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Abstract: This research report compares the mine closure costs in the DME's financial provision guideline with the real costs of mine rehabilitation projects. The data analysed for this research report indicates that the real industry rates, as evidenced by the tendered costs for actual mine rehabilitation projects, exceed the guideline rates published by the DME in most cases. These findings support the conclusions of other researchers that mines which have been using the DME guideline rates in the period from 2005 - 2016 have probably under-priced their closure liabilities in relation to actual market costs.

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Declaration

I declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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Seventeenth (17th) of July 2018 at Johannesburg

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Signature **Date**

ABSTRACT

In 2004, the Department of Minerals and Energy (DME, predecessor to the current Department of Mineral Resources - DMR) published a guideline to calculate the amount that a mining right holder would require for financial provision at mine closure. This research report reviews the guideline, specifically focussing on the "rules-based approach" for determining the quantum of financial provision. Some authors have recorded the misapplication of this guideline in practice and their research supports a conclusion that the guideline does not provide adequately for the real costs of mine closure.

This research report makes a comparison between the DME guideline master rates for mine closure costs and actual tendered prices for those same elements of mine closure in the period from 2009 – 2016. The analysis of the actual tender prices for the various master- and component rates in comparison with the DME guideline rates delivered mixed results. While the actual tender values exceeded the guideline master rates in most cases, there were notable exceptions where the actual tender results lagged the master rates. The data obtained from the actual tender prices for mine rehabilitation projects by a third party suggests that the use of CPI to escalate mine rehabilitation costs was very quickly overtaken in reality by higher annual costs and rate increases for most of the DME guideline master rates that relate to surface mining. It means that the DME guideline master rates were not reflective of actual rehabilitation costs by the time that the use of the DME guideline was superseded by the publication of new regulations by the Department of Environmental Affairs in November 2017. Whilst no perfectly linear and distinct relationship could be deduced, the results broadly support the findings of several authors that the actual costs to rehabilitate a mine are much more than the DME guideline document would lead a mine to provide for.

The application of a rules-based approach remains an exercise mired in controversy and with many potential inaccuracies. The new NEMA regulations for financial provision completely negate the need for a guideline and relevant State Departments and mining companies alike are consequently dependant on third parties to prepare closure cost estimates.

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LIST OF SYMBOLS, ACRONYMS AND ABBREVIATIONS

ARC Agricultural Research Council

BCI Building Cost Index

BOQ Bill of Quantities, a detailed list in the specification for construction work that provides an itemised estimation of all required cost elements to complete the work.

CIDB Construction Industry Development Board

CPG Community Participation Goals

CPI Consumer Price Index, a measure of the cost of a fixed basket of goods, specifically applied in statistical methods to measure the rate of change of the price of this basket of goods, i.e.: inflation.

DEA Department of Environmental Affairs. National government department of the Republic of South Africa.

DME Department of Minerals and Energy. National government department of the Republic of South Africa. Predecessor to the Department of Mineral Resources (DMR)

DMR Department of Mineral Resources. National government department of the Republic of South Africa.

DPW Department of Public Works. National government department of the Republic of South Africa.

EMP Environmental Management Programme

Ha/ha hectare (1ha = 10,000 m^2)

m^2/m^3 Square metre (surface area) & Cubic metre (volume) respectively

MPa MegaPascal, an SI unit of pressure. Usually measures compressive strength when applied to surface compaction in civil engineering works.

NEMA National Environmental Management Act, 1998. Act 107 of 1998. An act of the Republic of South Africa that serves as the overarching environmental management legislation in the country – framework for several other specialised environmental laws.

PPI Producer Price Index. The PPI records changes in the producer prices of locally produced commodities, including exports.

PPPFA Preferential Procurement Policy Framework Act. (Act 5 of 2000) An Act of the Republic of South Africa.

US$ United States Dollars

1 INTRODUCTION

Mining has historically been a cornerstone of the South African economy. An unfortunate legacy of more than a century of mining in South Africa is the existence of a significant number of abandoned mines. One of the mechanisms employed by the government of South Africa to curb future risks of mining is the legal requirement for a mining company to make financial provision to fund mine closure and so to internalise the risk of the environmental impacts of mining. It also provides and builds up a fund to pay for final closure of the mine and a form of insurance in case a company cannot close the mine itself. The need for financial provision or financial assurances to reduce the risk to governments and internalise the environmental risks of mining is an established international principle and most mining jurisdictions require this as a precondition to granting a mining right.

In 2004, the Department of Minerals and Energy (DME, predecessor to the current Department of Mineral Resources - DMR) published a guideline to calculate the amount that a mining right holder would require for financial provision at mine closure. This guideline was based on several international guidelines available at the time and introduced an approach of using predetermined rates per mine component to be rehabilitated at closure, called the 'rules-based approach' to determine the quantum of financial provision.

This research reviews the guideline published in 2004 by the DME[1], (Department of Minerals & Energy, 2004) specifically focussing on the "rules-based approach" for determining the quantum of financial provision. This guideline has often been misapplied in practice (Hewitson, 2012) and has been superseded in its application by the publication of new mine financial provision guidelines by the Department of Environmental Affairs in November 2017. (Department of Environmental Affairs, 2017) The approach is to use actual mine rehabilitation project data to review the guideline values and to draw inferences of the rate at which mines which did follow the guideline rate over the years from 2005 to 2017 were costing their closure liabilities. This comparison may have value in determining if the DME guideline and rules-based approach was a valid tool to arrive at a reasonable cost estimate for closure. The publication of actual mine rehabilitation cost data is considered valuable in itself as there is a

[1] The financial provision guideline that is the main subject of this report was published by the Department of Minerals and Energy (DME) That Department has since changed its name to the Department of Mineral Resources (DMR) following the split from the Department of Energy. The financial provision guideline will be referred to as the "DME guideline" throughout this report as it was published when the Department was still officially called the DME.

general dearth of this information in the public domain. Whether the research proves correlation with the guideline rates published compared to actual tender values or not, the outcomes may be useful for possible future publications to support the new financial provision regulations or perhaps an updated mine closure cost estimation guideline.

1.1 Research aim and objectives

This research report aims to determine if the values in the DME's financial provision guideline are an accurate and reasonable reflection of the real cost of mine rehabilitation. This will be achieved by a comparison of the real costs for mine rehabilitation projects as tendered for State rehabilitation projects. This analysis allows conclusions of the probable past and current costs for surface mine rehabilitation and the applicability of published DME guideline rates to actual mine rehabilitation costs. As an outcome of this analysis, the following key questions could potentially be resolved:

a. Did the guideline values published by the DME in 2004 provide useful guidance to calculate current mine rehabilitation costs in the period from 2005 – 2016 when compared to actual tender data?
b. In what significant areas did the guideline values deviate from/ concur with actual mine closure costs?
c. Are mines which diligently applied the DME guidelines in the period from 2005 to 2016 over- or underfunded?

The focus of this report lies in the comparison of the values of mine financial provision made or probably made by mines, assuming they used the formulae of the DME guideline until 2016, with actual mine closure costs. It is believed this comparison can give an indication of whether the financial provisions of those mines are likely to be under-funded or not. This might give mines and government agencies alike an insight into past funding practices compared to the real cost of rehabilitation. In comparing these values, new rules or guidelines can perhaps be drafted for future mine rehabilitation cost provision calculations.

1.2 Outline of this research report

This research report is structured over 6 chapters as follows:

- Chapter 1 is an introduction to the report, the background to the problem, the rationale therefor and the research aims and objectives.
- Chapter 2 is the literature review in which the issue of financial provision for mine closure is addressed from a global perspective and then narrowed to a South African focus. The problems that other authors have noted with financial provision are also highlighted.
- Chapter 3 describes the methodology followed to address the stated objectives presented in this research report.
- Chapter 4 presents the results of the findings of the research work and constitutes the main body of the work performed in this report.
- Chapter 5 provides a discussion of the findings, especially in the context of recently changed legislation around mine financial provision and the relevance of the findings in the context of this new regulatory regime.
- Chapter 6 is the conclusion of the report and summarises the findings and the context of the report. It also introduces some further potential research questions and unresolved matters.

2 LITERATURE REVIEW

The history and impacts of mining in South Africa and the negative effects of mine closure processes that traditionally externalise the environmental risks and result in significant financial burdens, are both well recorded. It is an accepted facet of the modern mining industry in all mining jurisdictions that companies who wish to mine or apply for a mining right must provide some form of surety, bond (Sassoon, 2009) or financial provision, as it is termed in South Africa. This serves to ensure that governments do not shoulder all the risks of a mining venture potentially failing and then consequently also failing to address the environmental legacy or impact of the mining that did take place. This chapter provides a look at the general need to provide funds for the environmental financial provision and then takes a closer look at how financial provision was addressed in South Africa in the past and also how it is done currently. The focus of this research report is not a general overview of the need and mechanisms for financial provision for mine closure; the focus is rather on the guidelines to determine the quantity of that provision.

2.1 Overview of the need to make financial provision for mining projects

Guidance on the philosophy and approach to financial provision for mine closure is relatively abundant. Park and Brorson (2004) reported from Swedish experiences with third party assurances for environmental performance that the existence of sound policy and the implementation of proper financial provision by a mine generally impacts positively on investor perceptions.

Laurence (2006) asserted that mines close for a variety of reasons and that mine closure plans must include legal and financial issues. He further found that the proper, planned closure of mines only occurs in a small percentage of cases and that, for a variety of reasons, the most mines close suddenly or prematurely.

According to data published for the World Mining Congress 2017, Reichl *et al* confirm that the world's 10 largest mining destinations, by US$ value of mining products (including fuel oils and bauxite) in 2016, were, in order of production value: China, USA, Russia (Asian), Saudi Arabia, Australia, Canada, India, South Africa, Brazil and Iran. Cheng and Skousen (2017) confirm that most mining jurisdictions require reclamation after mining and that this requires posting a bond or surety upon application for the right. These 2 authors list the 6 most common mining reclamation bond types and compare the mining reclamation bond processes and cost calculation models for three main mining destinations. In the USA, the Office of Surface Mining Reclamation and Enforcement produced a handbook to help determine the value of the bond which is broadly based on the estimated cost of reclamation. The value is based, much like the South African guideline, on actual costs of all the cost components of the mine's total rehabilitation state, preliminary and general costs of a rehabilitation project and also allows for adjustment in inflation. The USA handbook prescribes the method and rules for calculating the value of the bond to be posted and against which the bond provided by the mine can be compared. In Canada, the size of the bond differs amongst the various provinces. The required bond value does not necessarily relate directly to total rehabilitation cost, as the specific mine's risk profile is also considered. Australia also has regional differences in bond value calculation amongst its main mining territories. In some instances, a fixed rate per area disturbed is used while the bond value for other projects is determined on a project-specific basis, taking total remediation cost into account and not necessarily full reclamation cost[2]. Regional variations also exist amongst the Chinese provinces in how the bonds for mining reclamation are determined but the basic principle is that the bond posted should be at least equal to the reclamation fee. Most importantly for this report, none of these countries (Canada, China and Australia) have a single prescribed bond value method.

Sheldon *et al* (2002) provided several insights into the typical costs of closure in various countries and found that these costs may vary greatly. The variance in the costs of closure can depend on the location and age of the mine, the type of mineral extracted and also on the type of mine developed. The physical size of the mine, its attendant infrastructure, the history of ongoing rehabilitation, (or not) and the volume of waste on surface are other factors that significantly influence the final closure cost. For small mines, these authors found that environmental closure costs could be as little as US$ 1 million per mine in places like Lithuania to hundreds of Millions of US$ for large lignite mines in Germany. The typical closure costs, however, range in the tens of millions of US$. Research conducted by these authors

[2] In Australia, a distinction is made between the term *remediation*, being effectively stopping pollution from a mine site, and *reclamation*, which is something more, and implies restoring the mined land to a more useful or natural end state.

indicate that medium-sized underground or open-pit mines that were operating up to 15 years previously could cost in the order of 5-15 million US$. For much older mines up to 35 years old (very similar to all South African asbestos mines) and which contain large waste and tailings facilities, the price escalates to upward of US$ 50 million. Additionally, the presence of Acid Mine Drainage problems adds significant costs to treat the water and to rehabilitate the tailings dams and dumps. The authors also affirm that, in most cases around the world, the "polluter pays" principle is applied and that is usually cheaper for mines to close themselves rather than for the government to conduct the closure afterwards, when a site is abandoned.

2.2 The South African approach to financial provision for mine closure

Van Eeden, Liefferink and Du Randt (2009) assert that, over the past century, the negative environmental and social impacts of mining have been largely ignored or underappreciated whilst the economical contribution of mining to South Africa has been overvalued. The authors claim that the abandonment of mines and the resultant unmitigated environmental impacts have worsened in the years prior to their paper. The authors feel that the failure of government agencies to effectively deal with mines being abandoned conflicts with the environmental quality as well as health and safety objectives of the Constitution and the many specific environmental laws that stem from it.

South Africa introduced the requirement for financial provision for mine rehabilitation through Regulation 5.16 promulgated under the Minerals Act of 1991 (Act 50 of 1991) This regulation required mines to make financial provision to fund closure and also to plan for premature or unplanned closure. To put this requirement in historical context, the promulgation of these regulations came just a few years after the first World Summit on Sustainable Development in 1992, so there was a raised public awareness of environmental responsibility in all aspects of business and life in general. Additionally, in South Africa, and all over the world, the market for asbestos had just collapsed in a very short space of time and many mines which had a long theoretical life-of-mine remaining, were closing or simply being abandoned. Clearly, there was a need for financial provision to limit the risk of the State inheriting the environmental legacies of mining. The issue that was raised by the industry very quickly after the promulgation of the regulation, was that there was no guideline or directive from the State on how much money should be put aside – how the calculation should be done. The DME guideline that is the focus of this report had its roots in this call from the mining industry in South Africa to provide such guidance.

Swart (2003) affirmed that the provisions for financing mine closure processes were already addressed in the Minerals Act of 1991 (Act 50 of 1991): She stated that the "polluter pays" principle was well understood and accepted by both the industry and government for damage to the environment caused by prospecting and mining operations. Swart also mentioned the appropriate regulations promulgated under the Minerals Act, 1991 for making financial provision in her paper.

The Auditor-General of South Africa conducted a performance audit of the rehabilitation of abandoned mines at the Department of Mineral Resources and produced a report to Parliament in October 2009 on this audit. One key finding recorded in this report is that the legacies of abandoned mine sites, the results of inadequate or inefficient closure processes or simply mine abandonment, are three root causes to one major environmental problem. The Auditor-General's audit found that the environmental impacts of unrehabilitated abandoned mines were extensive and that adequate measures were not in place to ensure that mines rehabilitate timeously and effectively, with the result that the social and environmental impacts of unplanned mine closure or abandonment are not addressed.

Brent and Fourie (2005) postulated that the closure objectives of the mining industry and the various government agencies involved in closure are misaligned and that this results in a legacy of unsuccessful mine closures. They propose using project management principles to assist government agencies with the effective evaluation of mine closures and to manage the mine closure process more diligently.

These authors referenced above have clearly identified problems with the mine closure process and with the funding for proper, planned closure of a mine. The focus of this research report is, however, on the actual costs of mine closure with specific reference to the DME guideline for financial provision and, on this topic, the sources and references are far less abundant.

There are several publications on the topic of the approaches to determine the financial provision but few that give actual rates and values to estimate mine closure costs. Anglo

American (2013) have published a worked example of the closure costs estimate using their Mine Closure Toolbox and a limited number of consultancies have published their own closure costing reports for mine clients online, like Golder Associates (2012) and Plan African (2007) In addition, the World Wildlife Fund (WWF) commissioned a review of the financial provision process applied in South Africa (van Zyl *et al*, 2012) This report noted persistent degradation of the environment from mining operations and high numbers of abandoned mining operations and argued that there is a need to improve rehabilitation in the mining sector. The report further raised questions about the cost of rehabilitation of a mine and the amount of financial provision made to allow for future rehabilitation. The report conducted a review of the method of making financial provision and makes certain recommendations for improvement. The authors' review of the mechanism of determining the amount of financial provision found that there were high levels of variation in the quality of environmental management plans with the consideration of the long-term effects of mining on water quality being a particularly overlooked aspect. In many cases, mines had no rehabilitation plans at all, which made it difficult to link the eventual cost of rehabilitation to actual tasks required on the ground to achieve closure objectives. The WWF report highlights the general failure of mining companies to adjust the DME's master guidelines rates for inflation and the resultant underestimation of potential closure cost. The report also notes the lack of concurrent rehabilitation by mines and the general lack of publicly available information to inform the review of financial provision to aid benchmarking. The report recommends that more stringent guidelines should be published, in line with more current research and that the guideline values should be updated.

2.3 Noted problems with mine closure and financial provision for mining operations in South Africa

In June 2006, Du Plessis and Brent published their approach to arrive at a more realistic closure cost model in the Journal of the South African Institute of Mining and Metallurgy. Their paper outlines the process they followed, using the master rates table published by the DME guideline in 2004. The authors correctly assert a basic assumption of the DME guideline that all regulatory and legislative mechanisms are assumed to have failed when the DME must take over the rehabilitation of a mine (as is the case with abandoned asbestos mines considered in this report) and that the use of the guideline assumes the worst-case scenario

- when the State steps in with taxpayers' money and a third-party contractor to close the mine. In their paper, the authors apply the master rates to a sample mine site with an area of 260ha and then use Monte Carlo analysis as well as an average escalation of the master rates based on the CPI, PPI, diesel prices and several other relevant variables to arrive at a risk model for likely closure costs. Worth noting here is that the master rates were escalated by the authors based on these diverse input rates not at CPI, but at an average of the selected published variable rates which is over 9.5% per annum for most master rates (The rates for fencing, maintenance and after case and specialist studies being the exception at just under 9% p.a.) This study is significant for its finding that the DME guideline master rates should escalate by significantly more than the published CPI, when other, perhaps more relevant escalation factors are considered. To quote the authors: "*When using relevant CPI and PPI tables for the last decade, it is shown that the mean of the distribution of escalating factors is higher than what is generally used in the mining industry to escalate closure costs*." The implication of this finding is that the actual cost of closure would depart very rapidly from the DME rates if the two were escalated at different rates year-on-year. The authors conclude their paper with the recommendation that their proposed model should be tested on completed projects and on more case studies to determine its accuracy in predicting closure costs.

Hewitson (2012) published on the topic of estimated mine closure costs in his MSc thesis, also using a Monte Carlo analysis to determine the probable values for mine rehabilitation cost items. That author found that, while closure costs are very significant, the amount of financial provision is inadequate in many cases. The approach of the study conducted by Hewitson was to apply a Monte Carlo analysis to the closure cost estimation of several mines to assess the accuracy of the financial provision in place. considered the escalation of closure costs and the uncertainty with respect to the master rates published by the DME. The report also looked at the way financial provision is made and suggests some improvements. Hewitson found that most mines underestimate their closure cost and make inadequate financial provision. He notes that mines either do not escalate the published master rates or adjust for CPI only, with no further consideration of the potential costs. Specifically, the results of Hewitsons' Monte Carlo analysis suggests that the mines that were assessed underestimate their possible future closure costs and generally provide for less than 50% of the possible future closure cost.

Milaras and others (2014) hold that mine closure is a serious issue for South Africa and that, although a lot has been written and there appears to be robust legislation and regulatory mechanisms around mine closure, sustainable mine closure is still not attained successfully. The authors believe that there is a disconnect between policy and practice in South Africa and they set out to explore this gap by structured interviews with professionals practicing in the mine closure environment in South Africa. Professionals from various sectors were interviewed, being in mining consulting, government and legal professions. A series of 19 open ended questions were posed to this group, which originally was a population of 169 professionals. A response rate of 35% was obtained. The survey found that detailed baseline environmental assessments are imperative to the formulation of an effective mine closure plan. The survey also found that professionals believed that rigorous liability costings must be conducted and that financial provision must be made accordingly. Rehabilitation must take place as mining continues so that the final landscape and mine condition as well as actions required to close do not represent unmanageable cost. Good cooperation between stakeholders is considered important, as is buy-in from senior management. The closure dialogue with stakeholders must be initiated well in advance to clarify the objectives, outcomes and final land use. The report concludes that mine closure in South Africa has been shown to be problematic and sustainable closure remains elusive. The professionals interviewed showed significant negative sentiment about the possibility of attaining sustainable mine closure. The failure of closure through the prescribed means is mainly attributable to poor management, lack of baseline environmental indictors, and a lack of government and public buy-in to the closure processes.

Van Druten & Bekker (2017) state that the complete and successful closure of a mine in South Africa remains problematic. Some of the problems noted by these authors include unclear roles and responsibilities, inaccurate closure management data and the inability of stakeholders to conceptualise and integrate closure information into business processes. These authors state that no mine has been granted closure and many mines are left abandoned and unrehabilitated. This results in risk to investors, impacts on surrounding communities and risks to regulators. The authors interviewed focus groups through a structured, rank order questionnaire to determine the relative importance of reasons why closure fails. The aspects uncovered through this process were then ranked and listed by the authors. The respondents listed the shortage of relevant skills and knowledge relating to closure within the regulator as the major problem. A lack of qualified and experienced mine closure auditors has also been listed as a main problem and the lack of dedicated mine closure project teams were identified as another concern. Out of 37 potential contributing factors for the failure of mine closure, it is commonly agreed that a lack of skills is the biggest problem. A lack of planning during feasibly stages of the project is another planning constraint to eventual successful closure. Institutional uncertainties and dual responsibilities paralyse decision making in institutions charged with regulating closure and there is fragmentation of responsibilities amongst government departments. Insufficient financial provision does not seem to be a deciding factor but the lack of providing for social impact costs could be a potential problem. The authors suggest that the closure model could be a lot more effective if the impacts on the society affected by mining and the post closure mining state can be more effectively communicated at earlier stages in the closure planning process. The authors recommend that these and other minor factors could be incorporated into an integrated mine closure model to improve the probability of attaining successful, sustainable closure of mines.

Alberts and others (2017) discussed the legal framework for mine closure and abandoned mine sites in South Africa in comparison with other mining countries and found that the legal framework for mine closure in South Africa is comprehensive. While the South Africa system conforms to international expectations, the system is very complex. Many individual laws, regulations, norms, standards and guidelines which are administrated through several Ministries, complicate the processes of mine closure in South Africa. This complexity, coupled with governance capacity constraints, goes a long way to explain the reasons why mine closure practice has fallen short of mine closure expectations and mandates. The authors list the raft of legislation and key regulations and other guidance that have a bearing on mine closure and the various entities that govern this to illustrate the complexity of these provisions. The paper illustrates this complexity with a view to prove whether recent changes in the legislation have made the mine closure process and framework any easier and concludes that the South African framework for mine closure is still very complex. While it is noted that the complexities in mine closure are not only prevalent in the South African jurisdiction, the authors note that it is the degree to which the formalised closure processes are administrated by the regulators that make a difference in the eventual success. The development of the skills of professionals in mine closure to develop relevant closure objectives, norms and standards to be attained at closure is seen as an important step to eventually attain and agree on closure outcomes. The legal framework does not often consider the human elements of mine closure, still a major shortcoming, and it ends up depending on the government to be the intermediary between community expectations and the mines to negotiate and change closure outcomes.

