keeping workers healthy curbs absenteeism*. (24 June 2003). Available from <http://btimes.co.za/99/0606/survey/survey18.htm>.
38. *Labour and labour welfare*. (24 June 2003). Available from <http://planningcommission.nic.in./plans/planrel/fiveyr/8th/vol2/8v2ch7.htm>.
39. *Absenteeism runs companies down*. Available from <http://btimes.co.za/99/0425/survey/survey14.htm>.
40. Bessemer, C. (12 November 2003). The Impact of HIV/Aids on Productivity in South Africa. *Financial Mail*. Available from <http://www.hiv aids.co.za/>. (Accessed 27 March 2003).
41. Anglo American Platinum Corporation Limited. (March 2003). *Discussion Document: HIV/Aids Impact Modelling*. Johannesburg: 55 Marshall St, Marshalltown, 2107.
42. Bissek, C. (June 2003). Leading the HIV struggle. *Mining Mirror*, 287: 32–35.
43. Troll, P. (2001). *Mining Optimisation Phase 2: Rediscovery – Blast Cycle and Functions*. Marshalltown: MAC Consulting, 55 Marshall St, 2107.

APPENDIX A:	FINANCIAL SUMMARY – OLD SYSTEM	50
APPENDIX B:	TECHNICAL SHEET	51
APPENDIX C:	MINING EQUIPMENT: LOCOMOTIVE	52
APPENDIX D:	MINING EQUIPMENT: WINCH	53
APPENDIX E:	LAYOUT.....	54
APPENDIX F:	PARAMETERS	55
APPENDIX G:	SHAFT LABOUR	57
APPENDIX H:	TRAMMING LABOUR.....	58
APPENDIX I:	GENERAL STOPPING LABOUR	59
APPENDIX J:	FINANCIAL CALCULATIONS – NEW SYSTEM	60
APPENDIX K:	DEVELOPMENT TARGETS	61
APPENDIX L:	SKILLED LABOUR	62
APPENDIX M:	TOTAL LABOUR.....	63
APPENDIX N:	DIP AND STRIKE OF A PLANE ⁴³.....	64

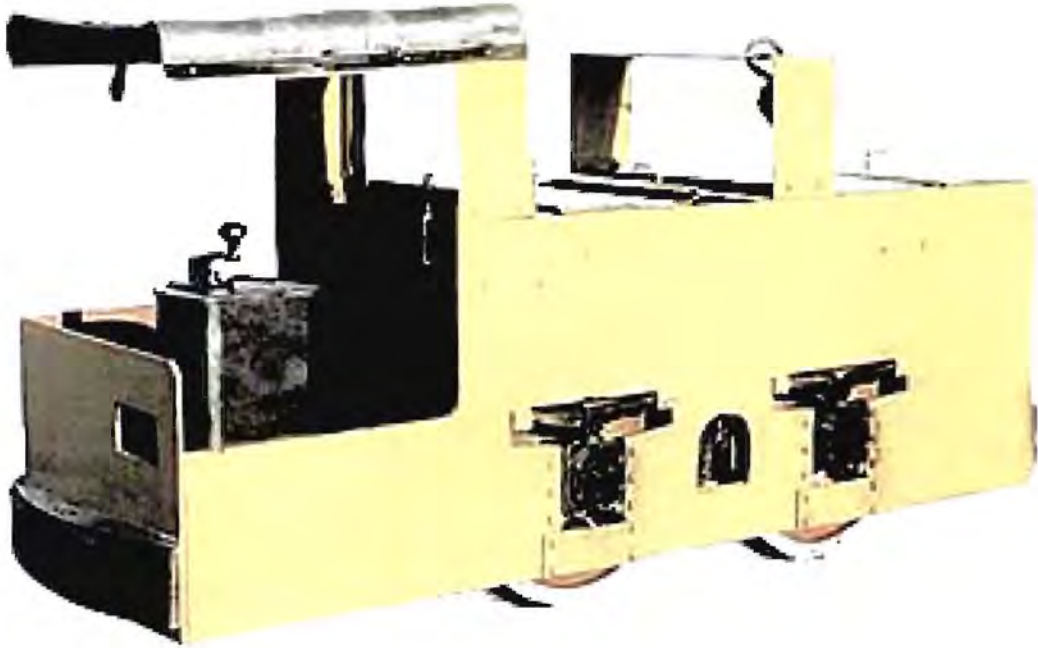
APPENDIX A: FINANCIAL SUMMARY – OLD SYSTEM