Humby (2014) found that there are serious gaps and lapses in the legal provisions for mine closure which, although they look comprehensive, allow mines to slip through legal cracks to avoid the formal closure process. Notably, the Companies Act allows mines to sell off their liabilities to less and less capable mining houses in successive sales of mines and transfers of mining rights, which ultimately leads to a mine owner not having the financial capacity to provide for closure and leading to abandonment and dereliction. To illustrate the point, Humby uses the example of Blyvooruitzicht mine, which has gone through successive owners and was ultimately abandoned. Humby also identifies the issue of inadequate legal protection of the funds put aside for closure in the financial provision of a mine during the ownership of rights transfer. The major loophole that Humby identifies is that the MPRDA allows the transfer of existing mining rights to other parties with little reference to other acts. The liability for pollution degradation of the environment, the pumping of mine water and residual impacts fall to the last holder of the right, who must also apply for the closure certificate. Humby concludes that, despite having very good legislation for regulating mine closure, the oversights and gaps created in the MPRDA regarding the transfer of rights has created serious gaps in the transfer of ownership and liabilities to a party less capable of fulfilling the closure obligations and the model of regulated mine closure is thereby undermined. The author (Humby) calls for authorities to address these issues or face increased dereliction of mining responsibilities and failures to close mines in accordance with the solid legal foundation provided.

In March 2017, a very significant report entitled: "*The Drivers of the cost of public Sector Construction: Assessment and Recommendations*" was published by the Construction Industry Development Board (CIDB) and the Department of Public Works (DPW). (Department of Public Works, 2017). The research that informed this report found that infrastructure spending by the various departments and agencies of the national, provincial and local spheres of government annually amount to R 220 billion and provide jobs to over 1,4 Million people. The scope of this work is therefore very significant. The report looks at the drivers of costs in public sector infrastructure spending and has some relevance to this research report as it also covers several aspects that have a direct bearing on the civil engineering nature of most mine rehabilitation projects.

The DPW/CIDB report proposes the Building Cost Index (BCI) as a better indicator of construction and engineering cost increases, as it includes the contractors' profit margins and better reflects actual market conditions. Historical data analysed for the DPW/CIDB report indicates an average annual increase in the BCI of 1% over the CPI in the period from 2005 to 2015. This report also considers the Output BCI, which reflects the cost to the client and includes allowances for risk and profit in addition to the actual contractor cost. The output BCI has risen with a significant 4.5% each year over the CPI in the period from 2010 to 2015. The combined findings of the DPW/CIDB report suggest that the noted increase in building costs could be ascribed to increasing profit allowances by contractors as well as allowances for risk factors, financing costs and the depreciation of the Rand over the study period. The study also found that plant- and material-intensive construction projects are more sensitive to cost increases than comparable labour-intensive projects.

The DPW/CIDB report used the actual data from the bills of quantities of a selected number of projects in the General Building and Civil Engineering categories and in the size ranges from CIBD grades 5 to 9[3] to track and analyse actual increases in various project cost elements. Using this data, the report developed a predictive modelling tool to determine the key drivers of construction costs.

Figure 2.1, below is taken from the DPW/CIBD report and reflects the headline PPI, building industries PI and Civil engineering PPI in relation to the CPI. While all these indices follow a similar pattern and there is a correlation in the general trends of these four indices over the recorded period, the difference between certain rates could be higher than 10% in each year. For an example of this trend, compare the CPI with the Civil Engineering PPI in 2009 and 2015 in Figure 2.1. Note that Figure 2.1 is copied directly from the DPW/CIDB report; the data

[3] The CIDB grading system of project values determines that projects at Grade 5 could range up to R 6 500 000 in value. Grade 9 is the highest CIDB grading and has no upper limit on project value.

underlying the graph was not freely available to graph the points of interest more distinctly for the purposes of this paper.

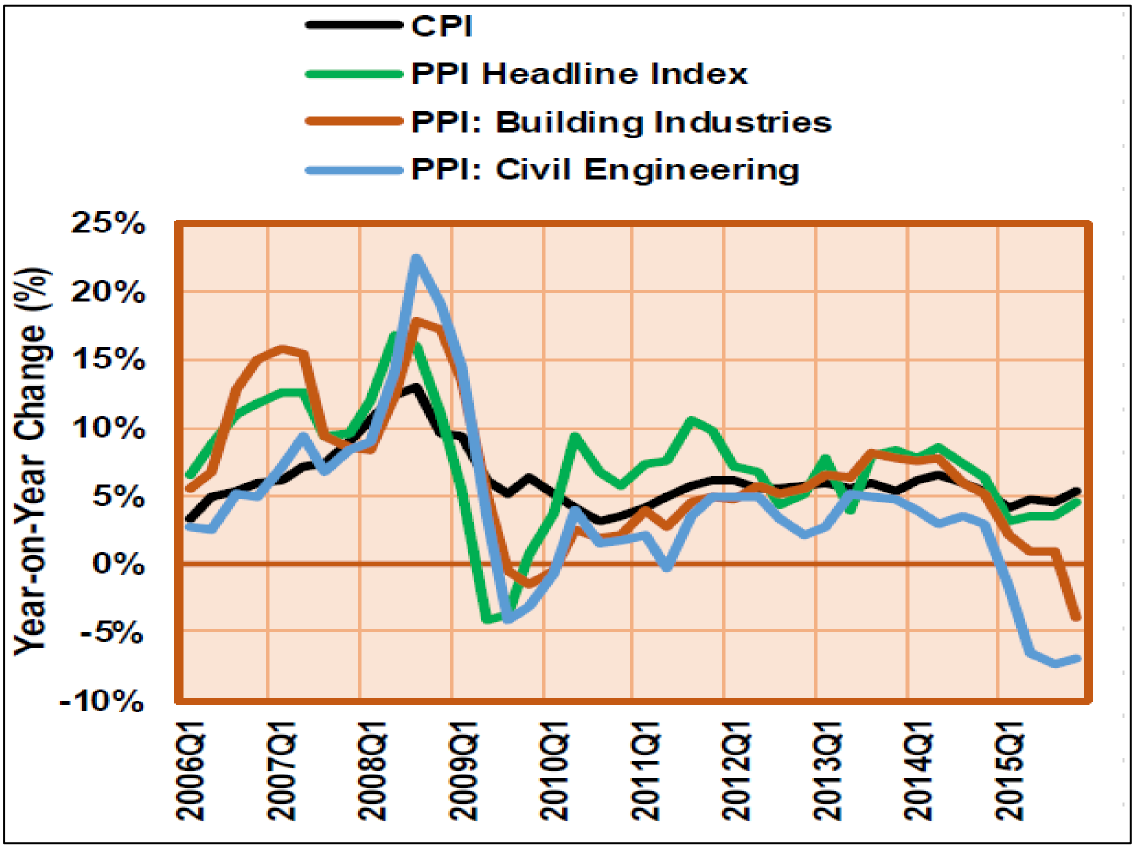

Figure 2.1: CPI and PPI with PPI for building projects and civil engineering highlighted: 2006 – 2015 (Source: Dept Public Works: 2017)

Additional to the headline PPI and Civil engineering and building PPI, the DPW/CIDB report also considered the costs of labour, plant and equipment used in construction and civil engineering projects. The graph produced by the DPW/CIDB (Figure 2.2) shows that the material index has tracked the CPI closely while the plant and equipment index lagged the CPI over the same period. (2006 – 2015)

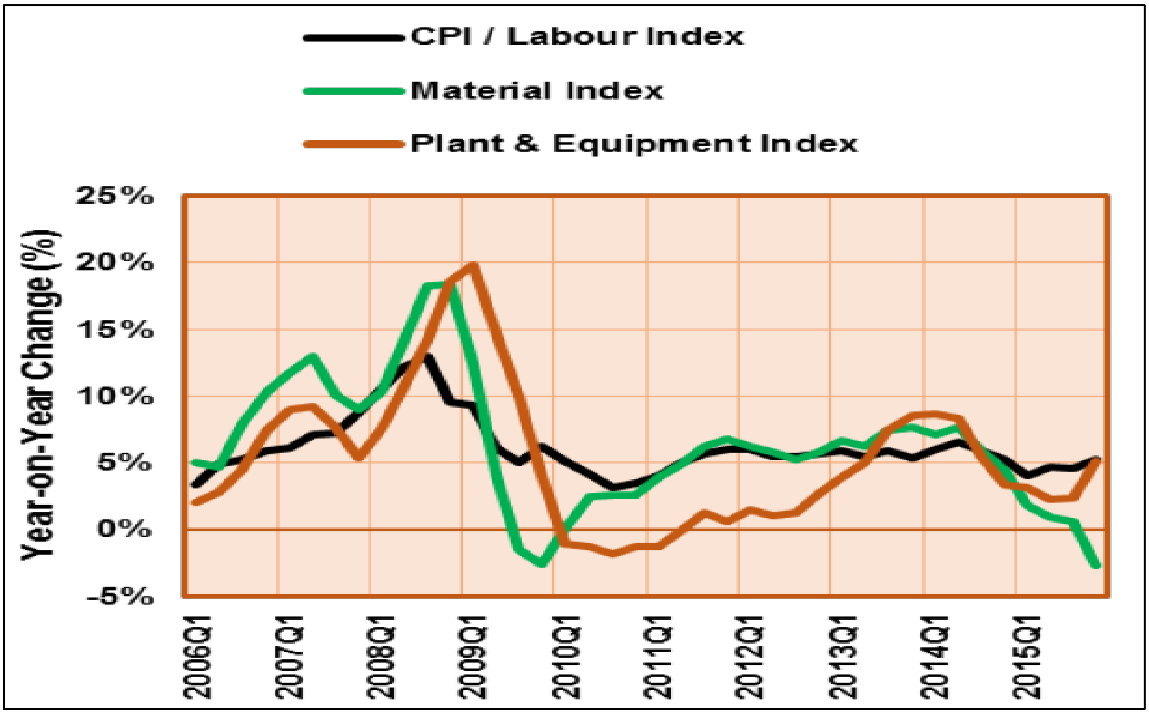

Figure 2.2: CPI, labour and Plant indices: 2006 – 2015 (Source: Dept Public Works:2017)

The DPW/CIDB reports finds that, in the period from 2010 to 2015, the cost of construction has increased at annual average rates varying between 1% to 4,5% higher than inflation. The report further indicates that these rates of escalation at a premium over CPI is likely to continue in the near future. It is noted that, while the input cost of construction has remained in line with CPI inflation over the past 10 years (despite volatility in fuel prices and plant and equipment costs) the output prices – what it would cost a state entity to employ a contractor to do the work, has increased at 1 – 4.5 % p.a. premium over CPI in the same period.

Equally significantly, the DPW/CIDB report addresses the issues of preferential procurement and developmental objectives that have become a standard feature and, indeed, legislative requirement of all government projects in terms of the Preferential Procurement Policy Framework Act (PPPFA) and CIDB project practice guidelines since 2011. These were obviously not anticipated when the DME guideline was compiled in 2004 but have been shown to add an additional price premium on government projects at both national and provincial levels. The DWP/CIDB report, citing research conducted by Letchmiah in 2012, indicates that the preferential procurement policy requirements add an additional 2% premium on government projects. Additional to the preferential procurement requirements, there are also developmental objectives that are considered a standard requirement of all government projects. As the DPW/CIDB report (Department of Public Work, 2017) states: "*A further cost driver that needs to be recognised is an increasing trend that is being observed due to requirements for developmental procurement and for contract participation goals (CPGs) in construction projects, as well as community demands and expectations related to construction works contracts*." (2017:24) The CIDB's own Practice Note 3: Balancing delivery and development on infrastructure Projects, recommends an additional premium of 2% over and above the other premiums already addressed.

The research conducted and published by the DPW/ CIDB is significant for later analyses of the DME's guideline and the master rates addressed in this report as it indicates not only the rates of change of construction and civil engineering projects in relation to the PPI and CPI, but also records these additional premiums on government projects which were not anticipated or addressed in any measure in the DME 2004 guideline document.

While the reports by both the DPW/CIDB (2017) and Du Plessis and Brent (2006) are very useful, neither contain specific data on mine rehabilitation costs. The DPW/CIBD project did use actual project data for some of its analyses, but these projects were not uniquely mine rehabilitation works. This matter could only potentially be addressed by using actual data from tenders submitted for mine rehabilitation projects by the State to verify the real market rates for rehabilitation components. The intention and core focus of this research report was conceived with this subject in mind.

2.4 Recent changes in the legislation for mine financial provision in South Africa

The national Department of Environmental Affairs (DEA) has recently assumed several roles related to the approval of mining projects, including the publication of regulations around the financial provisions for mining operations under NEMA. This is a significant development that changes the status of the financial provision guideline published by the DME and it must be considered here.

Subsequent to the publication of the draft financial provision regulations in 2015, the DEA also published a clarification note on 30 June 2016 in which the DEA answered specific questions about the rates used in the mining industry and the role of third-party contractor's rates. One of these questions related to the determination of the quantum and the DEA confirmed that the contractor's rates (or other external rates used in industry) will be used and that the draft regulations did not provide a separate methodology to determine the value of the financial provision. Suzette Hartzer-Marais (2016) records that: "*the rates that must be used must be external contract rates according to general practice, although the Regulations do not specifically provide for this*". In calculating financial provisions quantity surveyor rates will therefore have to be used.

On 10 November 2017, the Department of Environmental Affairs published the new regulations in terms of NEMA for financial provision to be supplied by the holder of a right for mining, prospecting, and other forms of mineral extraction. The regulations give instructions on the determination of financial provision, methods acceptable for making financial provision and provides a new methodology for determining the amount of financial provision for both new and existing mining and prospecting rights applications. While general guidance on the methodology is provided, specific rates are not given.

The regulations give guidance on the need to make financial provision for all aspects of planned closure of a mine or prospecting operation, and the immediate costs of potential closure and remediation. The management of residual impacts must also be provided for, and are linked to the risk of these impacts occurring. The regulation does not introduce any new mechanisms for providing the financial provision from those known before. The cash deposit, trust fund and bank guarantee options that have all existed since the Minerals Act, are still the only ones recognised in South Africa.

The onus is now on the holder of the mining right to determine the total cost liability of closure and remediation and is subject to independent verification. If the Minister of DMR is not satisfied[4] with the amount provided, the holder must pay a second independent assessor to provide additional input. Failing that, the holder must pay for a third-party auditor, appointed by the State, to confirm the amount provided has been calculated correctly. The use of CPI to escalate cost for up to three years of aftercare post-closure is regulated to escalate the full closure cost amount initially calculated.

The principles and method for calculating the amount provided are contained in two appendices to the new regulations. These principles determine that the calculations must

[4] The new NEMA regulations provide no mechanism of guidance for the Minister of DMR to determine the adequacy of the amount of financial provision. (Refer to Footnote 6, page 41)

assume that a third party will be employed to do the rehabilitation work. They also determine that mine infrastructure will have zero asset value. No provision is made for Preliminary and General (P&G) costs, as it is already included in the CPI escalation.

The entire state mechanism for assessing the quantum of financial provision to be provided by a mine has now departed from the DME guideline and the rules-based approach. It might appear then, that an in-depth review of the rules-based approach and the old DME guideline mechanism is redundant. This research report does have a bearing on how much a mining company, having followed the rules-based approach from 2005 to 2016, might be under- or overfunded at the point of alignment with the new financial provision regulations, so there might still be some value in this comparison.

In summary, the issue of the correct amount of financial provision for the closure of a mine is an important matter that has received significant academic, operational and regulatory attention internationally and in South Africa since the publication of the DME guideline. What is not adequately addressed, is the use of real data for mine rehabilitation projects conducted by the State, as it would have to do in the case of default of a currently operating mine and the measurement of that actual data against the predicted guideline values. While the use of the DME guideline has been superseded by the regulation issued by DEA in 2017, many mines may be in a position that they have diligently used the DME guideline and may need to determine if they have under- or overprovided for closure. The consensus view of the researchers who have published on this topic in the past, and have used various simulation techniques, is that these operations may be underprovided for by as much as 50%, before the additional effects of the PPPFA requirements and CPG's are accounted for. Most recent reports by the DPW/CIDB suggest that these factors may introduce even higher rates of change of prices related to costs which are already significantly outdated.

3 METHODOLOGY

This report presents quantitative research based on secondary data. This research report uses secondary data gathered from tender submissions in the period from 2009 to 2016. This data was analysed statistically and the actual median cost values so obtained were then compared to escalated DME guideline rates and the rates predicted by the CIDB report escalation figures. The results of this comparison are presented in a descriptive manner for each master rate or component analysed.

3.1 Background to the methodology applied in this research report

Chu (2017) conducted a research study to determine which nomenclature researchers attach to different methodologies and what terminology is used. He also states that scholars must choose between qualitative, quantitative and mixed research methods depending on what the intended focus of the study is. Most research methods are able to collect both qualitative and quantitative data, despite being oriented to a particular type of data.

Brown & Lindley (1986) state that quantitative research is a systematic effort to make a quantitative assessment and usually involves mathematical formulation.

Leppink (2017) held that the goal of science is to establish laws and principles that help us explain phenomena in our world in a systematic manner and, in many cases, how we may be able to predict or even influence these phenomena. Leppink found that mixed-method research is becoming more popular and combines the best of both quantitative and qualitative research methods. Qualitative methods can address the ‘how’ and ‘why’ aspects of research findings obtained from quantitative research that cannot be determined by quantitative methods alone.

Allwood (2012) identified the key characteristics of quantitative research methods as (a) being able to quantify the results, (b) not being emancipative, (c) not being interpretative, (d) not being able to use words as data, (e) not studying the meaning of contents and (f) assuming that there is an independent reality whether it is investigated or not. Allwood states that research methods are qualitative at the core and are equally objective. The use of quantitative data does not eliminate the intersubjective element that underlies social research. Research results from qualitative methods are applicable only to the sample while quantitative data and methods render results that may be generalisable to the entire population.

Goertzen (2017) said of quantitative research methods that they collect and analyse data that is structured and can be represented numerically. The findings of quantitative research can display behaviours and trends but do not provide insight as to 'how' or 'why' the underlying measurements change. The motivation behind the changes in the data, the causal effects cannot be known from quantitate data alone. The characteristics of quantitative research, according to these authors, is that it (a) usually deals with numbers to assess information, (b) uses data that can be measured or quantified, (c) aims to be objective, and (d) employs statistical analysis. Quantitative research also allows results to be summarised, compared and generalised and the results represent complex problems through variables. The advantages to quantitative research noted by Goertzen are that findings can be generalised to the specific population but the limitations are that the underlying causal relationships to changes reflected in data remain hidden. Also, quantitative studies could be time consuming and require data collection over long periods to render trends and display temporal factors.

De Vos (2011) says that quantitative data analysis are the techniques by which researchers convert data to numerical form and subject it to statistical analysis. This analysis allows the researcher to present from the data a meaningful picture of patterns and relationships. Quantitative methods of analysis fall into four main categories, being (a) descriptive, (b) association, (c) causation and (d) inference. As the last three categories usually concern themselves with multivariate analysis, the descriptive analysis technique will be used in this research report. Aims of the descriptive techniques relate to univariate data and focus on only one variable. These focus on describing the patterns in the data according to one or more of frequency, central tendency or dispersion.

Saunders & Thornhill (2012) say that using secondary data in research involves undertaking analysis of data that already exists and was collected for another purpose. Secondary data may include both raw data or published summaries of data. They list the advantages of secondary data primarily as having fewer resource requirements as the data is already collected. Using secondary data also allows access to potentially larger data sets. Using secondary data in research is unobtrusive and the researcher can almost "eavesdrop" and so obtain unadulterated results. Secondary data can also provide comparative and contextual analyses and can result in unforeseen discoveries. Secondary data has a permanence as it is usually collected as part of larger programmes and this data record stands for future comparison. The authors advise that the disadvantage is that secondary data may not be collected for the intended current use, so may only be partially usable or not relevant at all. Access to secondary data may be difficult or costly and one has no real control over the quality of secondary data as it was not collected yourself. Additionally, the researcher has no control over the aggregation processes used and inaccuracies in data processing may affect your research outcomes.

Welman *et al.* (2005) defined several types of non-probability sampling used in quantitative research. The data obtained for this research report does not fit clearly into any one of the categories defined by these authors. Firstly, it is not purely accidental or incidental sampling. Although the audience or sample population could be seen as captive, there is a degree of self-selection in the typical profile of the population of bidders who submit tenders. In the second place, the sampling supporting the research presented here is not self-selection sampling, however, as bidders did not know beforehand that their data would be used in this report. The data was collected for another purpose and after the fact of the tender submission and evaluation. Thirdly, the sampling method does not fit the strict definition of quota sampling as no pre-selection of respondents according to a given classification was done. The sampling method employed is probably most closely aligned to purposive sampling, in which the researcher deliberately decided which samples to include. In this case, the exclusion of certain years was not purposive, but the exclusion of years in which sample sizes were too small, does represent a degree of prior selection on the part of the researcher. Some elements of convenience sampling are relevant in the data selected, as the data was readily at hand within the researcher’s organisation. Because there is no planned intervention based on the data obtained, the research design also closely simulates the real-life conditions and could therefore be considered a form of field data survey.

3.2 Methodology applied in this research report

This research report aims to provide an insight into the accuracy or usefulness of the original DME guideline by analysing the difference between the rates for mine closure indicated by the guideline in comparison with the actual costs of mine rehabilitation projects funded by the State. In this instance, the source of the data for State-funded rehabilitation projects is the actual cost data for surface mine rehabilitation projects in South Africa. These projects are all asbestos mine rehabilitation works conducted by Mintek, a State-owned enterprise, which has been doing this work as an implementing agent for the DME since 2009. It follows that the real cost data is only available from 2009 as that is the year that the first State rehabilitation project was conducted by Mintek. The data set ends in 2016, the last year that the tender data was recorded. This comparison uses several of the master rates in the DME guideline and compares the predicted rates with the actual evidence gathered from State mine rehabilitation tenders. This comparison should allow one to see if the values in the DME's financial provision guideline were an accurate and reasonable reflection of the real cost of mine rehabilitation costs.