Reef tons per month	40,700	
Waste tons per month	2,282	
Total tons per month	42,982	
Reef tons per day	1,702	
Waste tons per day	71	
Tons milled per day	1,458	
Half levels to be worked	3	
Square meters per day	302	
Panels to be blasted per day	14	
Advance per blast	1.00	
Monthly face advance	15	
Pt ounces per month	2,435	
Winches 75 HP	113	
Winches 50 HP	58	
Locomotives 10 ton	48	
Locomotives 5 ton	24	
Square meter per total employee	14.87	
Square meter per stoping employee	14.62	
	Reef	Waste
Grade over required reef width in block (4e) g/t	4.8	0.5
Rand value per 4e gram (mill feed)	R95.00	
Max current tramming distance (one way)	2 500	2 500
Relative density of reef (mined width)	3.35	2.95
Channel width	1.29	
Stoping width	1.45	
Head grade (g/t) – 4e	4.36	
Revenue	R14,186,644	
Cost	R9,900,000	
Profit	R4,286,644	

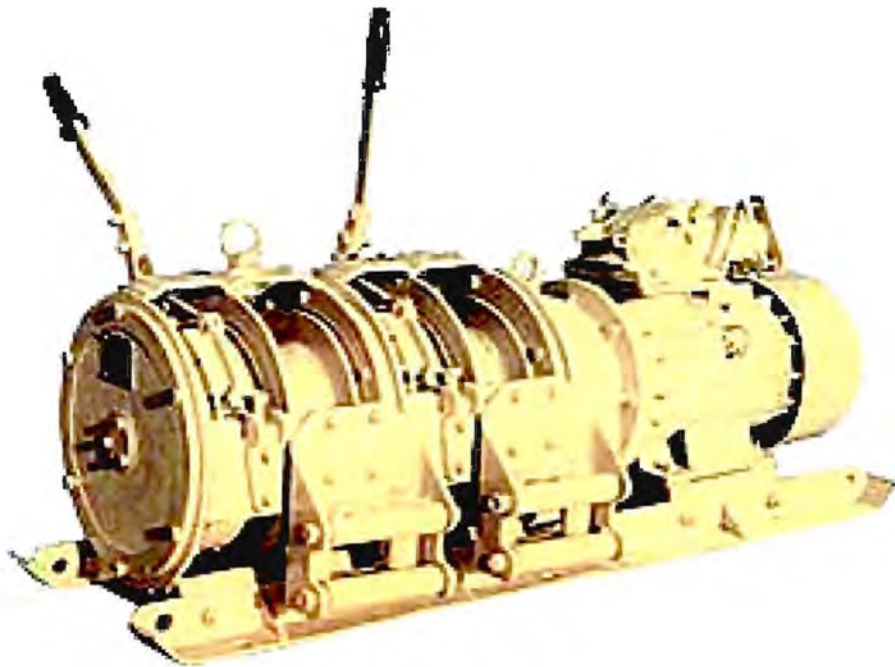
APPENDIX B: TECHNICAL SHEET

HALF LEVEL DESCRIPTION:		Shaft Name				71	0			
SHIFTS IN MONTH Blast frequency % Advance efficiency % Blast efficiency % Pt ounces	Development	23	23	monthly m						
	Stopping	79%	80%	m/SHIFT	3	0	Centare override			
		85%	80%	monthly m ²	2500	0	2500			
		67%	64%	m ² /SHIFT	109	0				
		877		Monthly revenue	R 5,108,343	R 0				
COMMON BLOCK DEFINITION				Monthly tons to REEF	14,655	-				