The approach followed can be explained in a number of steps as follows:

Step 1: The published DME guideline master rates were increased for every year since 2004 (2005 – 2017) with the actual CPI rates as published by Stats SA. A table was created for each of these master rates and they were used as the basis for the graphs that were generated in MSExcel™

Step 2: Additional to the data points and basic graphs obtained in Step 1, data obtained from the predicted increase as found by the CIDB's research for state funded construction projects was added to the DME guideline rates data and plotted as an additional line overlaid on the DME guideline rate in the graphs generated in MSExcel™. The rate of increase predicted by the CIBD report was taken as a 2% per annum premium over the CPI for PPPFA compliance plus an additional 2% per annum for CPG's. The predicted CIDB rate in the graphs is therefore a linear 4% per annum premium over the DME guideline value escalated by CPI over the period from 2006, when the CIDB report data started, to 2017.

Step 3: The actual tender values were tabulated and plotted in the same graphs created in Steps 1 and 2 above for the years for which there is data. These tender values were calculated as the median value for each entry of all bids submitted for a line item in the Bill of Quantities (BOQ) for any year, notwithstanding the type of project, landscape or location that the project was situated on. In cases where it was not possible to match all the Master rate components to the tender specification, the most relevant component factors that were originally used to calculate the master rate in each closure element, from Appendix C.3 (2.6.4) of the DME guideline were used. This generated several graphs in instances where the master rate only published one overall master rate – an example being the master rate (R/ha) for waste deposit rehabilitation (Master rate 8C) which contains several sub-components. Thus, instead of only one graph for waste deposit rehabilitation (Master rate 8C) there is one graph for each component rate used to compile that master rate, as this more closely aligns with the values available from the actual tenders. The master rate for this example (waste dump rehabilitation) has been broken down into several graphs, one for each component rate, including shaping of the dump, covering of the dump, topsoiling, etc. In some cases, it was not possible to compare rates directly, so the underlying cost components of each master rate were used to compare and analyse the trends. If these underlying costs changed, it is a reasonable assumption that the master rate would also change concomitantly.

Step 4: The graphs of the guideline master rates, increased by real CPI and the predicted rates of change using the CIDB rates of escalation as well as the data from the tenders over the same period were then all combined in one graph for each master rate or subcomponent of a master rate. Note here that tender data was only available for the years 2009 – 2016, with a gap for the year 2013 when no tender data was reported. Additionally, the type of rehabilitation projects for which data could be obtained, do not contain all the rehabilitation components for which master rates were published, so the overall data sample only addresses surface mine rehabilitation. (see Table 4)

Step 5: Using the graphs created in the step above, analyses and conclusions were derived from observations in the data. Figure 3.1 below provides a graphic illustration of the process followed in this report.

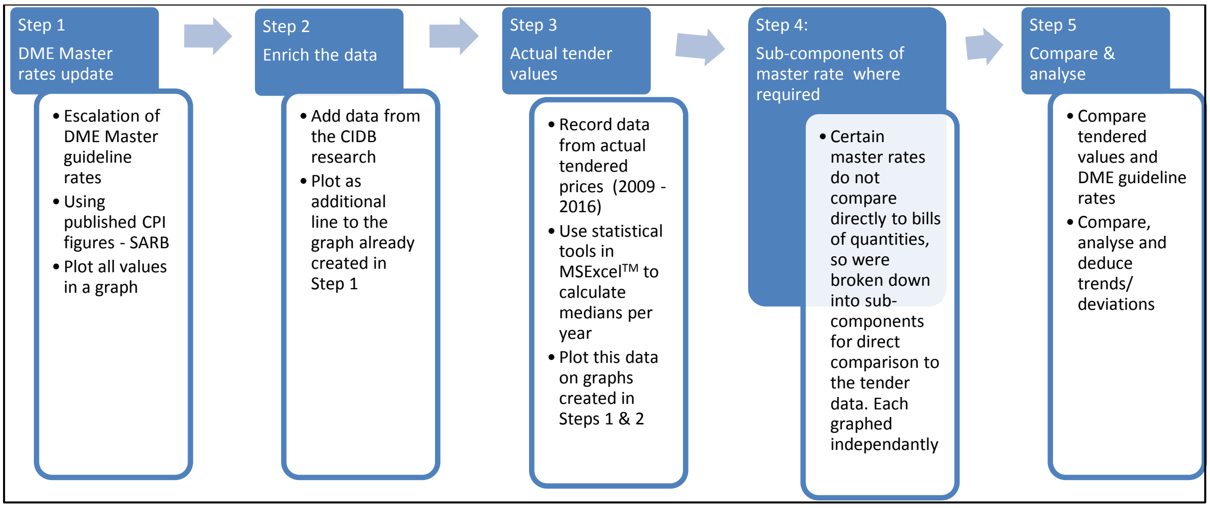

Figure 3.1: Illustrated methodology followed in this study

The key objectives of the research report were attained through tabulating and analysing historical actual mine rehabilitation values, obtained from project tender data. This allowed a comparison of the historical actual tender data values per mine rehabilitation item to the rates tables published in the DME guideline. This methodology allowed analysis and conclusions on the probable current and future costs for surface mine rehabilitation and the applicability of published rates to actual costs. In the process, the report provides evidence to determine if the guideline values published by the DME in 2004 are an accurate reflection of actual rehabilitation costs when compared to actual tender data.

3.3 Source of the data used in this research report

The Council for Mineral Technology (Mintek) is a State-owned enterprise reporting to the Department of Mineral Resources. Since 2009, it has been acting as implementing agent for the DME on a State-funded programme to rehabilitate abandoned asbestos mines around the country. As implementing agent, Mintek is responsible, amongst a host of other tasks related to the overall management of the asbestos rehabilitation programme, for the procurement of designed projects from third party contractors. As a fundamental input to this research report, the actual values returned by bidders for tenders advertised by Mintek[5] in the period from 2009 – 2016 was collected and entered into spreadsheets. The names of the projects

[5] Mintek gave permission for the use of the tender data in this research report (see **ANNEXURE D**)

and the names of bidders have been removed in the final data tables. This information is not considered essential to the analysis as median values across all projects and from all bidders in any given year were calculated for comparison to the master rates. The tenders are legally required to be entered by hand onto paper, so electronic data was not available and the actual tendered values from each individual bid had to be entered by hand into spreadsheets that record each line item of the BOQ. The tables of the values entered followed exactly the specified Bill of Quantities that was required for the scope of works of each project. It follows that no two tenders are exactly the same and the direct year-to-year comparison of all cost elements was therefore not possible.

3.4 Population and sample sizes of the cost data obtained from tenders for mine rehabilitation projects

The data collected for this study can be understood as both population (n) and sample (s) values. The population value (n) reflects the number of projects for which detailed price data was captured. This value is recorded as *n* and, after discounting projects with too few response data entries, the population size is 50% of the total number of projects advertised in the period from 2009 to 2016.

Table 3.1: Number of tenders advertised and actual BOQ data captured per year (n) for the period 2009 - 2016

Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**TOTAL**
Number of tenders advertised	3	2	1	9	3	6	6	4	**34**
Number of tenders for which cost data is recorded	3	1	1	1	0	5	3(5)*	3	**17**

**In 2015, the data for 5 returned tenders were captured, but the data sets were too small (only one qualifying respondent in two cases) so that data is excluded from this study.*

Over the period from 2009 – 2016, the data for 17 projects out of a possible 34 were usable to include in this study. The population (*n*) for the entire data set is therefore 17. No suitable data was collected in 2013 and this year presents a gap in the entire data set.

The sample value (*s*) is the number of actual tendered BOQ's submitted per individual project and from which the data was obtained. This *s*-value reflects the depth of data used to arrive at median prices per line item in the final comparison tables.

The preparation and advertisement of tenders is a very involved process and the design that precedes a tender varies widely depending on the complexity of the work at hand. In addition to this, funding delays and other factors play a role in the consistency with which tenders are awarded. Table 3.2 below reflects the projects for which cost data was obtained. The year reflected is the year in which the particular tender closed and the data was recorded.

Table 3.2: Projects per year of tender closure and number of respondents (s) for each tender used in the data for this research report

Year that tender closed (data input)	Project name	Number of respondents: Sample (s) of data set per project
2009	Project A	7
	Project B	30
	Project C	14
2010	Project D	15
2011	Project E	12
2012	Project F	10
2013	*No tender data*	*No tender data*
2014	Project G	7
	Project H	5
	Project I	4
	Project J	8
	Project K	7
2015	Project L	6
	Project M	10
	Project N	3
2016	Project O	17
	Project P	16
	Project Q	12

3.5 The application of statistical methods to the data recorded

Each tender contains a detailed bill of quantities ("BOQ") which is essentially a list of the cost items that bidders must submit for financial comparison and evaluation of their bids. The BOQ represents the engineer's estimation of what will be required to do the work. The data gathered from the individual respondents for each tender was entered into a spreadsheet program and statistical formulae were then applied to obtain the median value for each line item in the Bill of Quantities of the collected tenders submitted. This data was then tabulated per similar line item per year for all years that data is available and plotted in graphs to see if the prices compare with the predicted DME and CIDB rates.

Figure 3.2 Illustrates the process of obtaining the data per line item from each tender received per year. The number of tenders advertised and returned per year differ (see Table 3.1) and the number of bids received per tender in each year, also differ (Table 3.2) It follows that the sample size that comprise the base data on which each line item's median value is based, differs amongst the various years and master rates.

The formula for calculating the median is $\{(n + 1) \div 2\}^{th}$ and can be calculated automatically in MSExcel™ by arranging the BOQ's so that each applicable line item aligns with all others before applying the built-in software formula.

Median values were selected as they are considered more representative of probable tendered values per year than averages. The use of average values could include an element of skewing if prices for a particular item were very high in some year or on some project for an unknown reason. With a median calculated across as many as 45 values (year 2016) there is a reasonable degree of confidence in the medians. The year 2012 rendered the least number of samples to calculate a median from, with only 10 values. The year 2016 delivered the best sample size of 45 BOQ's from which to calculate the median.

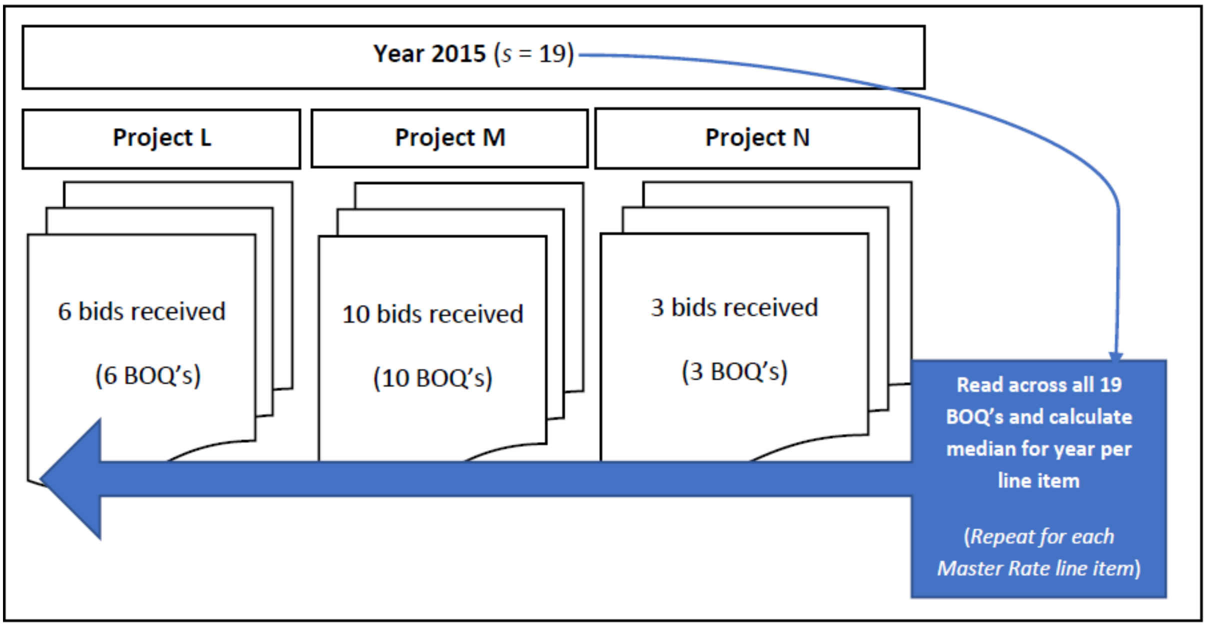

Figure 3.2: Illustrated method of deriving the median values from BOQ's for different projects in a year used in this research report

It must be noted that, because not all projects are the same, the projects do not all contain similar elements in their design and BOQ's. A project in a given year may have gabions, for example. The next project, in the following year, may not have gabions work at all so, although there is data for the next project, there is no comparable entry for that design element and the datum for that following year on that item in the BOQ cannot be recorded.

3.6 Notes on the operation of the 2004 DME guideline to determine financial provisions

The DME guideline contained a usage guide in Section B: Working Manual for the assessment of the quantum. The interpretation of the methodology and its comparison to the DME guideline master rates assumes some knowledge of or access to the original DME guideline on Financial provision on the part of the reader. The key focus of this research report is the rules-based approach for assessing the quantum of financial provision and its comparison with market rates. To fully interpret this and the following section, the entire guideline, with its appendices, are ideally required.

The DME guideline provided three possible methods to determine the amount of financial provision. The selection amongst these possible methods was discussed in Section B of the financial provision guideline and was essentially based on the amount of information available (See Figure 3.3 below)

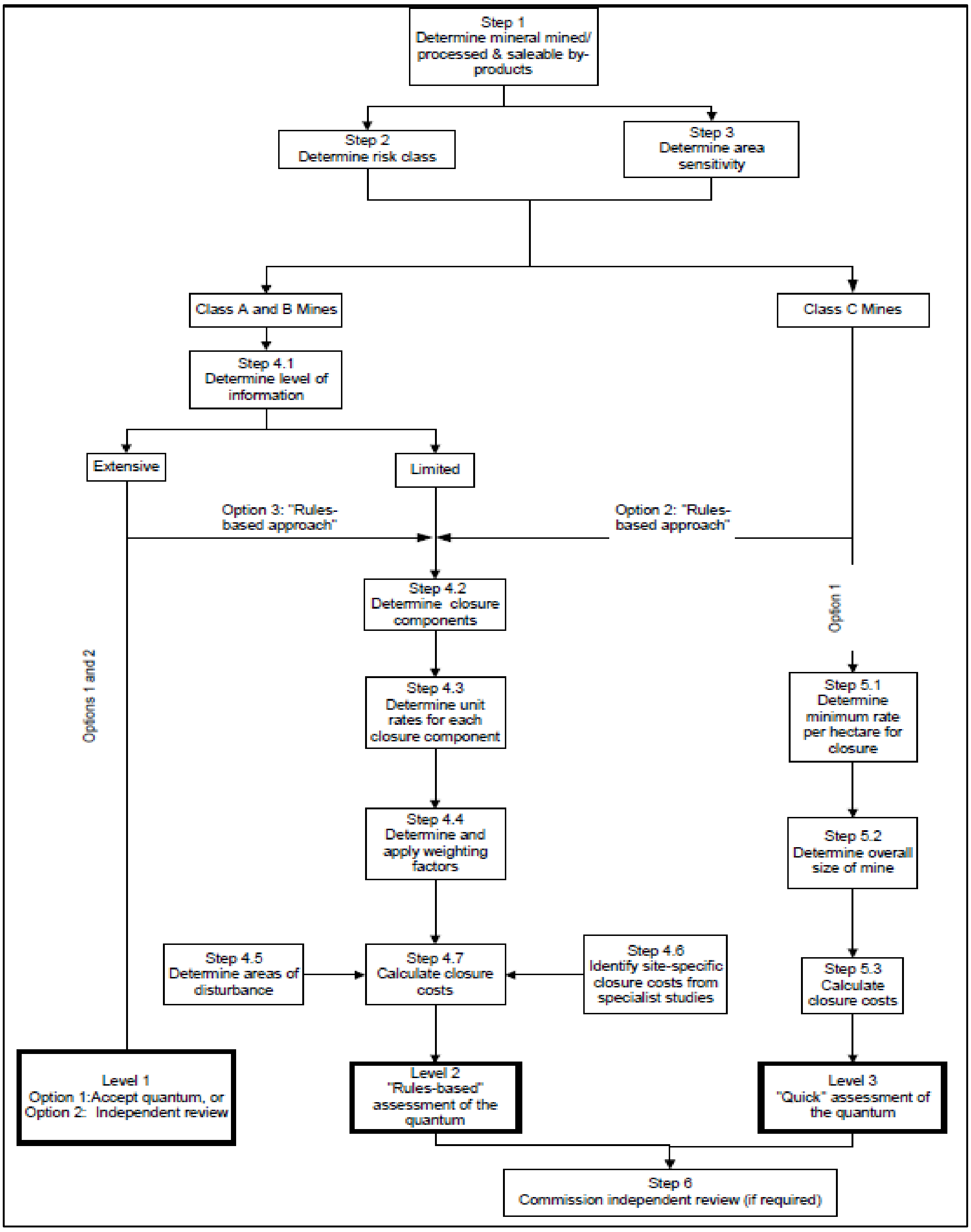

Figure 3.3: Extract from DME guideline – three methods for calculating financial provision explained (Source: DME Guideline, 2004)

The first method was to just accept the determination of the cost done by a third party professional in cases where extensive information was available. The second option, with limited information availability, was the rules-based approach, wherein several key elements of the typical mine is broken down into component parts, measured from mine plans by surface area or volume and the master rates then applied to obtain a probable closure cost. This is the method that is the focus of the current research report. The last option that could be applied with only limited information about the mine concerned, was only supposed to be used for small mines and prospecting operations, wherein a flat rate was charged per surface area of the mine right. This intention was that this method was reserved for instances where too little information was available to apply any other method and it was probably never used in practice.

In this research report, the Master rates prescribed for the Rules-based approach are analysed. It is therefore necessary to describe the process followed for the rules-based approach for open-cast asbestos mines which are the example used in this research report. Table 3.3 below provides a step-by-step guide to using the guideline for the example at hand:

Table 3.3: Step-by-step use of the DME guideline

Guideline step	Reference	Result
Step 1 – Determine mineral mined/ processed and saleable by-products	Guideline Section B, Table B.12, Page 17	Asbestos mines are listed
Step 2 – Determine Risk Class[6]	Guideline Section B, Table B.12, Page 17	Asbestos mine, mine waste, plant and plant waste are all classified as **Risk Class A**
Step 3 – Determine area sensitivity	Guideline Section B, Table B.3, Page 7	By virtue of the selection of sites prioritised for rehabilitation, most asbestos mines are classified mostly as lying in **highly sensitive** areas based on mostly social considerations
Step 4.1 – Determine level of information	Guideline Section B, Paragraph 4.4.1, Page 8	For abandoned mines, no EMP and no closure plan exists. No expert closure costing, either. Information is therefore limited. The guideline prescribes using the "rules-based" approach.
Step 4.2 – Determine closure components	Guideline Section B, Table B.4, Page 9	Common closure components have already been selected for opencast asbestos mines – see Table 4.2 in Section 4 of this report.

[6] It is interesting to note that the guideline specifically requires of Regional Office personnel of the DMR to perform several of these steps.

Guideline step	Reference	Result
Step 4.3 – Determine unit rates for each closure component	Guideline Section B, Table B.5, Page 10	These are the Master Rates[7] for each identified cost component with values as originally published in 2004. (Refer to ANNEXURE A in this report for updated values)
Step 4.4 – Determine and apply weighting factors	Guideline Section B, Tables B.6 & B.7, Page 12	The Master Rates are adapted by Weighting Table B.6 to account for terrain access difficulties[8]. This is applied to all master rates applicable to the mine/ project in question. Table B.7 is only applicable to the Preliminary and General costs.
Step 4.5 – Determine areas of disturbance	Guideline Section B, Step 4.5, Page 12	This is done on a site-specific basis for the asbestos mines closure projects in the project scoping report phase, but is not relevant for this research report.
Step 4.6 – Identify site-specific closure costs form specialist studies	Guideline Section B, Table B.8, Page 13	This is done on a site-specific basis for the asbestos mines closure projects in the project scoping report phase, but is not relevant for this research report.
Step 4.7 – Calculate closure costs	Guideline Section B, Table B.9, Page 14	Intended to be site-specific as applied in the guideline - not relevant for this research report.

The results of the methodology described here are presented in Chapter 4: Results.

[7] The guideline provides additional information on what assumptions and rehabilitation methods each master rate was based on. This appears in Appendix C.3 to the guideline and are copied in ANNEXURE B of this report for reference. Additionally, a more detailed breakdown of the underlying values that each master rate is composed of, the element rates, are given in Appendix C.3.1 of the guideline – from page 13 onwards

[8] This step was performed in this research report as the projects in most years were located what would be termed 'rugged' terrain. The master rates for all graphs used in this study were therefore adapted by the prescribed weighting factor of 1.20 (20%) increase over the base rate.

4 RESULTS

4.1 Update of the 2004 DME guideline rates to present values using published CPI values

When the DME financial provision guideline was published in 2004, it contained the express instruction that the master rates should be updated by CPIX[9] each successive year. In order to use the correct current master rates for comparison at present values in this research report, the rates table published by the DME in their 2004 guideline was updated to the current values for each item using the published annual CPI figures for South Africa. As Hewitson and other authors have noted, the update of the master rates was often not applied in practice, resulting in the guideline values quickly falling far behind industry rates in those cases.

The annual average CPI rates as published by Statistics South Africa were used to escalate the master rates published in the guideline in 2004 to 2017. Using this method, the annual average values obtained for South Africa's CPI is tabulated below:

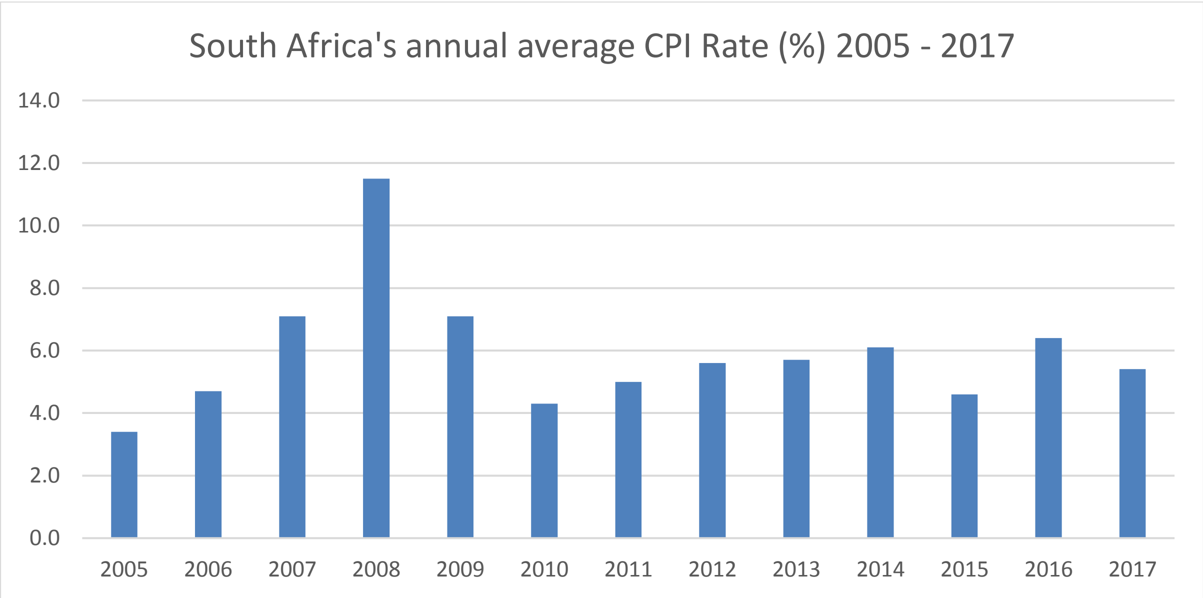

Figure 4.1: South Africa's annual average CPI; 2005 – 2017 (Source data: StatsSA; 2017)

[9] Technically, the DME guideline required update of the master rates by CPIX annually. Statistics South Africa changed the naming and composition of headline CPI measures in January 2009, however, and this effectively replaced CPIX as the measure for government inflation targeting. Only CPI is used from 2009 onwards.

Statistics South Africa re-valued the CPI in February 2009, introducing various methodological and other changes, including reweighting with the introduction of new expenditure weights, the introduction of the Classification of Individual Consumption by Purpose (COICOP) and rebasing values so that 2008=100. This process and outcomes are fully explained in Statistics South Africa's explanatory booklet entitled: "*Transition to the 2009 CPI*" dated 1 July 2008.

Applying these updated CPI values to the originally published Master Rates table from 2004, we get the following values (Table 4.1):

Table 4.1: Master rates published by DME in 2004 updated by published CPI values to 2017

Rate Component S1.2	Description	Unit	Published rates 2004	CPI Adjusted values in 2017
1	Dismantling of processing plant	m^3	R 6.82	R 13.22
2A	Demolition of steel buildings & structures	m^2	R 95.00	R 184.21
2B	Demolition of reinforced concrete structures	m^2	R 140.00	R 271.47
3	Rehabilitation of access roads	m^2	R 17.00	R 32.96
4A	Demolition and rehabilitation of electrified railway lines	m	R 165.00	R 319.95
4B	Demolition and rehabilitation of non-electrified railway lines	m	R 90.00	R 174.52
5	Demolition of housing and facilities	m^2	R 190.00	R 368.43
6	Opencast rehabilitation including final voids and ramps	ha	R 99 600.00	R 193 132.27
7	Sealing of shafts, adits and inclines	m^3	R 51.00	R 98.89
8A	Rehabilitation of overburden and spoils	ha	R 66 400.00	R 128 754.84

Rate Component S1.2	Description	Unit	Published rates 2004	CPI Adjusted values in 2017
8B	Processing waste deposits and evaporation ponds (salt)	ha	R 82 700.00	R 160 361.83
8C	Processing waste deposits and evaporation ponds (acid, metal)	ha	R 240 200.00	R 465 766.77
9	Rehabilitation of subsided areas	ha	R 55 600.00	R 107 812.79
10	General surface rehab and grassing	ha	R 52 600.00	R 101 995.55
11	River diversions	ha	R 52 600.00	R 101 995.55
12	Fencing	m	R 60.00	R 116.34
13	Water management	ha	R 20 000.00	R 38 781.58
14	2 to 3 years of maintenance and aftercare	ha	R 7 000.00	R 13 573.55

The above table illustrates that the net effect of inflation in the period since 2005 to 2017 has effectively almost doubled the originally published master rates. A full table providing the annual escalation for all intervening years between the date of publication of the guideline and the present is provided in **ANNEXURE A**: Master Rates table escalated to 2017.

The type of rehabilitation work performed by Mintek over the period, which involved mostly surface rehabilitation of smaller dumps, resulted in a situation where not all these master rates were applicable in every year. Only some of the master rates are applicable to the typical project that was rehabilitated and could be used for comparison. (see Table 4.2 below)

4.2 Selection of applicable rehabilitation elements for comparison

Section B of the DME guideline (the working manual) describes in detail how the guideline should be used. The guideline determines that Asbestos mines are all Risk Class A. (Section B, Part 4.1 & 4.2 and Table B.12) This has implications for the application of modified master rates for Component 6; Opencast Rehabilitation (including final voids and ramps) and the master rate for Component 8(C) Processing Waste Deposits & Evaporation ponds (acidic, metal-rich waste).

The scoping of a rehabilitation project can be likened to the Step 4.2 described in the DME guideline working manual Section B item 4.4.2; Determine the closure components. As most of the projects were asbestos mining operations, several of the master rates are not applicable and were not considered further in the comparison. The applicable master rates that were used for comparison in this research report going forward are reflected in Table 4.2 below:

Table 4.2: Applicability of cost items from the master rates table in the DME guideline to surface mine rehabilitation project for abandoned asbestos mines

Rate Component S1.2	Description	Applicable to typical asbestos surface mining rehabilitation operation?
1	Dismantling of processing plant	No
2A	Demolition of steel buildings & structures	No
2B	**Demolition of reinforced concrete structures**	**Very rarely**
3	**Rehabilitation of access roads**	**Yes**
4A	Demolition and rehabilitation of electrified railway lines	No
4B	Demolition and rehabilitation of non-electrified railway lines	No
5	Demolition of housing and facilities	Very rarely
6	Opencast rehabilitation including final voids and ramps	No
7	**Sealing of shafts, adits and inclines**	**Yes**
8A	Rehabilitation of overburden and spoils	*No – asbestos under 8C*

Rate Component S1.2	Description	Applicable to typical asbestos surface mining rehabilitation operation?
8B	Processing waste deposits and evaporation ponds (salt)	*No – asbestos under 8C*
8C	**Processing waste deposits and evaporation ponds (acid, metal)**	**Yes**
9	Rehabilitation of subsided areas	No
10	**General surface rehab and grassing**	**Yes**
11	River diversions	No
12	**Fencing**	**Yes**
13	Water management	No
14	2 to 3 years of maintenance and aftercare	No

The nature of the typical abandoned asbestos mine, of which several remain in the country of varying sizes, is somewhat different from opencast workings for other types of mineral mined in bulk from tabular seams. Asbestos seams were often exploited by tunnelling from surface in small-diameter adits or simply digging trenches from surface to the extent of the economical deposit into the usually narrow seams. There are a few exceptions where the ore deposits warranted larger operations to produce on large scale from vertical or incline shafts.

4.3 Comparison of the DME guideline master rates and analysis of the results

The DME guideline document also provides, in its Appendix C.3, a set of generally accepted closure methods. These explain the underlying assumptions and specific rehabilitation protocols and component rates on which the master rates were based. These rehabilitation methods and component rates on which each master rate was based, are copied verbatim from the original DME guideline for information and appears as **ANNEXURE B** to this research report. The applicable master rates and the specific cost components of a typical asbestos rehabilitation project are: (3) Rehabilitation of access roads, (7) Sealing of shafts, adits and inclines, (8C) Processing waste deposits and evaporation ponds (acid, metal), (10) General surface rehab and grassing and (12). Fencing. The first master rate that will be reviewed, however, is the Demolition of reinforced concrete structures (2) This element is not often encountered on asbestos mine sites and therefore has only a few data points from the tenders analysed. Master rates for the closure of shafts and for the rehabilitation of processing waste deposits both contain more than one underlying components, the individual rates of which are compared where appropriate.

The analysis that follows is based on the graphs drawn from tender data and the DME and CIDB guideline rates. A format is followed where the actual tender data is represented by columns in each year for which there is data. These columns can only cover the years from 2009 to 2016, as those are the years in which there was tender data available, except for 2013, in which there were no tenders. The DME guideline rates are represented by a solid line (brown) for the period from 2005, the first year that CPI escalation was to be applied, to 2017, the last year for which a full CPI value is available[10]. Another (green) line closely follows this, being the CIDB/DPW projected rate of increase on government construction projects, including the CPI increase, the PPPFA premium and the CPG premium, each rated at 2% and which collectively add another 4% to the DME rate for each master rate or component above the usual CPI increase. In temporal terms, this line extends from 2006, when the CIDB research was conducted, to 2017.

Where sufficient data was available, a linear trend line was inserted to reflect the trend in the actual tender data and to enable a visual comparison of the rate of change *vis-à-vis* the DME and CIDB rates. This was only done for master rate graphs where 4 or more data points exist. Where data only exists for three or fewer years of a given master rate or component, this trend line is omitted as it is considered that the data is not sufficient to indicate a definite trend.

Figures 4.2 – 4.14 below provide the results of the comparison described above: the actual tendered prices for the various cost elements compared to the DME guideline values and the predicted rate of escalation as encountered in the CIDB report. The data gaps, rates of escalation and trends, where sufficient data was available to insert them, are self-evident.

[10] Note that all DME master rates are escalated by an additional 20% over the DME value plus CPI due to most project sites being located in rugged terrain, as per the guideline, Step 4.4., Table B.6

For detailed descriptions of the work involved in each of these steps when actual rehabilitation work is performed, please refer to **Annexure C**.

4.3.1 Master rate (2): Demolition of concrete structures

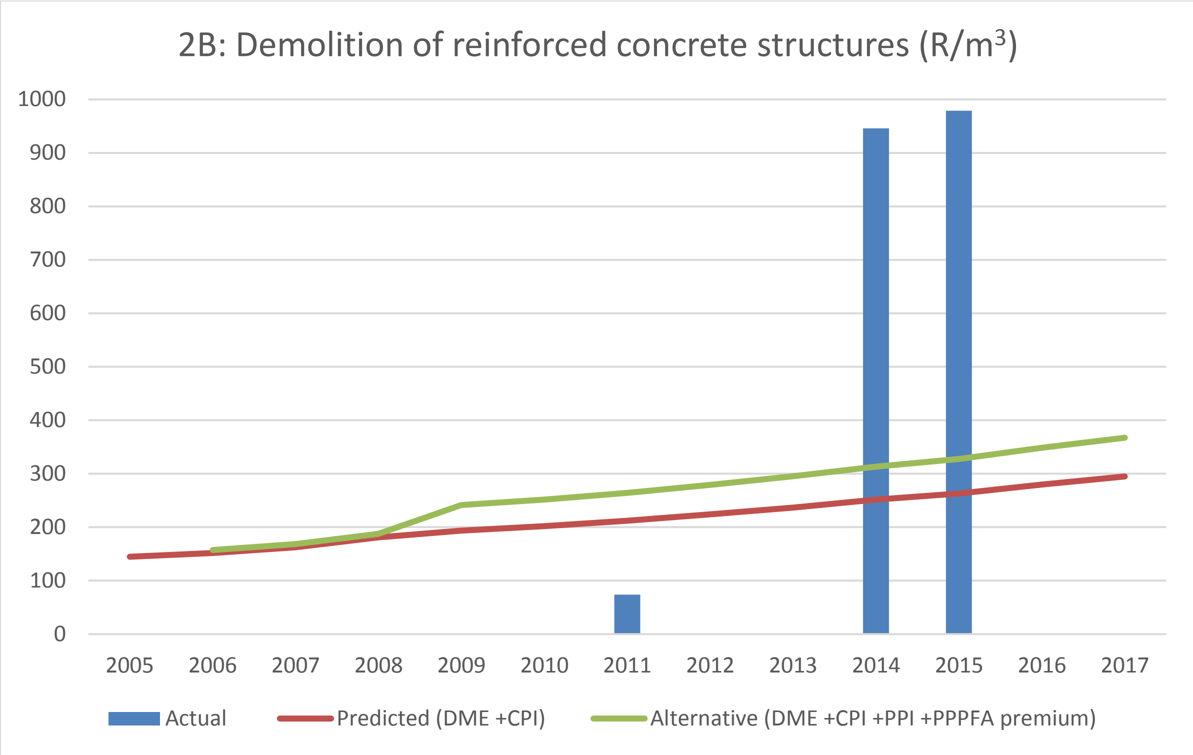

Figure 4.2: Comparison of actual tendered prices for the demolition of concrete with DME and CIDB guideline rates

The results of the comparison of the actual tendered values for the demolition of concrete structures appears in Figure 4.2 above. The description of the actions required during this task on a project appears in **Annexure C.** Only 3 data points were available and these show marked departure from the predicted costs by both the DMR guideline and the CIDB escalated value in later years.

4.3.2 Master rate (3): Rehabilitation of access roads

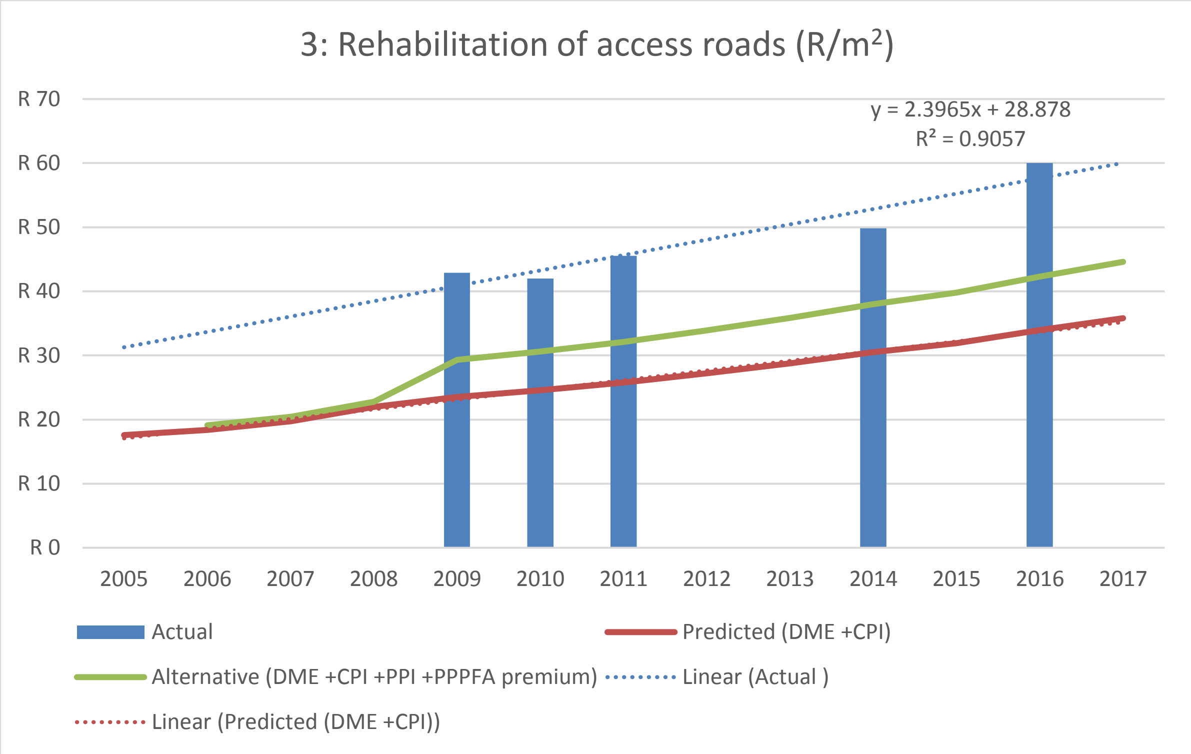

Figure 4.3: Comparison of DME Guideline values and actual tender data. Guideline item 3: Rehabilitation of access roads

With 5 data points across the temporal range, it was possible to insert a linear trendline across the data points for the rehabilitation of access roads (Figure 4.3) The formula for the trendline is y = 2.3965x + 28.878. The intercept value confirms the visual indication that the DME guideline rate started out too low. The slope of the equation indicates an annual rate of increase of almost R 2.40/m^2 compared to the guideline predicted rate of increase of only around R 1.57/m^2 per year, if the overall CPI value is averaged out to an annual value over the 12 years of escalation. (Compare **ANNEXURE A**) The R^2 value of 0.9057 indicates that the linear trendline fits the data very well (correlation approaches 1) and that the trendline is therefore a very good predictor of the underlying data set.

4.3.3 Master rate (7): Sealing of shafts, adits and inclines

The first underlying component rate used to compile the master rate for the sealing of shafts and adits includes a rate to backfill the shaft or adit. The description of the practical execution of this task on site appears in **Annexure C**.

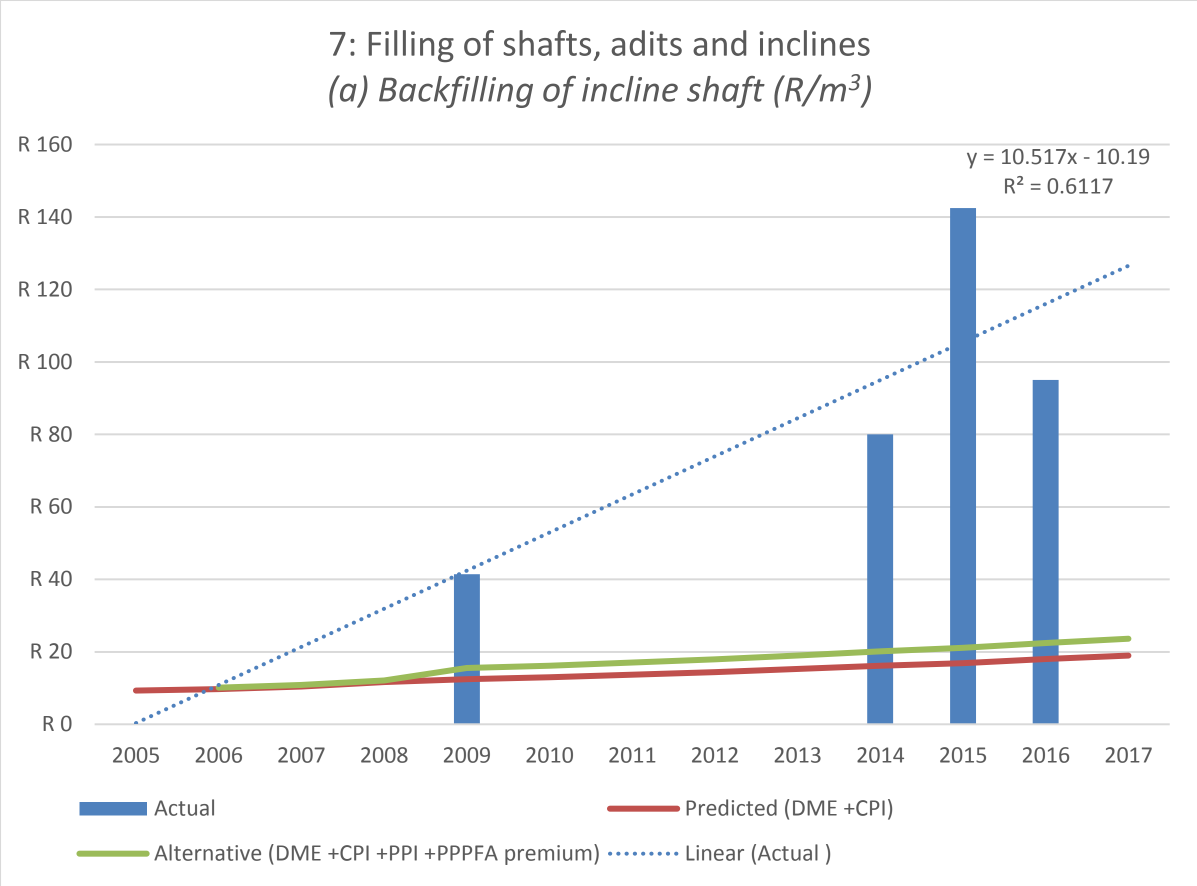

Figure 4.4: Comparison of DME guideline values and actual tender data. Guideline item 7: Backfilling of shafts

Figure 4.4 provides a comparison of the actual tendered prices for the backfilling of incline and vertical shafts with the DME guideline values and the predicted costs from the CIDB report. Data was only available for the year 2009 and for the period from 2014 to 2016. In other years, no data was available or no shaft closure was required at any project in that year.

The results presented in Figure 4.4 are self—evident and are summarised in Table 4.6 below.

The other significant underlying rate used to compile the master rate for the sealing of shafts and adits is a rate per cubic metre to provide the concrete cap for the shaft or adit.

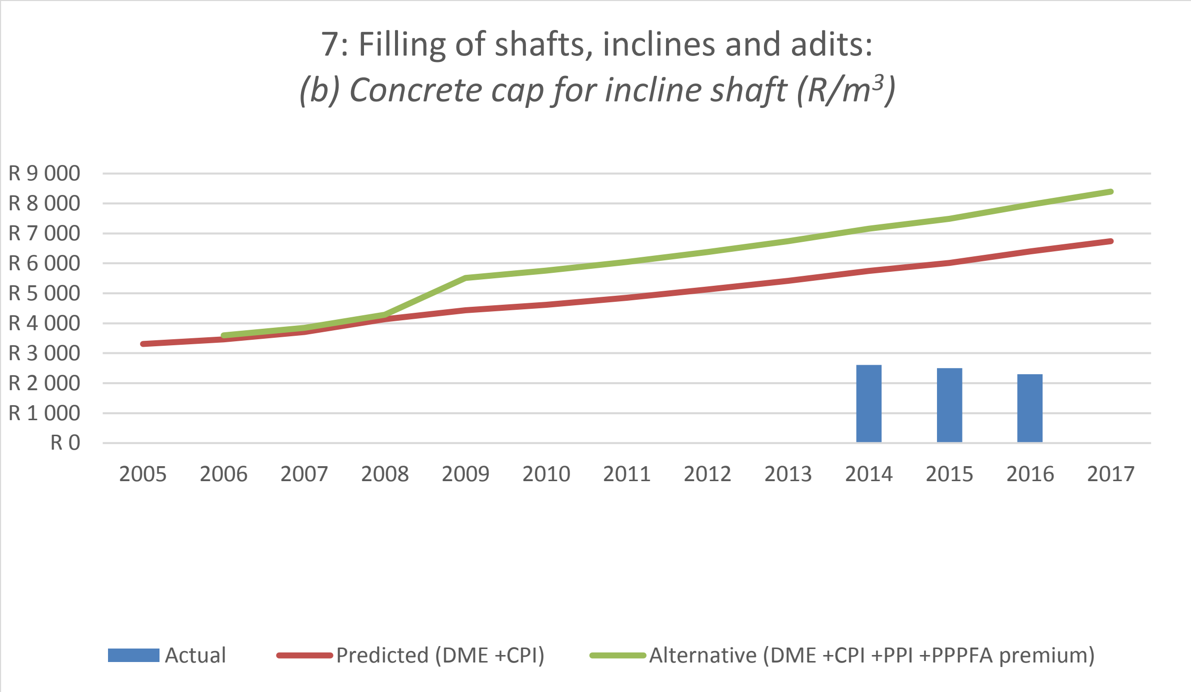

Figure 4.5: Comparison of DME Guideline values and actual tender data. Guideline item 7: Backfilling of incline shafts

Figure 4.5 illustrates that the rate per m^3 to provide concrete for capping of shafts or adits according to the specification is significantly less than the rate predicted by the DME guideline and the CIDB report.