				Monthly tons to WASTE	608	-				
				Head grade	4.36 g/t 4e	0.00 g/t 4e				
Development end name	Length (m)	Width (m)	Height (m)	Max possible adv/blast	Max adv/month	Current adv/month	m ² /m	m/m ²	Minimum monthly Development	
Haulage	200	3.1	2.9	2	46	31	138	0.0073	18.1	
Cross-cut	200	3	2.9	2	46	31	138	0.0073	18.1	
Box 1	45	1.8	1.8	0.8	18	12	613	0.0016	4.1	
Box 2	35	1.8	1.8	0.8	18	12	788	0.0013	3.2	
Box3	25	1.8	1.8	0.8	18	12	1103	0.0009	2.3	
Funkhole	8	1.5	1.5	0.8	18	12	3448	0.0003	0.7	
STEP-OVER	8	1.8	2.2	1.8	41	28	3448	0.0003	0.7	
TAWAY	20	1.8	2.4	1.8	41	28	1379	0.0007	1.8	
Raise	200	1.8	2.4	2	46	31	138	0.0073	18.1	
Sub Development - all ends in block	45	1.5	2.4	1.5	35	23	613	0.0016	4.1	
						0				
Block dimensions	Width (m)	BACK Length (m)	Height (m)	Area (m ²) pre-losses	Area (m ²) available	Geological losses(%)	Other losses(%)	Total losses(%)	Remove on-reef development from area pre-losses	
	200	200	1.3	39573	27582	18%	15%	30%	12.3	
Average stoping panel	Length (m)	Width (m)	Height (m)	Max possible adv/blast	Max adv/month	Current adv/month	m ² /panel per month	Working panels	Equipped panels (minimum requirement)	
	33	(N/A)	1.45	1	23	15	485.8	5.1	6.80	

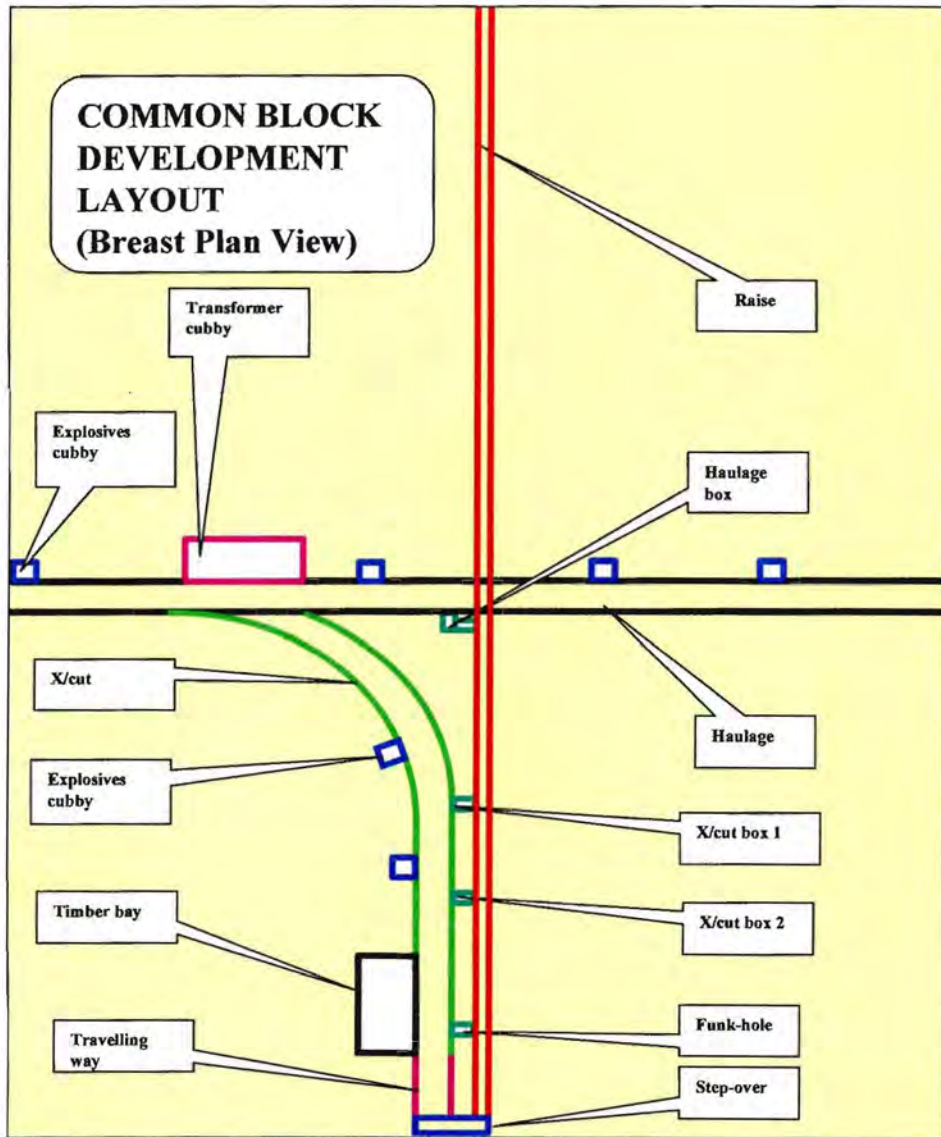
APPENDIX C: MINING EQUIPMENT: LOCOMOTIVE