4.3.4 Master rate (8C): Processing waste deposits and evaporation ponds (acid, metal)

The unit rates for all the underlying items that relate to this master rate are readily available from the tenders and can be used, if not directly relatable to the master rate, to analyse trends in the underlying components of this master rate to arrive at an indication of the rate of change in price of these components over the period that is the subject of this study.

4.3.4 (a) Slope modification to 18º (2.6.4.1)

The first individual cost component that forms a part of the master rate in the DME guideline for the rehabilitation of processing waste deposits (of the type encountered on asbestos dumps) is slope modification. This process involves digging into the waste dump with the aim of moving the material usually dumped at angle of repose, to a slope angle of 18º maximum.

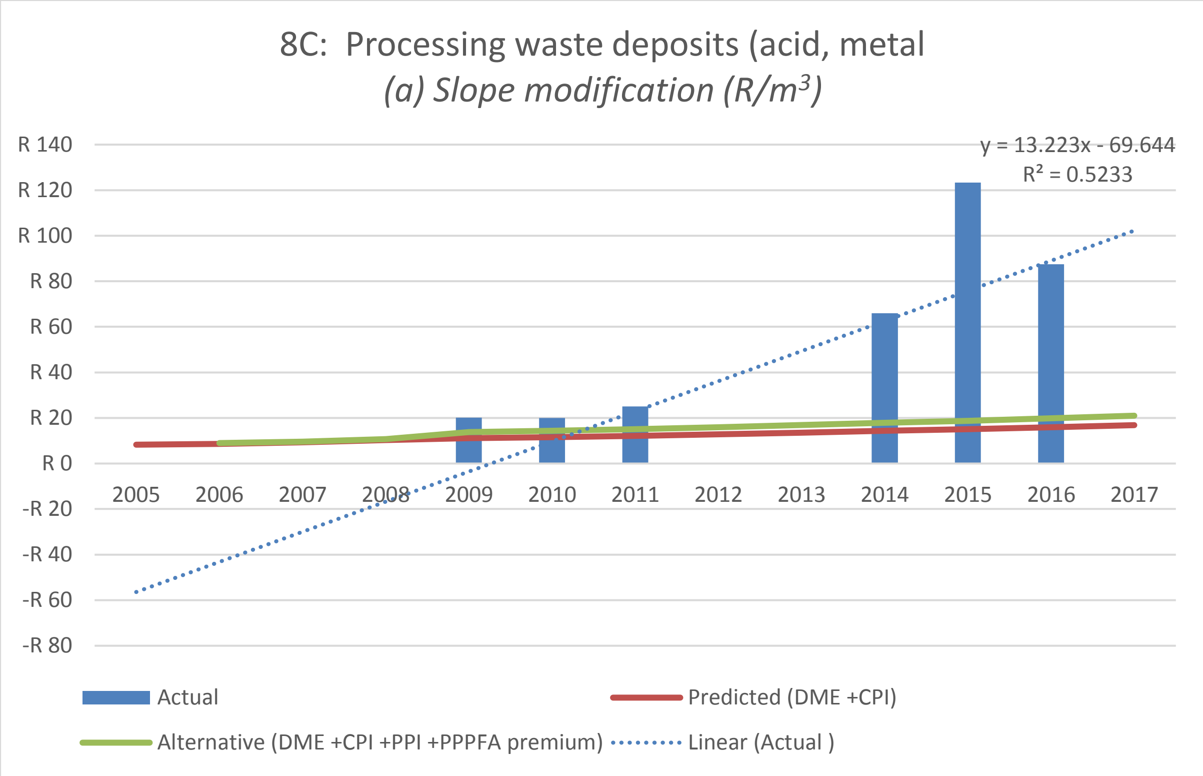

Figure 4.6: Comparison of DME guideline values and actual tender data. Guideline item 8C (a) Slope modification

Figure 4.6 above represents the results of the compared tender cost medians with both DME and CIBD estimated values. The linear trendline across 6 data points has the formula: y = 13.223x - 69.644, equating to an annual rate of increase of almost R 13.22/m^3 compared to the guideline predicted rate of increase of only around R 0.74/m^3 per year, if the overall CPI value is averaged out to an annual value over the 12 years of escalation. (Compare **ANNEXURE A**) The R^2 value of 0.5233 indicates a weak positive correlation of just over 50% with the underlying data and the trendline is therefore only a mediocre predictor of the underlying data. Wide annual variances could be expected from the trendline, as the actual data indicates.

4.3.4 (b) Earthworks to shape dumps to the required angle of slope

The next individual cost component that forms a part of the master rate in the DME guideline for the rehabilitation of processing waste deposits (of the type encountered on asbestos dumps) is the shaping of the dump. This happens after the desired dump slope angle has been attained and involves the smoothing and final shaping of the waste dump with the aim of preparing the surface for the placement of cover layers, water runoff management and erosion control as well as vegetation. More details on this process step are provided in **Annexure C**.

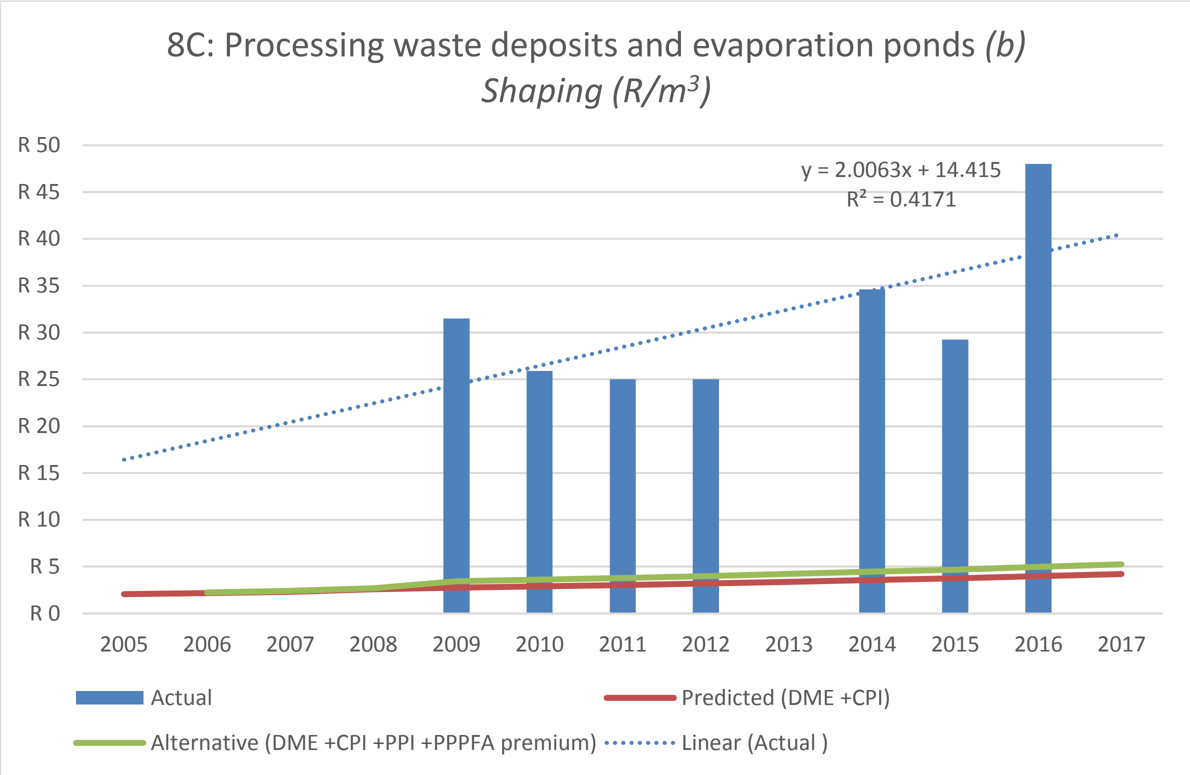

Figure 4.7: Comparison of DME guideline values and actual tender data. Guideline item 8C (b) Shaping

As Figure 4.7 illustrates, seven (7) data points were available in the period and it was possible to insert a representative linear trendline across these points to indicate the rate of increase in the actual tendered prices for the shaping of waste deposits. The slope of the linear trendline equation indicates an annual rate of increase of about R 2.01/m^3 compared to the guideline predicted rate of increase of only around R 0.18/m^3 per year, if the overall CPI value is averaged out to an annual value over the 12 years of escalation. (Compare **ANNEXURE A**) The R^2 value of 0.4171 indicates only a weak positive correlation of just over 40% with the underlying data and wide annual variances could be expected from the trendline.

4.3.4 (c) The placement of dedicated covers over the dump (Component rate 2.6.4.2 in guideline)

The next step in the rehabilitation of a processing waste deposit, is the placing of a layer of rocky material. Details of this step appear in **Annexure C**.

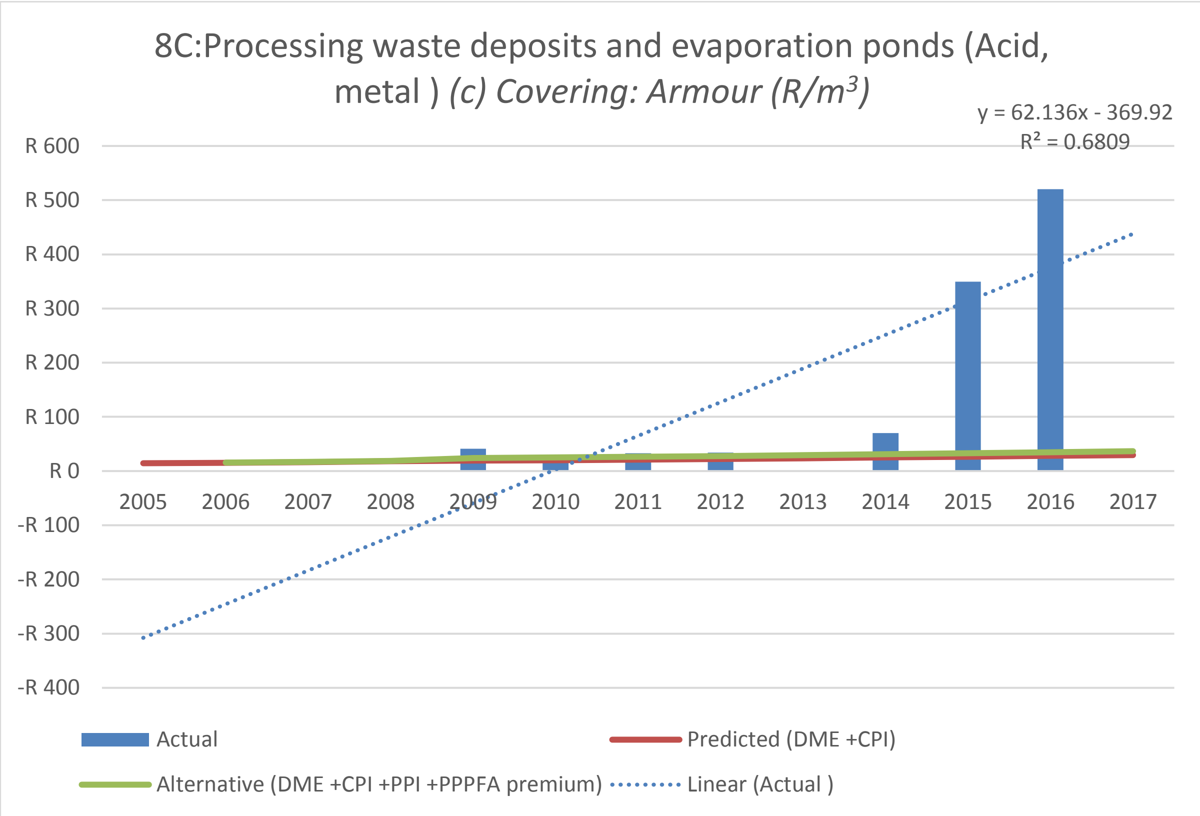

Figure 4.8: Comparison of DME guideline values and actual tender data. Guideline item 8C (c) Covering: Armour

The third-party rate per m^3 to place the rocky cover layer on dumps according to the specification, as actually tendered, followed the recommended guideline rate closely in the years from 2009 - 2012. In the period from 2009 – 2012, the predicted rate of cover layer placement was in the range of R21 – R25 per cubic metre. The actual tender data during this period started out at R 40 per cubic metre in 2009, double the guideline rate, but then decreased in the following three years (2010-2012) to follow the guideline rate very closely. There is a gap in the data for the year 2013 but the next data point, in the year 2014, indicates that the rate had risen significantly to R 70 per cubic metre against a predicted guideline rate of only R37/m^3. In the next two years, this rate increases dramatically to almost R 350 and finally to R 520 per cubic metre in the last year for which there is data (2016).

The 7 data points that were available in the period allowed a linear trendline to be calculated across these points to analyse the rate of increase in the actual tendered prices. The formula for the trendline is y = 62.136x - 369.92 and the slope of the trendline equation indicates an annual rate of increase of almost R 62.17/m^3 compared to the guideline predicted increase of only around R 1.29/m^3 per year on average over the 12 years of escalation. (Compare **ANNEXURE A**) The R^2 value of 0.6809 indicates a moderate positive correlation approaching 70% with the underlying data.

4.3.4 (d) Placing a topsoil cover of 300mm

Following the armour or rocky layer over a the prepared waste deposit during rehabilitation is a cover of soil, usually at least 300mm thick.

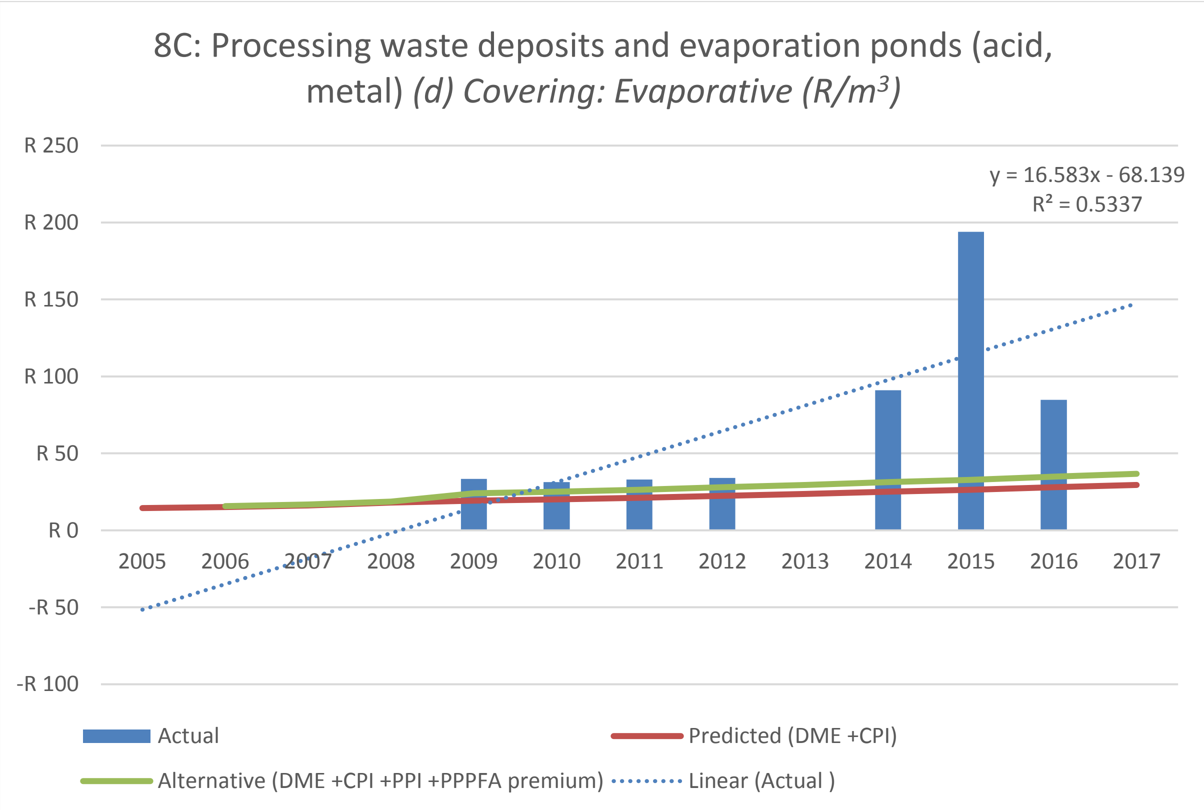

Figure 4.9: Comparison of DME guideline values and actual tender data. Guideline item 8C (d) Covering: Evaporative

Figure 4.9 above displays the data and includes the linear trendline across the 7 available data points. The trendline (y = 16.583x - 68.139) indicates an annual increase of almost R 16.58/m^3 compared to the guideline predicted increase of only around R 1.29/m^3 per year. Only moderate positive correlation with the underlying data (R^2 value of 0.5337) is achieved by this trendline, though.

### *4.3.4 (e)	Vegetation*

The final individual cost component that comprises the master rate in the DME guideline for the rehabilitation of processing waste deposits is vegetation of grassing.

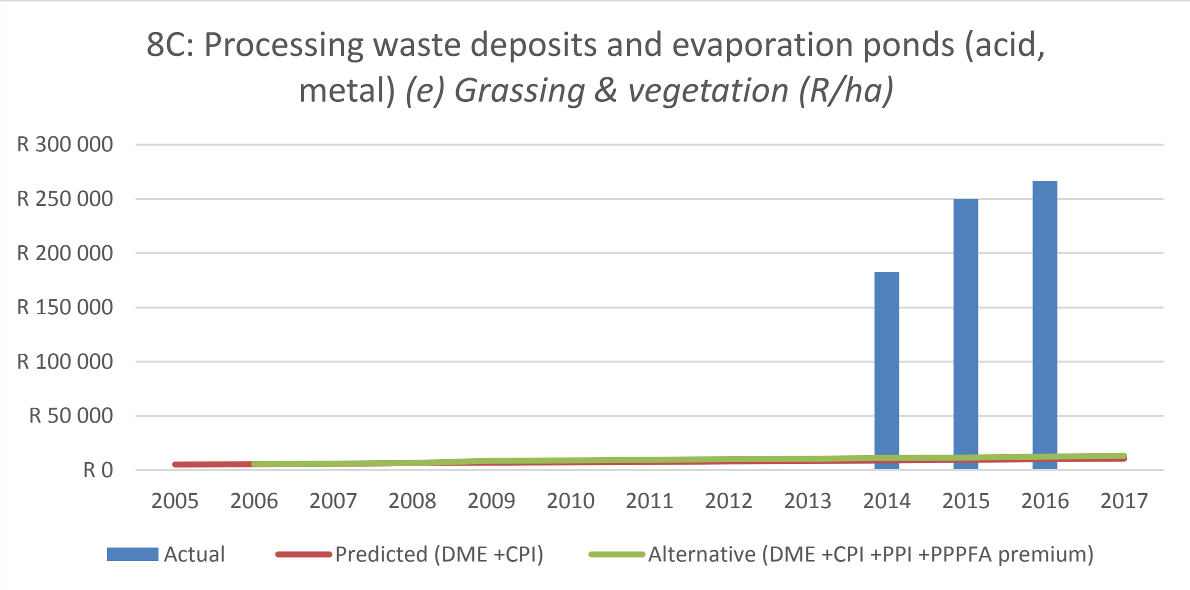

Figure 4.10: Comparison of DME guideline values and actual tender data. Guideline item 8C (e) Grassing & vegetation

The third-party rate per hectare to establish vegetation on dumps according to the specification vastly exceeds the predicted rate by the DME guideline and the CIDB increased rate in all 3 years for which there is data.

4.3.4 (f) The establishment of a borrow pit to obtain cover and topsoil material near the dump

The DME guideline rate provides for the establishment of a borrow pit to obtain material to place on the dump.

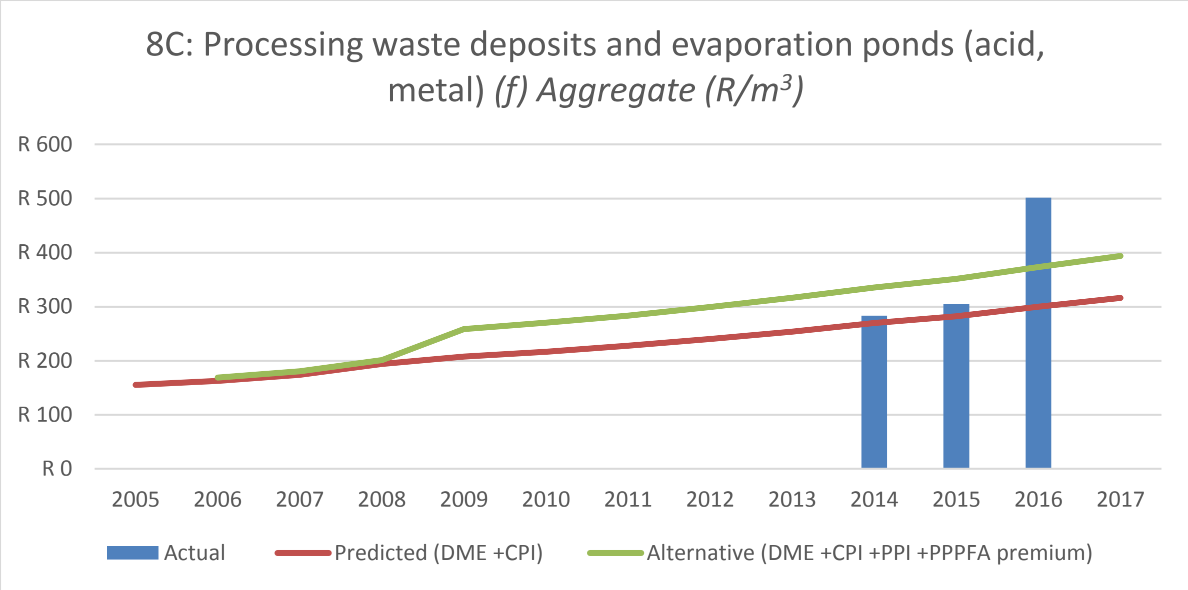

Figure 4.11: Comparison of DME guideline values and actual tender data. Guideline item 8C (f) Aggregate

The third-party rate per m^3 to source and place aggregate on dumps according to the specification follows the predicted DME and CIDB rates closely, but show a steady increase over those rates in the three years for which there is data. In the period from 2014 – 2016, the predicted rate of rehabilitation was in the range of just under R 280/m^3 to over R315 per m^3. The actual tender data during this period was R 283 per cubic meter in 2014, rising through R 204.00 per m^3 in 2015 and then increasing sharply to just over R 500 per m^3 in 2016.

Another specific material cost component included in the master rate in the DME guideline for the rehabilitation of processing waste deposits is the purchase and placing of geotextile used in the covering of the dump and stabilisation of the soil for protection against erosion. This material is a specialised membrane used to stabilise soil and protect against erosion and several standard varieties are available from suppliers. Figure 4.12 provides a comparison of the actual tendered prices for the sourcing and placement of geotextile on waste deposits to the DME guideline values and the predicted rate of escalation from the CIDB report.

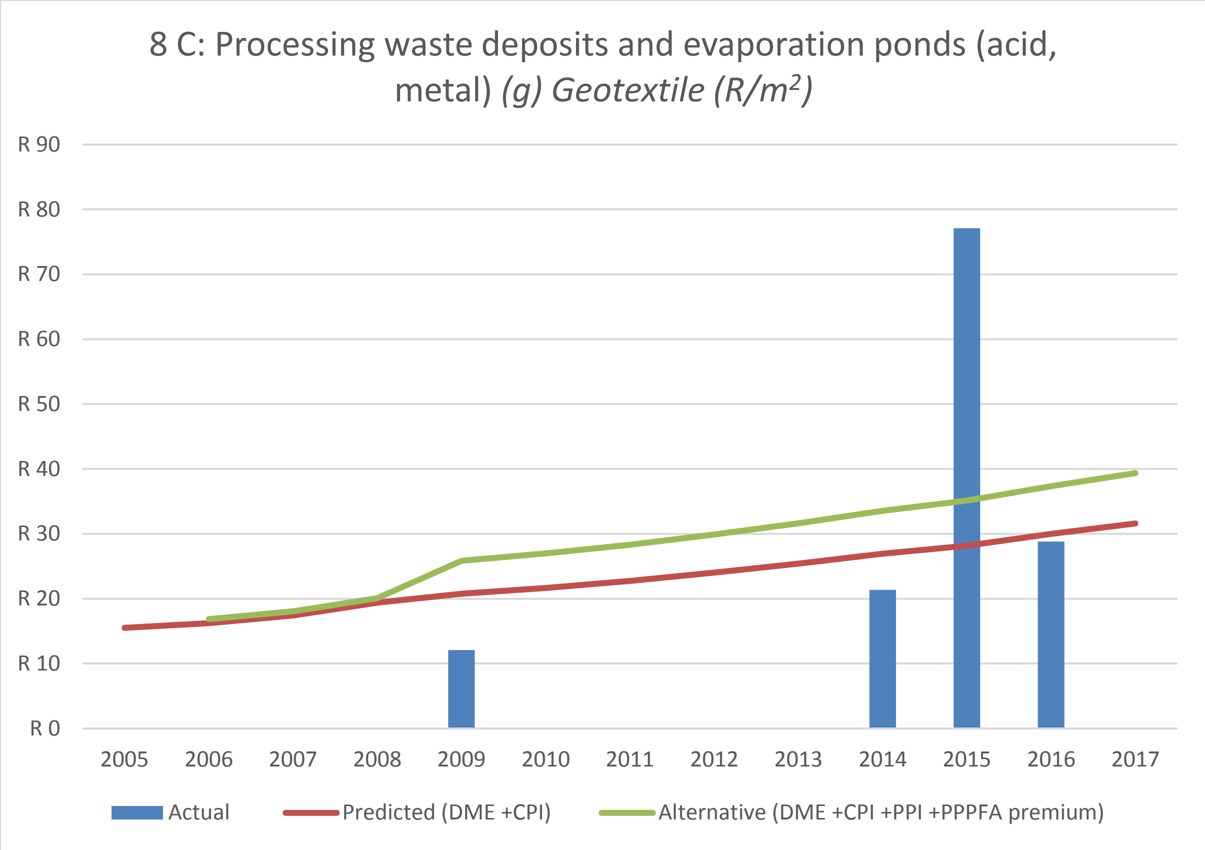

Figure 4.12: Comparison of DME guideline values and actual tender data. Guideline item 8C (g) Geotextile

Although only 4 data points are available, the data displays a similar price pattern to several other master rates analysed in this research report in that the year 2015 provides an anomaly in the recorded results with very high prices for many project components. For the supply and installation of geotextile, 2015 was no exception, when R 77.08/m^2 real prices were tendered versus a predicted R 29.25 per square metre. In other years, the use of the DME guideline rate would have resulted in over-pricing for this cost element.

The unit of measurement of the master rate for overall waste deposit rehabilitation in the DME guideline is ha but the underlying unit rates of the components that comprise this master rate relate more directly to the way the tenders are priced. The overall costs for rehabilitation of waste deposit have therefore been considered in relation to its component values.

4.3.5 Master Rate (10): General surface rehab and grassing

While the master rate for item 8C already includes most of the cost elements that constitute the majority of the work on a typical asbestos rehabilitation project, general surface rehabilitation and grassing is a rate addressed in item 2.7 of the generally accepted closure methods in the DME guideline for areas which are not covered elsewhere. Details of the practical implementation of this step are provided in **Annexure C**.

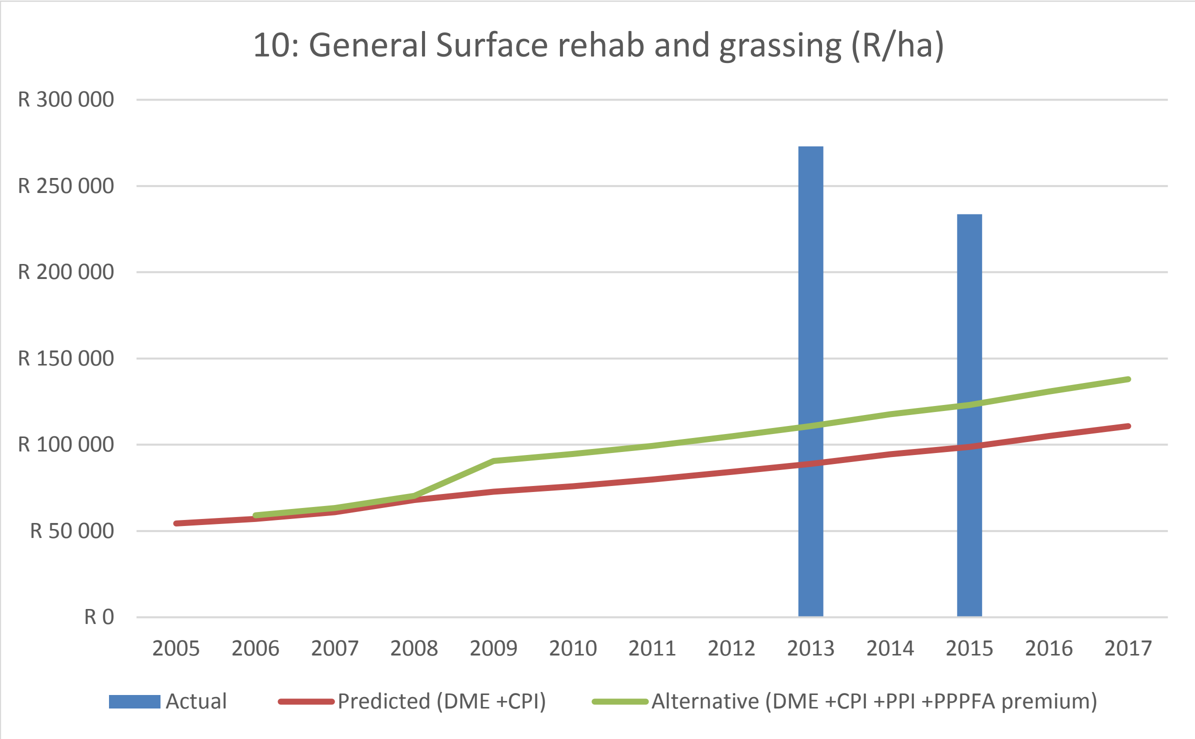

Figure 4.13: Comparison of DME guideline values and actual tender data. Guideline item 10 General surface rehabilitation and grassing

Data was only available for the years 2013 and 2015. This is a result of the manner in which the tenders were compiled. In most other years, the costs for the surface rehab and grassing were broken down into their components and priced accordingly, so calculating a rate per hectare was not possible from a selection of these unstructured component costs for dissimilar projects.[11]

[11] In a quick comparison, the rates for vegetation from the US are presented here: The popular USA mine closure costing tool “Nevada Standardised Reclamation Cost Estimator” (http://nvbond.org) provides an average rate of US$ 776.64 per hectare for seed mix (2008 values). Organic and chemical soil ameliorants as well as mulches should be added to the per hectare seed mix value but these latter elements are costed per kg and the ratio per hectare is not known, so only the seed mix value can be compared here. Allowing for escalation from 2008 and converting to SA Rand at 2013 & 2015 exchange rates, this equals just over R 7,700 per hectare in 2013 and over R 10,100 in 2015. Because this value only relates to the seed mix, the results cannot be directly compared.

4.3.6 Master Rate (12): Fencing

The final master rate in the DME guideline and considered in this report is the erection of fencing to protect the works and restrict access after rehabilitation is completed. The fencing standard is as specified for stock fences in the ARC guideline. (See **Annexure C** for details)

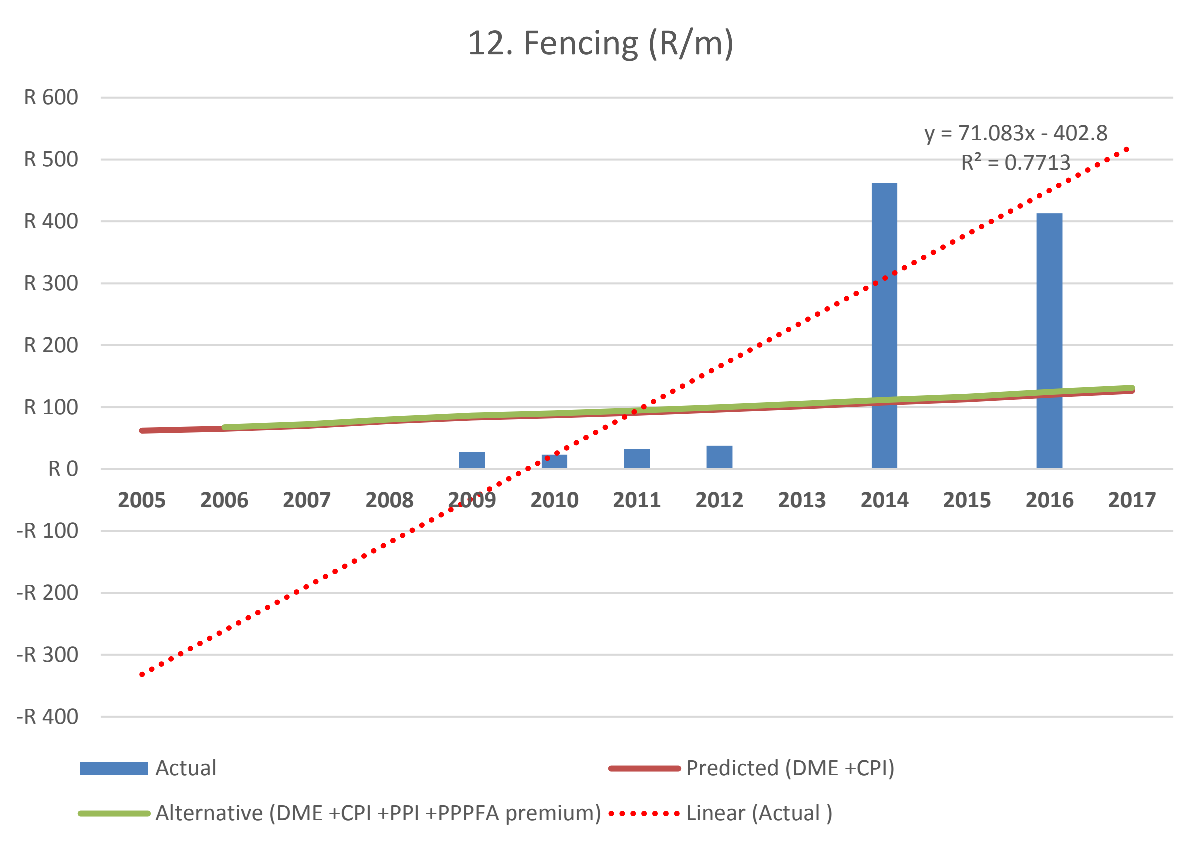

Figure 4.14: Comparison of DME guideline values and actual tender data. Guideline item 12 Fencing

Figure 4.14 provides a comparison of the actual tendered prices for the erection of standard stock fences around rehabilitated project sites with the DME guideline values and the predicted rate of escalation in the CIDB report.

The data for fencing provided 6 data points across the temporal range and it was possible to insert a linear trendline across these points with the formula: $y = 71.083x - 402.8$ The slope of the equation indicates an annual rate of increase or price change of R 71.10/m. Compare this to the guideline predicted rate of increase of only R 5.53/m per year, if the overall CPI value is averaged out to an annual value over the 12 years of escalation. (Compare **ANNEXURE A**) The R^2 value of 0.7713 indicates that the linear trendline fits the data moderately well (correlation over 75%) and that the trendline is therefore a reasonable predictor of the underlying data set.

For the years that data on fencing prices does exist, the data reveals mixed results and does not display a clear pattern. In the years from 2009 – 2012, the actual prices lag the guideline rate by almost 300%, only to then exceed the guideline rate by the same percentage in later years. The rates for fencing are averaged out between the different projects in different areas in any given year, so the effect of local stock availability, etc. would have cancelled out regional economic effects.

4.4 Master Rates other than direct construction works

Preliminary and general costs are costs associated with the establishment of the plant and equipment that need to be mobilised to a project site before commencement of a civil construction project. The DME guideline's master rates tables also contain costs incidental to the establishment of a mine rehabilitation project by a third party, as would be required if the State had to take over the rehabilitation duties when the holder of a right defaults. With the detailed tender and price data obtained from actual submitted bids in the period from 2014 - 2016, it was possible to also graph this data for another insight into the relative cost components.

The master rates table makes allowance for management and administrative costs as follows:

Table 4.5: Extract from DME guideline master rates table for preliminary and general and administrative costs

Additional management and administrative cost item	Percentage of cost item recommended in guideline
Preliminary and General	12.5% of Subtotal 1[12]
Administration and supervision costs	6.0% of Subtotal 1

It was possible to obtain the tendered median values for the preliminary and general as well as administration and supervision costs from the bids submitted for work in the period 2014 – 2016 as a percentage of the median project values. The total prices for all bids submitted in the years before that were not recorded, so a similar comparison could not be made for that earlier period. Note that the administration and supervision cost plotted here reflect internal construction company overheads and supervision and not external supervision and admin by

[12] Subtotal 1 in this instance being the sum of all project master rates, multiplied by their respective factors and quantities for the actual physical rehabilitation components of the specific project site, according to the DME guideline.

the third party implementing agent, who would report to the DME in the case of the State rehabilitating an abandoned mine.

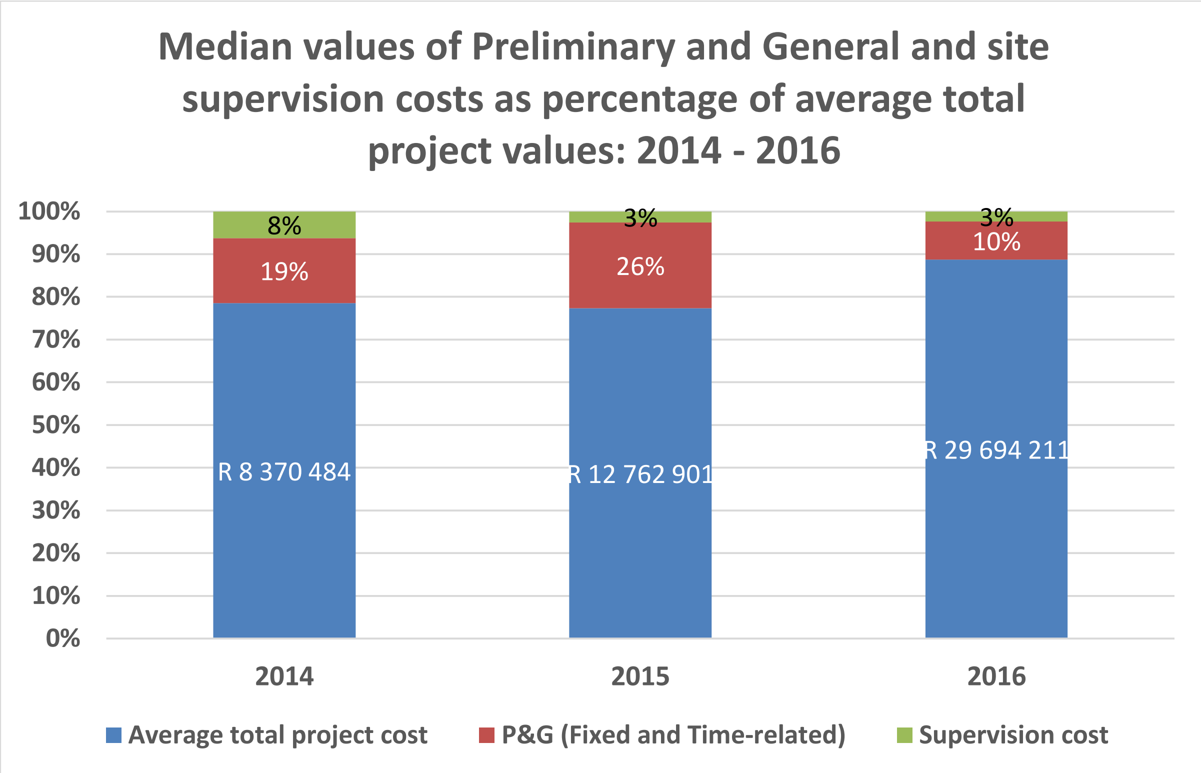

Figure 4.15: Median project values over the period from 2014 – 2016 with the percentages attributable to preliminary and general and site supervision costs

The median values for site supervision (by the contractor on site only) and for preliminary and general costs were calculated from the data obtained from the bids submitted in the period from 2014 – 2016. A significant rise in proportional value for preliminary and general costs in 2015 in attributable to the nature of the projects. In this year, Projects L, M and N were conducted. (see Table 4.2 above) All three of these projects were located in very remote areas. Note here that Section B of the DME guideline makes provision to apply a weighting factor to the rate for preliminary and general cost of projects located in rugged, remote areas and this adds a potential 10% to the price for these projects[13], which would have the overall result of reducing the effective percentage of the P&G cost as part of the overall project cost. (Guideline Section B, Part 4.4.4, Table B.7) It is believed that the relatively higher preliminary and general costs reflect the real cost of establishing all required facilities, plant and

[13] Note here that the guideline allows up to 20% on all master rates for the ruggedness of terrain (Table B.6) and an additional 10% maximum on the Preliminary and General items only for remoteness factor (Table B.7) While projects L, M and N are highlighted here, most projects evaluated are located in remote areas.

equipment on these remote sites where no facilities and amenities or services were available. The guideline document makes no distinction between fixed and time-related preliminary and general project establishment items, and these have been added together to arrive at a final preliminary and general value for the projects in each year. Larger projects typically have lower fixed preliminary and general costs as a percentage of total project value than smaller projects. Also, the time-related aspects of preliminary and general project costs – maintenance of the site facilities – usually affect projects of longer duration differently than shorter duration projects.

The graph in Figure 4.15 above reflects that the P&G's for all projects conducted in 2014 – 2016 varies quite significantly, from 19% recorded in 2014 to 26% 2015 and then again lower than the guideline's prescribed 12.5% at 10% in 2016. It is worth noting the average project values over the same period and the relative remoteness of all projects in the sample for 2015 to help understand these variances. The average project size grew significantly year-on-year, which will affect the median values for preliminary and general costs compared to overall project prices.

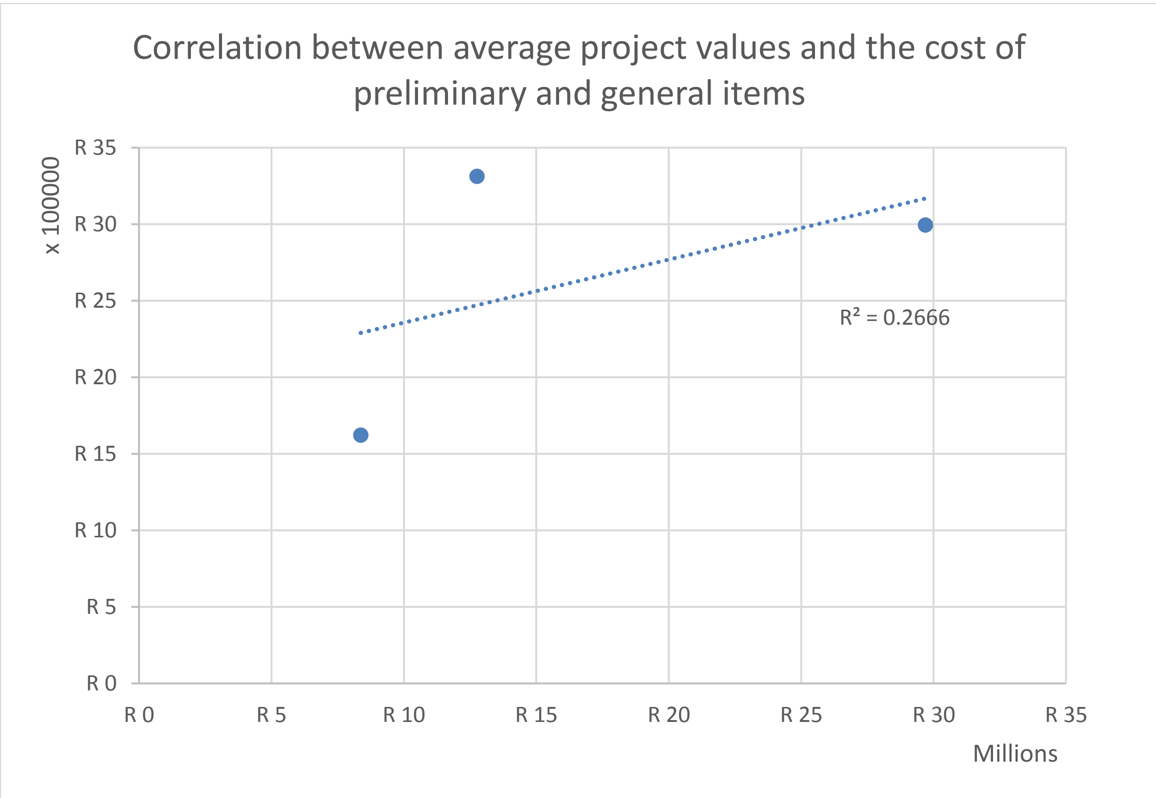

Figure 4.16: Correlation between average tender costs and preliminary and general costs

Figure 4.16 displays the same data as that presented in Figure 4.15 but with the addition of the linear equation for the correlation between the final tender price (as an average of the sample (s) per year) and the median P&G values over the same period. The R^2 value of 0.266 indicates a weak positive correlation between these two elements.