APPENDIX D: MINING EQUIPMENT: WINCH



APPENDIX E: LAYOUT



APPENDIX F: PARAMETERS

Mining	Factor
Crew per panel	13
Vamping crew per panel	0.25
Vamping employee per crew	1
Stope construction team per panel	0.25
Stope change-over crew	0.12
M/O general	0.25
Development construction crew	1
Logistics	Factors
Average tramping distances	1.72
Standard tons km per loco	180
Tramming crew per loco	2.2
Stope equipping crew per panel	0.25
Stope equipping employee per crew	4
Winch-erecting crew per panel	0.25
Winch-erecting employee per crew	3
Reclamation crew per panel	0.1
Reclamation employee per crew	3
Transport levels on shaft	4
Transport crew per loco	3
Stope transporting crew per panel	0.15
Stope transporting employee per crew	2
Tons hoisted per haulage maintenance crew	115
Tons hoisted per hoisting crew	6000
Tons hoisted per hoisting maintenance crew	10000
Tons hoisted per belt crew	270
Tons hoisted per incline hoisting crew	10000
Tons hoisted per belt maintenance crew	500
Surface employees	3%
Services, and services and engineering	5%
Training	2%
Leave	12%
Development – Labour	
Development – end	Employees per end
Haulage	6
Cross-cut	6
Travelling way	4
Turning bay	6
Loop bay	6

Raise	4
Box 1	3
Box 2	3
Step-over	4
Subdevelopment	4
Shaft Logistics – Labour	
Cementation	10
Supervision	5
Sanitation	2
First-aid	3
Dams and drains	6
Tribal representatives	3
Electric loco crew	4
Jumper checker	4
Chair lift	7

APPENDIX G: SHAFT LABOUR

Base Data	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06
Tons Hoisted	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395
Tons per Worker	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Hoisting workers required	0	0	0	0	0	0	0	0	0	0	0	0
Tons Hoisted	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395
Tons per Worker	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Shaft Maintenance workers required	0	0	0	0	0	0	0	0	0	0	0	0
Tons Hoisted	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395
Tons per Worker	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Incline Shaft hoisting workers required	0	0	0	0	0	0	0	0	0	0	0	0
Tons Hoisted	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395
Tons per Worker	270	270	270	270	270	270	270	270	270	270	270	270
Belt workers required	9	9	9	9	9	9	9	9	9	9	9	9
Tons Hoisted	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395
Tons per Worker	500	500	500	500	500	500	500	500	500	500	500	500
Belt maintenance workers required	5	5	5	5	5	5	5	5	5	5	5	5
Cementation	10	10	10	10	10	10	10	10	10	10	10	10
Supervision	10	10	10	10	10	10	10	10	10	10	10	10
Sanitation	5	5	5	5	5	5	5	5	5	5	5	5
First-Aide	3	3	3	3	3	3	3	3	3	3	3	3
Dams&drains	8	8	8	8	8	8	8	8	8	8	8	8
Tribal Rep	7	7	7	7	7	7	7	7	7	7	7	7
Electr Loco Crew	-	-	-	-	-	-	-	-	-	-	-	-
Jumper Checker	5	5	5	5	5	5	5	5	5	5	5	5
Chair lift	-	-	-	-	-	-	-	-	-	-	-	-
Total Shaft Logistics	62	62	62	62	62	62	62	62	62	62	62	62