It is already recorded that the guideline prescribes an allowance of 6% for supervision and management costs and that the data from the submitted bids only records the contractors' on-site supervision cost and not that of the implementing agent. The data reflects that the supervision cost, as percentage of total project size, varies in respect of the size of the project. In 2014, when the average project size was just under R8,4 M, the supervision cost was 8% of the total project value. This percentage dropped sharply to a stable 3% in 2015 and 2016, when average project values rose first to R 12,8M and then to R 29,6M. These last two values are well within the 6% prescribed by the DME's guideline document.

4.5 Summary of findings

The findings from the investigations above are summarised in table form as Table 4.6 below. The results present a mixed result containing widely varying values from the DME and CIDB expected values.

Table 4.6: Summary of findings of tender cost comparison with DME guideline values

Rate Component S1.2	Description	Key findings
2B	Demolition of reinforced concrete structures	Actual tender values far exceed guideline master rates and CIDB rates in two of the three years for which data exists. Data considered too sparse for definitive conclusions.
3	Rehabilitation of access roads	Actual tender values exceed guideline master rates and CIDB rates in all years for which data is recorded.
5	Demolition of housing and facilities	No useful tender data recorded – only one data point (one year) Not evaluated in this report.
7	Sealing of shafts, adits and inclines	Actual tender values are a mixed result when compared to DME guideline master rates. Certain component rates are lower than guideline rate and others higher.

Rate Component S1.2	Description	Key findings
		Component rate (a) – Four datum points indicate that real costs for backfilling of shaft vastly exceed master rate and CIDB rate in all years for which there is data. Component rate (b) – Real rates for providing concrete caps for shafts is much lower (less than 50%) than the DME guideline rate and CIDB rate in all years.
8C	Processing waste deposits and evaporation ponds (acid, metal)	Actual tender values far exceed guideline master rates. Component rates differ widely from DME guideline master rates: (a) Slope modification of dumps: Actual tender values exceed guideline rates and CIDB rates in each year – greater difference in later years. (b) Shaping of dumps: Actual tender prices significantly and consistently exceed the guideline values in every year. (c) Armour cover layer: Actual tender prices match the guideline and CIDB rates in earlier years and then exceed the guideline rates by a very large margin in later years. (d) Soil cover layer: Actual tender prices slightly exceed the guideline and CIDB rates in earlier years and then exceed the guideline rates by a very large margin in later years. (e) Grassing and vegetation: Only three data points but these greatly exceed the guideline master rate in every year. (f) Aggregate: Only three data points which follow the master rate with an exceedance in the final year. (g) Geotextile: Four (4) data points which all lag the guideline rate, with the exception of 2015, when there is a large difference.
10	General surface rehab and grassing	Actual tender values far exceed guideline master rates for years with data. Only two data points available so the results are not considered sufficient for a valid conclusion.
12	Fencing	Actual tender values lag far behind guideline master rates in early years, only to exceed the master rates in later years.
	Preliminary and General	The Preliminary and General costs exceed the guideline rate of 12.5% on smaller projects but seems to decrease to under 10% on larger projects. The correlation between this relationship is weak, however.

The analysis of the DME, CIDB and actual tender prices for the various master rates and component rates presented in the preceding chapter presents a mixed result. In most cases, the actual tender values exceed the guideline master rates. Also, as a general observation, the total of 4% difference that the CIDB report introduces, does not make any meaningful difference to the DME master rates when compared to the amount of the actual values and their differences to the baseline or guideline rates. The CIDB escalation is therefore an equally poor indicator of real tender values than the DME guideline rate. There are some areas where the DME guideline predicted the rates escalation of the master rates rather accurately, but these are the exceptions to the general observation. Also observable is that the rates seem to escalate fairly evenly until 2012 and that there is a distinct rise in the rates from 2014 onward, with the year 2015 providing the greatest of these variances.

As an overall trend, it is notable that a sharp increase in prices is evident across almost all cost values from the 2015 tenders. In this year, Mintek elected to obtain the assistance of an engineering consultancy to assist in compiling the tender documentation, which it had been doing in-house before. As a result, the tender specifications became a lot more complex. This complexity need not necessarily have translated to increased costs on a per line item basis, unless bidders were costing in additional overhead costs on the projects.

The prices and cost estimates at overall project cost levels paint a different picture altogether. Here, other factors play a role in determining, in many cases, that the final project cost is much lower than an item-by-item analysis of the median values of the component rates might suggest. (See Chapter 7) The purely statistical approach to the component rates of rehabilitation costs seem to suggest that costs are much higher in most cases than the DME and CIDB predicted rates.

5 DISCUSSION

The data obtained from the actual tender prices for mine rehabilitation projects by a third party suggests that the use of CPI to escalate mine rehabilitation costs was very quickly overtaken in reality by different, higher annual costs and rate increases for most of the DME guideline master rates that relate to surface mining. It means that the DME guideline master rates were not reflective of actual rehabilitation costs by the time that the use of the DME guideline was effectively scrapped by the DEA in 2017.

It is acknowledged that the data used to compile this report represents only a small sample of the actual data that is required to fully cost an operational mine for closure. The original population size (n) was significant at 50% of the total population of projects undertaken from 2009 to 2016. The sample of bids submitted from which the BOQ level data could be extracted to work with within the population (s) was also sufficient in most cases. The issue here is the limited scope of a typical asbestos mine surface rehabilitation project and the resultant limitation on the wider applicability of the findings of this report to the overall objective. Mines are very large, complex industrial organisations in themselves and to fully cost for their closure is the work of teams of experts over many months. This analysis points to values recorded for simpler types of surface remediation works only and many other values are required with several specialist inputs, to arrive at real values.

The analysis of the actual tender prices for the various master- and component rates in comparison with the DME guideline rates delivered mixed results. While the medians of actual tender values exceeded the guideline master rates in most cases, there were notable exceptions and instances where the actual tender results lagged the master rate. It was also found that introducing the premiums for PPI and CPG's suggested by the CIDB report resulted in no better predictive ability in the variation of actual prices from the DME master rate. Indeed, the rise in prices reflected in the CIDB's own report for the 2009 year in BCI and PPI was not reflected in any of the master rate tender price data. There is a myriad of potential factors that could potentially explain the vast differences observed in later years' tender prices form the guideline rates. One interesting possibility is that the significant rate increase across many of the master rate and component values after 2011 could be linked to increased CPG and legislative requirements under the PPPFA, as explained in the CIDB report. Other potential factors include, but are not limited to: regional price differences, the effects of more complex designs and planning, opportunism in government tenders, over-engineering of projects and real actual input price increases, though this is not supported by the research conducted by the CIDB. The reported CIDB escalation rates are equally poor indicators of probable mine rehabilitation costs than the DME guideline rate. The reasons for the deviations remain unclear. What is known, is that any mine that followed the DME guideline closely, is likely to have an inaccurate result on several master rates and thus financial provision if a third party were to do the work.

Whilst no perfectly linear and distinct relationship could be deduced, the results seem to broadly support the findings of Du Plessis and Brent (2006), Hewitson (2012) and, to an unproven extent, the Department of Public Works (2017) in that the actual costs to rehabilitate a mine are much more than the guideline document will lead a mine to provide for. Similarly, the report of van Zyl *et al*, which found that the financial provision of most mines in South Africa are underfunded and which recommends an update of the guideline values, must likewise be supported. This author must necessarily agree with these previous works in their assessment that the DME guideline rates do not provide adequate financial provision, even if used correctly and duly escalated, to properly close a mine at industry-related rates, as borne out by the actual tender data from real mine rehabilitation projects.

An additional key observation in counterpoint to the observed data trends for rehabilitation components, which are statistical medians, is the real award of projects to the lowest bidder. The data on observed total project costs presented in Chapter 7 below indicate lower prices in most cases than the predicted costs for each project. Although the underlying cause was not analysed, it is a likely conjecture that the market force of competition, tied to the strict rule of awarding work to the lowest bidder, plays a powerful role in keeping actual costs lower than predicted by the engineers and lower than median component rates would suggest.

6 CONCLUSION

It must be realised that the use of a mine's financial provision, or state funds, for that matter, to rehabilitate an abandoned mine or a mine where the owner has failed to rehabilitate for whatever reason, presents the worst-case scenario for all role-players concerned. It implies that all systems that are currently legislated and regulated to ensure the proper, planned closure of a mine, have failed. The analysis conducted in this research report, using actual tender data from past mine rehabilitation projects conducted by the State in the interest of ensuring a safer and healthier environment for the people of South Africa, illustrates the rates of change in the cost of these projects.

To return to the stated objectives of this research report, the guideline values published by the DME in 2004 seem to have failed to provide useful guidance to calculate mine rehabilitation costs when compared to actual tender data. The guideline values deviate significantly from the actual mine closure costs as evidenced by the responses to mine rehabilitation project tenders in several areas and for several years. As a result, it is very likely that mines which used the DME guidelines in the period from 2005 to 2016 have significantly underfunded their closure and rehabilitation provisions.

These rates of change outstrip CPI and fell out of alignment with the master rates prescribed by the DME rather quickly. In addition, new requirements for State projects in the form of preferential procurement and community participation or developmental initiatives have exacerbated this problem that the rates published are further removed from the real rate of cost increases introduced by contractors in seeking compliance with new legislation.

In conclusion, the data obtained from the actual tenders for mine rehabilitation projects provided only a limited insight to the probable rates for rehabilitation project cost components. The statistical analysis and use of median of all rates tendered, while useful, hides the final project overall costs, which are subject to other forces. In many cases the median rates are much higher (in some cases up to 10 times) than the rates predicted by the guideline. In other instances, the actual tender costs closely trace the predicted guideline values and then spike massively in later years. In either event, the real tender award prices are most often lower than predicted and lower than the average of all bids submitted. It is surmised that the median values analysis may point to industry cost trends but not necessarily predict actual tender costs ion final award. There are no clear explanations for the noted anomalies from the research conducted and further work will be required to find the root cause of these price increases.

With regards to the regulatory environment to make financial provision, the replacement of the DME guideline has left the State without its own mechanism for assessing the quantum of financial provision for mine closure – deficient or not. This report has borne out similar results to those found by Hewitson, Brent and Du Plessis and van Zyl *et al*, namely that the DME guideline was perhaps not an accurate predictor of closure costs. However, there are other points that relate to the new financial provision regulations which are very relevant for future consideration:

1. Firstly, by totally doing away with an internal, stand-alone guideline to determine or at least gauge overall closure costs, the State is placing heavy reliance on independent assessors, auditors and a supporting network of quantity surveyors and civil engineers. The removal of the guideline also removes the ability of the State to conduct an independent review of potential or estimated closure costs and no doubt serves to improve business conditions for the independent auditors.
2. The results presented in this research report supports the findings of Du Plessis, Brent and Hewitson as well as van Zyl and the CIDB that the escalation of closure costs, however calculated, by CPI on an annual basis is not sufficient.
3. The exclusion of Preliminary and General cost elements from the new financial provision regulations is nonsensical. The preliminary and general costs on State rehabilitation projects are proven from historical data presented in this research report to be between 10 and 26% of project costs as an average of several projects sampled for this research report. If a third party is used to conduct the rehabilitation, these costs will have to be incurred. Likewise, the exclusion of VAT from the market rate in the new regulation is a nonsensical step as VAT would certainly have to be paid for a third party to do the rehabilitation work.

The philosophy of the South African system of making provision for mine closure is not to act as deterrent by elevating the risk of loss versus the decision to rehabilitate the mine. However, the logical choice must always be to reduce the amount of outstanding closure cost by performing concurrent rehabilitation from operating expenditure. The simple provision for third part preliminary and general cost, and site establishment already adds 25% to any provision made. While the mine has operating capital and equipment, it is still the most cost-effective way to concurrently rehabilitate. The question is, however, what rates the consultant provided for in the new regulations under NEMA will use. If mines have been diligently using the guideline rates set by the DME in the guideline, their overall cost estimate and hence amount of provision will be out; higher in some cost elements and lower in others. The individual situation will differ amongst mines. Certainly, the mine rehabilitating for itself is a much more cost-effective option and the intention of all legislation that governs mine rehabilitation.

The results of the research presented in this report has highlights the risks at looking at the available data from one perspective only. When considering only the statistical data from the master rates, one could surmise that the State is potentially paying a steep premium for mine rehabilitation projects. Additional data on the total awarded tender prices compared to the engineers' estimates and average price of bids received suggest otherwise. The overall cost data seem to indicate that the State Procurement formulae that enforce award of the work to the lowest bidder is working, along with competition for work in the market, to drive costs lower than predicted. The reasons behind some of the massive cost variations observed in some years and for some cost elements remains an untested phenomenon. The population of tender data only provided an insight into the costs of small and simple opencast mining operations and it a fair question if these results will be the same for other elements of other forms of mine or underground operations? These aspects will require much more extensive research and more in-depth data collection to develop better insights into the underlying causes of the observed patterns.

7 POSTSCRIPT: FURTHER INSIGHTS FROM TENDER PRICES

During the course of making the final amendments to this research report, after evaluation and grading by both internal and external examiners, the author realised that the *line item* values of tenders, as expounded in this paper, do not match the *overall* project costs as awarded to bidders. This discrepancy does not make sense at first glance – how could the underlying line items be proven to cost more than the estimate, yet overall project costs are almost always much lower than predicted? There is, of course, a perfectly logical explanation for this.

The analysis performed in Chapter 4.3 above on a line item basis for the various cost elements, clearly indicate higher than anticipated costs of the various closure elements. The noted discrepancy with overall project costs forced the author to take another perspective on total costs per project completed and thus to see how the *overall* project costs compare to professional estimates. Various role players in the mine rehabilitation process have different objectives for the mine rehabilitation projects and this affects their pricing philosophy. It is generally considered that the design engineers would hedge their reputational risk in their cost estimates and thus make conservative allowances in the project pricing estimate. The contractors, on the other hand, compete for projects on the open market, but must also make profit. As Mintek is a state-owned enterprise, the procurement practitioners are bound by strict rules that favour the lowest bidder.

It follows that each project has three comparable values or estimates of cost even before it starts. The engineer provides the first (usually conservative) cost estimate. The average of all bids received at tender phase is probably a good indication of the real market value for the project cost and here it would be reasonable to assume that a normal distribution curve would fit the distribution of total project costs received from all bidders. The procurement rules, however, force the project owner to select the lowest bidder.

This additional data illustrates that the use of medians of the actual tendered prices, as was done in 4.3 above, might hide the reality of tender awards: That markets operate in a competitive environment. While median item cost analysis per line item may be a statistically sound endeavour, it annuls the fact that the prescribed formula[14] to award competitive bids, always favours the lowest bidder. The purely statistical analysis of the data points to a given result on a per-line item level, but other factors point to more reasonable costs on an overall project cost basis. Overall project execution costs, when compared to the engineer's cost estimate and even the average of bids submitted, is almost always lower. (See Figure 7.1 below)

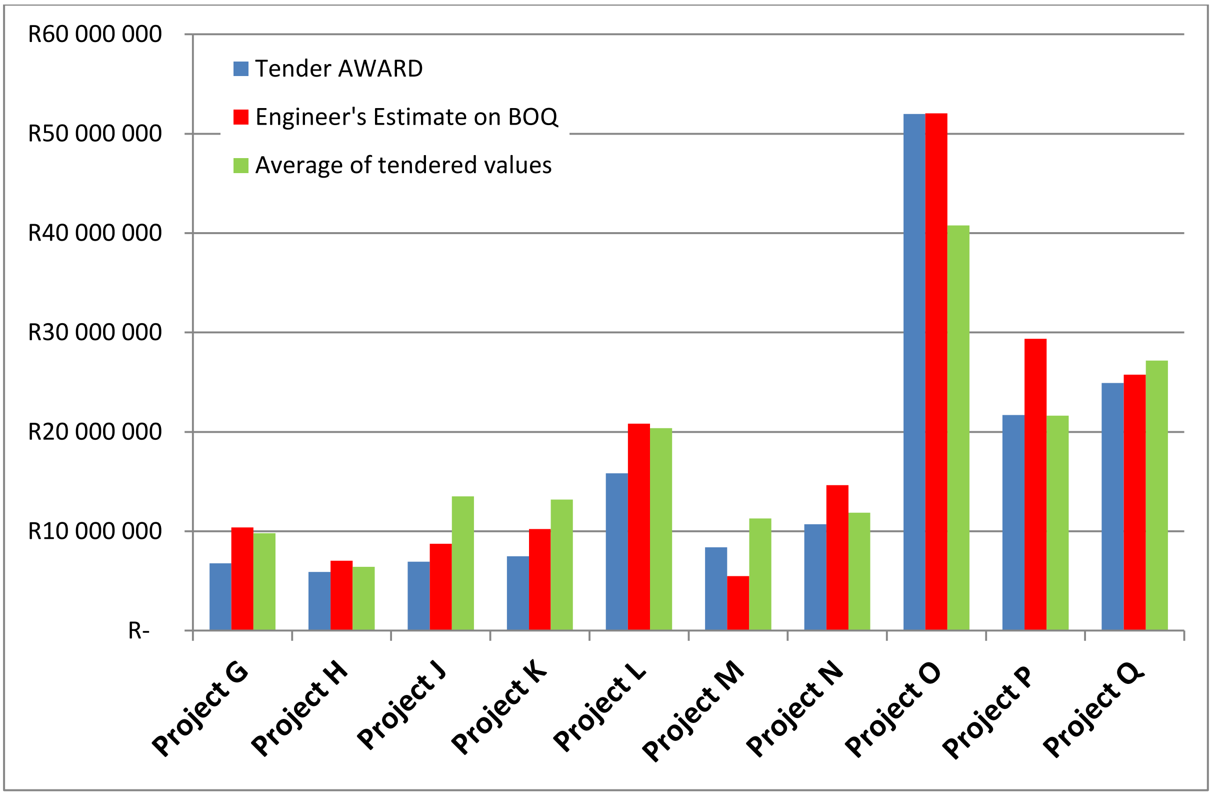

Figure 7.1 Comparison of total awarded project cost with engineer's estimate and average of all bids submitted for selected projects

Figure 7.1 offers a comparison of actual tender award prices with the engineer's cost estimate and the average of all bids submitted for selected projects which are the subject of the analyses conducted in 4.3 above. As can be seen, the projects are usually awarded for a lower value than the engineer estimates, with only Project M being the exception from this norm.

[14] The formula prescribed by National Treasury in the Preferential Procurement Regulations, 2001 and other Treasury Instructions applies to all government tender or tender awarded by State -owned enterprises, with little variation. This formula is: $Ps = 90(1 - (Pt - Pmin)/Pmin)$The formula works out a percentage point score for price that normalises all scores on the lowest bidder, who scores 100%. All other, higher bidders score less. The formula can only change to base the score on 80 or 90 % for price. The rest is made up of a preferential procurement score based on the bidder's BEE credentials, which are also prescribed. It implies that the lowest bidder who qualifies to do the work, has the advantage and must be awarded the bid.

Additionally, projects are usually awarded to the lowest bidder and the project cost is thus typically less than the average of all bids submitted. From the sample reflected in Figure 4.26, only Projects O and P were exceptions to this general observation.

This insight into the relative values of project prices does not necessarily distract from the findings of the research report. The research report looked at general trends in industry prices versus the predicted costs of the DME guideline. The comparison to median values is a sound approach to analyse trends in the industry pricing and the method followed is capable of drawing robust conclusions. What this final insight shows is that, while one can be aware with certainty of underlying trends in the industry in terms of pricing, the overall project costs are artificially forced to award the project to the lowest bidder in a competitive market. In hindsight, one must therefore not look at median tendered values to get a good indication of probable project costs when compared to the DME guideline values, but rather at the first quartile values. The comparison of the first quartile values rather than medians would potentially give a vastly different outcome to the data analysed but could not be performed within the timelines required to submit the final research report. This is considered a logical next step and a potentially fertile area for further work in this field.