APPENDIX H: TRAMMING LABOUR

Base Data	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06
Broken Tons for tramping per Month	59,877	55,087	57,482	55,087	57,482	55,087	59,877	59,877	57,482	59,877	55,087	55,087
Blasting Shifts	25	23	24	23	24	23	25	25	24	25	23	23
Broken Tons for tramping per Day	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395
Average Tramping Distance	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Tons Kilometer	4,120	4,120	4,120	4,120	4,120	4,120	4,120	4,120	4,120	4,120	4,120	4,120
Standard Tons Kilometer per locomotive	180	180	180	180	180	180	180	180	180	180	180	180
Numbers of Locomotives Required	23	23	23	23	23	23	23	23	23	23	23	23
Workers Per Crew	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Tramming Workers	50	50	50	50	50	50	50	50	50	50	50	50

APPENDIX I: GENERAL STOPING LABOUR

Slope Equipping crew per panel	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Crews required	5	5	5	5	5	5	5	5	5	5	5	5
Workers Per Crew	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Slope Equipping workers required	19	19	19	19	19	19	19	19	19	19	19	19
Winch Erecting crew per panel	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Crews required	5	5	5	5	5	5	5	5	5	5	5	5
Workers Per Crew	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Winch Erecting workers required	14	14	14	14	14	14	14	14	14	14	14	14
Reclamation crew per panel	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Crews required	2	2	2	2	2	2	2	2	2	2	2	2
Workers Per Crew	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Reclamation workers required	6	6	6	6	6	6	6	6	6	6	6	6
Transport levels on Shaft	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Crews required	4	4	4	4	4	4	4	4	4	4	4	4
Workers Per Crew	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Transport workers required	12	12	12	12	12	12	12	12	12	12	12	12
Slope Transportcrew per level	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Crews required	3	3	3	3	3	3	3	3	3	3	3	3
Workers Per Crew	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Slope Transport workers required	6	6	6	6	6	6	6	6	6	6	6	6
Tons Hoisted	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395	2,395
Tons per Worker	115	115	115	115	115	115	115	115	115	115	115	115
Haulage Maintenance workers required	21	21	21	21	21	21	21	21	21	21	21	21
Total Mining commons	129	129	129	129	129	129	129	129	129	129	129	129

APPENDIX J: FINANCIAL CALCULATIONS – NEW SYSTEM

Summary

Reef tons per month	55,000	
Waste tons per month	2,282	
Total tons per month	57,282	
Reef Tons per day	2,300	
Waste Tons per day	95	
Tons Milled per day	1,970	
Half levels to be worked	4	
Square meters per day	408	
Panels to be blasted per day	19	
Advance per blast	1.00	
Monthly face advance	15	
Pt ounces per month	3,290	
Winches 75 HP	113	
Winches 50 HP	79	
Locomotives 10 ton	48	
Locomotives 5 ton	24	
Square meter per total employee	13.88	
Square meter per stoping employee	38.86	
	REEF	WASTE
Grade over required reef width in block (4e)g/t	4.8	0.5
Rand value per 4e gram (mill feed)	R95.00	
Max current tramming distance (one way)	2500	2500
Relative density of reef (mined width)	3.35	2.95
Channel width	1.29	
Stoping width	1.45	
Head grade (g/t) - 4E	4.36	
Revenue	R19,171,141	
Cost	R11,440,000	
Profit	R7,731,141	

APPENDIX K: DEVELOPMENT TARGETS

	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Year
Haulage	71	65	68	65	68	65	71	71	68	71	65	65	816
Cross-out	71	65	68	65	68	65	71	71	68	71	65	65	816
Box 1	16	15	15	15	15	15	16	16	15	16	15	15	184
Box 2	12	11	12	11	12	11	12	12	12	12	11	11	143
Box 3	9	8	9	8	9	8	9	9	9	9	8	8	102
Furkhole	3	3	3	3	3	3	3	3	3	3	3	3	33
STEP-OVER	3	3	3	3	3	3	3	3	3	3	3	3	33
TWAY	7	7	7	7	7	7	7	7	7	7	7	7	82
Raise	71	65	68	65	68	65	71	71	68	71	65	65	816
Sub-Development	16	15	15	15	15	15	16	16	15	16	15	15	184
Total metres	279	257	268	257	268	257	279	279	268	279	257	257	3208

APPENDIX L: SKILLED LABOUR

BAM	1	Half Level	
Operations Manager	2	Mine Overseer	0.5
Logistics Manager	1	Shift Supervisors	1.5
HR Manager	1	Stoppers	2
HR	3	Developers	1
ARM	1	Cleaner - Stopping	1
Finance Manager	0	Cleaner - Development	0.5
Finance	2	Fitters	0.5
Pay-Roll	3	Electrician	0.5
T\$A	2	Boilermaker	0.25
Senior Ventilation Officer	1		
Ventilation Officer	4		
Chief Surveyor	1		
Surveyor	5		
Samplers	3		
Rock Engineering	2		
Geologist	1		
Engineer	2		
Engineering Overseer	1		
Fitter Foreman	2		
Electrical Foreman	2		
Shaft Foreman	1		
Shaft Chargehand	1		
Shaft Fitter	2		
Shaft Electrician	2		
Shaft Boilermaker	2		
Banksman	3		
Ontsetter	6		
Shaft Timberman	3		
Hostel	0		
Mine Overseer	2		
Shift Supervisors	6		
Stoppers	8		
Developers	4		
Cleaner - Stopping	4		
Cleaner - Development	2		
Section Fitters	2		
Section Electrician	2		
Section Boilermaker	1		
Total	89		

APPENDIX M: TOTAL LABOUR

	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06
UMO	89	89	89	89	89	89	89	89	89	89	89	89
MDP (Stoping)	251	251	251	251	251	251	251	251	251	251	251	251
MDP (Stoping Commons)	129	129	129	129	129	129	129	129	129	129	129	129
MO General Gang	5	5	5	5	5	5	5	5	5	5	5	5
Vamping Gang	5	5	5	5	5	5	5	5	5	5	5	5
Stope Construction	5	5	5	5	5	5	5	5	5	5	5	5
Total Mining commons	143	143	143	143	143	143	143	143	143	143	143	143
MDP (WC Development)	61	61	61	61	61	61	61	61	61	61	61	61
MDP (WC Dev Commons)	10	10	10	10	10	10	10	10	10	10	10	10
MDP (Shafts)	63	63	63	63	63	63	63	63	63	63	63	63
ARM and HR	26	26	26	26	26	26	26	26	26	26	26	26
ENG Working Costs	26	26	26	26	26	26	26	26	26	26	26	26
Total Underground Employees	670	670	670	670	670	670	670	670	670	670	670	670
Training	13	13	13	13	13	13	13	13	13	13	13	13
Leave (Under ground)	80	80	80	80	80	80	80	80	80	80	80	80
MDP (Surface) Strength	20	20	20	20	20	20	20	20	20	20	20	20
MDP (Surface) Service	22	22	22	22	22	22	22	22	22	22	22	22
Total Employees (On Strength)	703	703	703	703	703	703	703	703	703	703	703	703
Total Employees (On Leave)	83	83	83	83	83	83	83	83	83	83	83	83
Total Employees (In Service)	786	786	786	786	786	786	786	786	786	786	786	786

APPENDIX N: DIP AND STRIKE OF A PLANE 43