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ANNEXURE A: MASTER RATES TABLE ESCALATED TO 2017

DMR Master rates table for financial provision

Adjustment of published guideline master rates with CPI inflation statistics (2005 - 2017)

Rate Component	Description	Unit	Published rates 2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
S1.2	Annual adjustment for published CPI figures	CPI %		3.4%	4.7%	7.1%	11.5%	7.1%	4.3%	5.0%	5.6%	5.7%	6.1%	4.6%	6.4%	5.4%
1	Dismantling of processing plant	m^3	R 6.82	R 7.05	R 7.38	R 7.91	R 8.82	R 9.44	R 9.85	R 10.27	R 10.71	R 11.17	R 11.66	R 12.16	R 12.68	R 13.22
2A	Demolition of steel buildings & structures	m^2	R 95.00	R 98.23	R 102.85	R 110.15	R 122.82	R 131.54	R 137.19	R 143.09	R 149.24	R 155.66	R 162.36	R 169.34	R 176.62	R 184.21
2B	Demolition of reinforced concrete structures	m^2	R 140.00	R 144.76	R 151.56	R 162.32	R 180.99	R 193.84	R 202.18	R 210.87	R 219.94	R 229.40	R 239.26	R 249.55	R 260.28	R 271.47
3	Rehabilitation of access roads	m^2	R 17.00	R 17.58	R 18.40	R 19.71	R 21.98	R 23.54	R 24.55	R 25.61	R 26.71	R 27.86	R 29.05	R 30.30	R 31.61	R 32.96
4A	Demolition and rehabilitation of electrified railway lines	m	R 165.00	R 170.61	R 178.63	R 191.31	R 213.31	R 228.46	R 238.28	R 248.53	R 259.21	R 270.36	R 281.99	R 294.11	R 306.76	R 319.95
4B	Demolition and rehabilitation of non-electrified railway lines	m	R 90.00	R 93.06	R 97.43	R 104.35	R 116.35	R 124.61	R 129.97	R 135.56	R 141.39	R 147.47	R 153.81	R 160.42	R 167.32	R 174.52
5	Demolition of housing and facilities	m^2	R 190.00	R 196.46	R 205.69	R 220.30	R 245.63	R 263.07	R 274.38	R 286.18	R 298.49	R 311.32	R 324.71	R 338.67	R 353.24	R 368.43
6	Opencast rehabilitation including final voids and ramps	ha	R 99 600.00	R 102 986.40	R 107 826.76	R 115 482.46	R 128 762.94	R 137 905.11	R 143 835.03	R 150 019.94	R 156 470.80	R 163 199.04	R 170 216.60	R 177 535.91	R 185 169.96	R 193 132.27
7	Sealing of shafts, adits and inclines	m^3	R 51.00	R 52.73	R 55.21	R 59.13	R 65.93	R 70.61	R 73.65	R 76.82	R 80.12	R 83.57	R 87.16	R 90.91	R 94.82	R 98.89
8A	Rehabilitation of overburden and spoils	ha	R 66 400.00	R 68 657.60	R 71 884.51	R 76 988.31	R 85 841.96	R 91 936.74	R 95 890.02	R 100 013.29	R 104 313.86	R 108 799.36	R 113 477.73	R 118 357.28	R 123 446.64	R 128 754.84
8B	Processing waste deposits and evaporation ponds (salt)	ha	R 82 700.00	R 85 511.80	R 89 530.85	R 95 887.55	R 106 914.61	R 114 505.55	R 119 429.29	R 124 564.75	R 129 921.03	R 135 507.64	R 141 334.47	R 147 411.85	R 153 750.56	R 160 361.83
8C	Processing waste deposits and evaporation ponds (acid, metal)	ha	R 240 200.00	R 248 366.80	R 260 040.04	R 278 502.88	R 310 530.71	R 332 578.39	R 346 879.27	R 361 795.07	R 377 352.26	R 393 578.41	R 410 502.28	R 428 153.88	R 446 564.50	R 465 766.77
9	Rehabilitation of subsided areas	ha	R 55 600.00	R 57 490.40	R 60 192.45	R 64 466.11	R 71 879.72	R 76 983.18	R 80 293.45	R 83 746.07	R 87 347.15	R 91 103.08	R 95 020.51	R 99 106.39	R 103 367.97	R 107 812.79
10	General surface rehab and grassing	ha	R 52 600.00	R 54 388.40	R 56 944.65	R 60 987.73	R 68 001.31	R 72 829.41	R 75 961.07	R 79 227.40	R 82 634.18	R 86 187.45	R 89 893.51	R 93 758.93	R 97 790.56	R 101 995.55
11	River diversions	ha	R 52 600.00	R 54 388.40	R 56 944.65	R 60 987.73	R 68 001.31	R 72 829.41	R 75 961.07	R 79 227.40	R 82 634.18	R 86 187.45	R 89 893.51	R 93 758.93	R 97 790.56	R 101 995.55
12	Fencing	m	R 60.00	R 62.04	R 64.96	R 69.57	R 77.57	R 83.08	R 86.65	R 90.37	R 94.26	R 98.31	R 102.54	R 106.95	R 111.55	R 116.34
13	Water management	ha	R 20 000.00	R 20 680.00	R 21 651.96	R 23 189.25	R 25 856.01	R 27 691.79	R 28 882.54	R 30 124.49	R 31 419.84	R 32 770.89	R 34 180.04	R 35 649.78	R 37 182.72	R 38 781.58
14	2 to 3 years of maintenance and aftercare	ha	R 7 000.00	R 7 238.00	R 7 578.19	R 8 116.24	R 9 049.60	R 9 692.13	R 10 108.89	R 10 543.57	R 10 996.94	R 11 469.81	R 11 963.01	R 12 477.42	R 13 013.95	R 13 573.55

ANNEXURE B: CLOSURE COST ELEMENTS USED AS BASE ASSUMPTIONS FOR CERTAIN MASTER RATES IN THE DME GUIDELINE: (verbatim from the DME guideline 2004: Appendix C.3)

Master rate items	Details of costing consideration/ units of measurement
2.5 Component 7: Sealing of shafts, adits and inclines	The sealing of vertical and incline shafts is primarily a safety consideration and this should be conducted in such a manner that potential safety risks are largely obviated. Normally, inert building rubble arising from the demolition of surface infrastructure should be deposited into the shafts. A mass concrete cap of 1 000 mm thickness is placed onto the building rubble deposited into the shaft. It should be noted that, in specific circumstances, dedicated engineering design and specification of these caps could be required. Allowance should also be made for methane venting of the underground mine workings with a methane formation potential by means of strategically placed venting boreholes. The unit cost is based on filling and capping of both vertical and inclined shafts of dimensions 12,5 m diameter and 5,5 x 5,5 m respectively. The Master rate allows for the average cost of rendering both vertical and an incline shafts safe. The costs of geotechnical investigations and surveying were fixed at R50 000 and R20 000 respectively. Professional fees were taken at 2.5 % of the rehabilitation cost. Supervision fees were not included.
2.6 Components 8 (A), 8 (B) and 8 (C): Overburden and spoils, Process plant	Overburden and spoils normally have a low pollution potential and hence only need to be shaped to create a stable landform. The Master rate thus includes shaping and grassing/vegetation of the overburden and spoils.

Master rate items	Details of costing consideration/ units of measurement
waste: basic, salt-producing and Process plant waste: acidic, metal-rich. 2.6.1 Component 8A: Overburden and spoils	
2.6.4 Closure elements 2.6.4.1 Slope modification	Slope modification is enforced by the Department of Minerals and Energy to achieve residue deposit stabilisation. Generally, average modified outer slopes of 1:3 (18°) are required. Experience indicates that mine residue deposits are normally formed by end-tipping, either by truck and/or overland conveyor. This results in outer slope at the natural angle of repose of the deposited material. This could vary between 25° to 35° and even steeper for more rocky material. Residue deposits normally vary between 10 and 40 m in height. Heights even up to 80 to 120 m are also encountered. The Master rate was based on a typical ellipse formed dump 30 m high, with unmodified outer slopes of 35°, covering a footprint area of 12 ha. In this case the sectional cut-and-fill volume to reduce this slope to 18° would equate to approximately 170 m^3/m. The creation of the required outer slope of 18° would require the movement of about 185 000 m^3 of material and would increase the footprint area to approximately 15 ha. The total outer slope area of the shaped residue deposit amounts to about 18 ha. Covers fulfilling the above functions could be of varying nature, comprising of natural and/or synthetic material.

Master rate items	Details of costing consideration/ units of measurement
	If natural materials are to be used, current practice allows for an evaporative cover, varying in thickness between 750 and 1 000 mm, with an outer cover layer of 300 m thickness of armouring or topsoil with vegetation. The armouring also requires vegetation, but this is not essential for the long-term integrity of the outer cover layer. Depending on the nature of the deposited material covered, capillary breaker layers between the evaporative cover and the deposited material could also be required. Seepage modelling is normally required to optimise cover thickness. The Master rate allows for an evaporative cover of sandy/loam material. It has been assumed that material of this nature is available within free haul distance from the residue deposit to be rehabilitated or has been stockpiled in close proximity of the residue deposit. The unit cost allows for the establishment of a borrow-pit to source evaporative cover material. Ideally, the established borrow-pit can be converted into a pollution control dam to collect and evaporate possible contaminated seepage arising from the rehabilitated residue deposit. The volume of material required to create an evaporative cover of 750 mm thickness on the hypothetical residue deposit with modified outer slopes, amounts to 135 000 m^3. The associated armouring material for the outer layer of 300 mm thickness amounts to 55 500 m^3. It has also been assumed that the armouring material can be obtained within a reasonable haul distance. Vegetation will have to be provided over an area of about 18 ha, including the upper surface of the residue deposit

Master rate items	Details of costing consideration/ units of measurement
2.7 Component 10: General surface rehabilitation	Final surface rehabilitation of areas disturbed by mining and related activities should be aligned to the selected final land use. Irrespective of the final land use, general surface rehabilitation normally should ensure the following: • Surface topography that emulates the surrounding areas and aligned to the general landscape character. Steep slopes in excess of 6 percent should also be avoided if possible. • Landscaping that would facilitate surface runoff and result in free draining areas. If possible, the drainage lines should be reinstated. • An area without unnecessary remnants of structures and surface infrastructure to give the rehabilitated area a "neat" appearance. Special attention must be given to shape and/or removal of heaps of excess material being the legacy of prolonged mining and related activity. • An area suitable for revegetation. The unit cost for general rehabilitation allows for shaping and landscaping of disturbed areas. The Master rate allows for the shaping of material to a depth/thickness of about 500 mm. An extra over allowance in the unit cost of 50 percent has been made to cover the removal and/or destruction of surface infrastructure remnants and/or other undesirable objects such as trees, foundations, concrete slabs, etc.

ANNEXURE C: EXPLANATORY NOTES ON APPLIED CLOSURE METHODS AND STANDARDS

The following are examples of the actual site conditions, brief descriptions methods employed and practical implementation considerations during the rehabilitation of asbestos mines. These notes provide more information on the master rates and components for which data is analysed in Chapter 4.3 of this research report.

Master rate (2): Demolition of concrete structures (4.3.1, Page 50)

It is rare to find concrete structures of the size and structural integrity that require demolition other than normal surface rehabilitation methods on an abandoned asbestos mine. These types of structures do occur, however. The DME guideline provides a master rate for the demolition of these structures that includes demolition to below ground level and then covering of the area while the rubble is buried, usually on the site.

Access roads (4.3.2, Page 51)

In the case of abandoned asbestos mines, most access roads are found in conditions where they have not been maintained for several decades. These roads usually require being rebuilt or constructed where they do not exist such as where the majority of operations were historically done by hand and mechanical equipment now require access to the site to rehabilitate. The DME guideline allows for a master rate calculated based on the grading of the road surface, placing of suitable wear layers and compaction to a specific hardness to convey equipment to the project site. This road is usually broken up and revegetated after rehabilitation is complete to enable vegetation to grow over the area again, along with the general surface rehabilitation. (Appendix C.3) The unit of measurement that the DME Master rate is based on, is square metres (m^2)

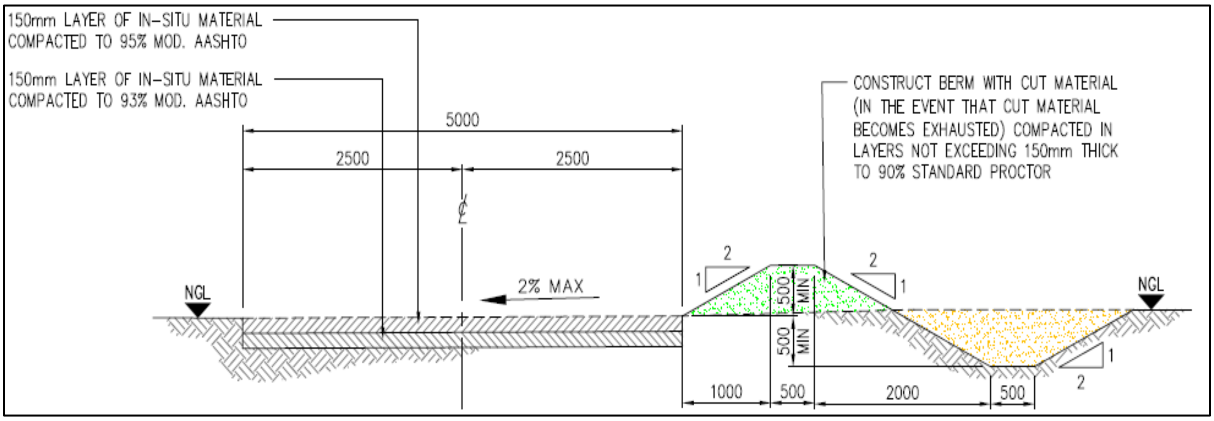

Figure A-3.1: Typical cross-section of access road rehabilitation details as specified in modern asbestos rehabilitation projects (Source: Mintek)

Master rate (7): Sealing of shafts, adits and inclines (4.3.3 , Page 52)

Many abandoned asbestos mine sites contain several open adits or vertical shafts. These adits are often overgrown with vegetation. In practice, these are usually closed by backfilling with waste rock available on site and then capped with concrete and/ or a gabion in the mouth of the structure before finally being covered with rocky material and soil to hide the entrance. Such sites are thus sealed physically and aesthetically.

Figure A-3.2: Adits are small, usually hand-dug inclined or horizontal entrances to asbestos seams that are found on most project sites (Source: Author)

The general approach to adit closure aligns closely with the methodology described in the DME guideline and the master rate is considered directly applicable. The DME guideline prescribes that the rate is based on a closure method that uses the polluted material to first backfill the shaft or incline shaft and then provide a concrete cap over the shaft entrance. The unit of measurement as prescribed in the DME master rate is cubic metres (m^3) but this rate has two component costs, being backfilling of the shaft or adit and the installation of a concrete cap, that relates more closely to the source data obtained from tender BOQ's.

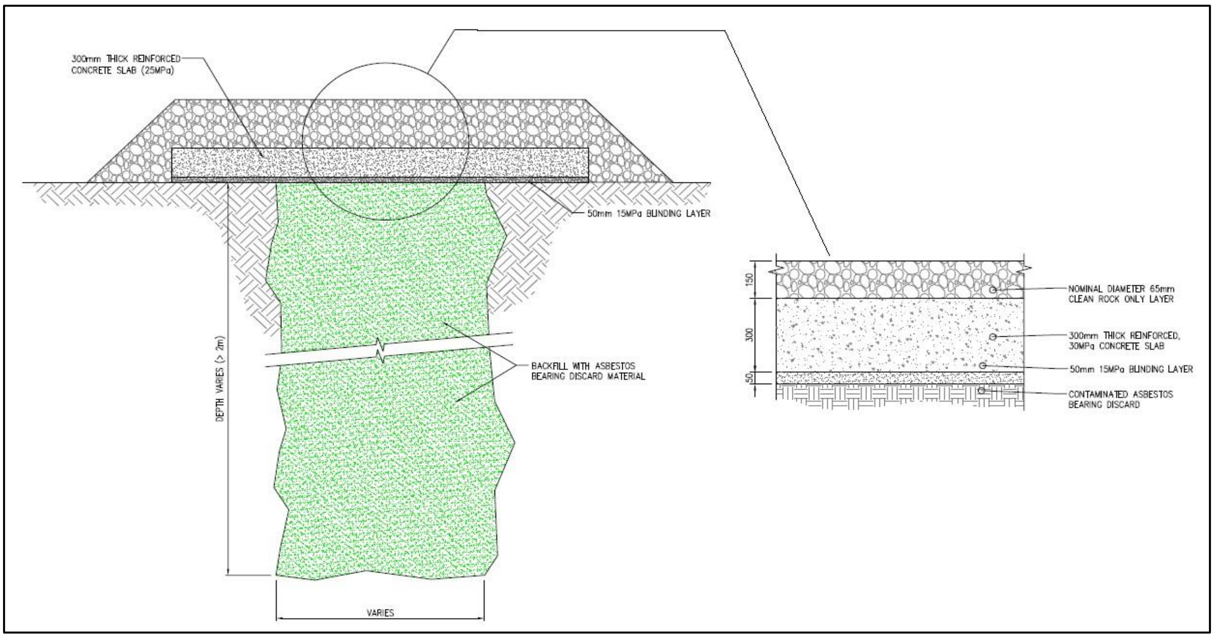

Figure A-3.3: Typical detail of how a vertical shaft is closed (Source: Mintek)

Vertical shafts are typically closed by first backfilling the shaft with the polluted material. In the case of asbestos, the shaft provides a handy place to dispose of the polluted material safely – back into the shaft. If the volumes of material allow, backfilling the shaft completely also allows a reduction in the potential future risk of a shaft cap failing and subsidence of the surface occurring. The backfilled shaft is then first capped with a light concrete binding layer which is followed by a strong concrete cap and finally covered along with the rest of the surface rehabilitation.

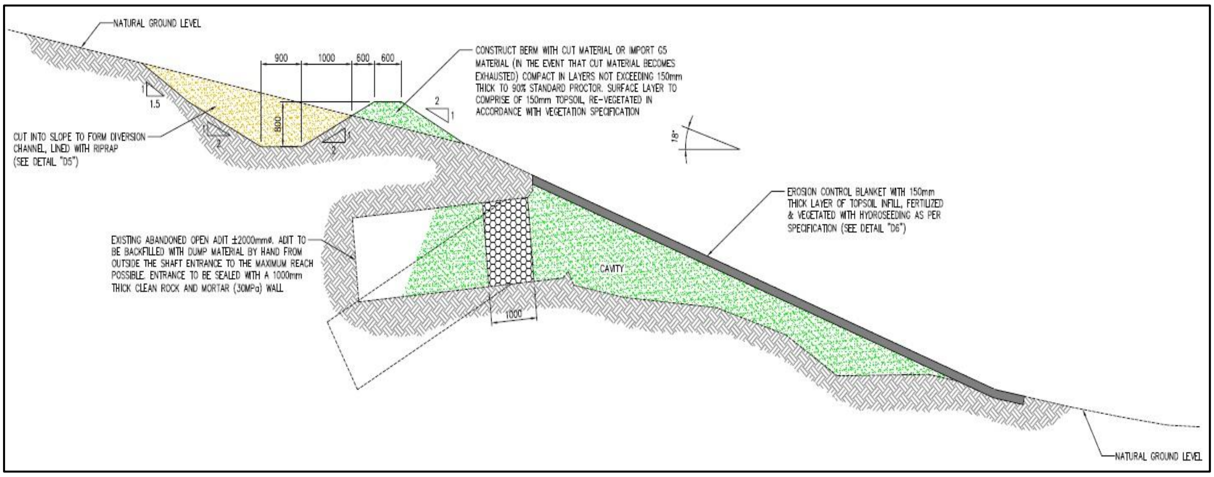

Figure A-3.4: Typical detail of how an adit is closed (Source: Mintek)

Incline shafts and adits, which are very often encountered on asbestos mine sites, are also backfilled as far as possible with the discard or polluted waste material. A concrete cap or gabion is installed to seal off the backfilled adit and the opening left is also backfilled with clean material before the area is covered.

Master rate (8C): Processing waste deposits and evaporation ponds (acid, metal) (4.3.4, Page 53)

The generally accepted closure methods in the DME guideline places asbestos mines under the category of acidic, metal rich residue deposits. (item 2.7.3 of the Generally accepted closure methods) The objective of the rehabilitation of these types of residue deposits is closely aligned with the approach followed on most asbestos mine projects where waste rock deposits rich in asbestos fibre or fine fibre dumps are encountered and is already described in the generally accepted closure methods.

Figure A-3.5: Asbestos waste and fine fibrous material was often end-tipped at steep elevations just outside shaft entrances (Source: Author)

In all cases, whether the original mine incline shaft was larger to allow the entrance of mining equipment or hand-dug, the waste material and unwanted fines were most often end-tipped. The material spoil dumps are usually difficult to access in order to consolidate and reshape them as part of the rehabilitation plan and often require significant earthworks and protection berms to prevent future erosion on the steep slopes where they are located.

Figure A-3.6: Contaminated waste rock deposits often encountered at abandoned asbestos mines (Source: Author)

Most asbestos mines that are rehabilitated contain varying amounts of asbestos fibre and fibre-contaminated waste rock. The approach is usually to shape these dumps of contaminated material and cover it with clean material sourced locally (on site) or imported if required.

Figure A-3.7: Some asbestos mines still contain very large dumps of fibre and waste rock (Source: Author)

While waste rock and asbestos fibre dumps of smaller volumes are a feature of almost all project sites, these dumps can be of much more significant proportions where the mine in question has been exploited commercially over several years.

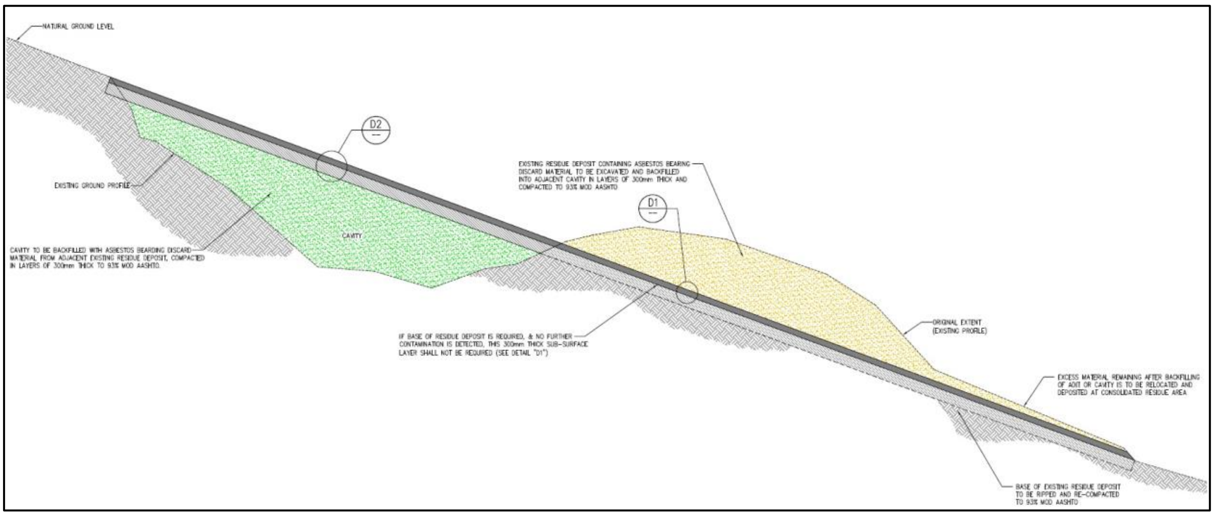

Figure A-3.8: Typical detail of how general surface shaping of asbestos dumps and rehabilitation is conducted (Source: Mintek)

The guideline rate is quoted in R/ha but it is made up of several component rates that include the modification of the dump slope, shaping of the dump, placing two separate cover layers, and vegetation. This work is never described in tenders on a per hectare basis, as site differences necessitate specific instructions for each step in the proper rehabilitation of these dumps. The manner in which the bill of quantities describes the work components align closely with the steps and components of the master rate in the DME guideline. This research report therefore uses the approach of looking at the component rates that make up the master rate as more directly comparable to the data obtained from tenders.

All these factors are very closely aligned with the objectives of the asbestos mine closure and the typical asbestos project therefore fits perfectly in this category. The Master rate is based on certain volumetric and size assumptions of the dump typically encountered on this type of mine and the volumes of material that would be used to rehabilitate it to standard. The approach here will be to analyse trends in the underlying rates that comprise this master rate.

Slope modification to 18^{o} (4.3.4 (a), Page 53)

The first individual cost component that forms a component of the master rate in the DME guideline for the rehabilitation of processing waste deposits (of the type encountered on asbestos dumps) is slope modification. This process involves digging into the waste dump with the aim of moving the material usually dumped at angle of repose, to a slope angle of 18o maximum.

Earthworks to shape dumps to the required angle of slope (4.3.4 (b), Page 54)

The next individual cost component that forms a part of the master rate in the DME guideline for the rehabilitation of processing waste deposits (of the type encountered on asbestos dumps) is the shaping of the dump. This process involves the smoothing and final shaping of the waste dump with the aim of preparing the surface for the placement of cover layers, water runoff management and erosion control as well as vegetation. This process happens after the desired dump slope angle has been attained.

The placement of dedicated covers over the dump (4.3.4 (c), Page 56)

The proper rehabilitation of a waste deposit or dump involves, after the slope modification and shaping steps, the placement of specific cover layers over the dump. These serve to protect the stability of the modified dump slope, to limiting the ingress of water and air into the dump material, the separation of the mineral deposit from surface runoff that could contaminate water courses and facilitates an aesthetic appearance after closure. The third individual cost component that the master rate in the DME guideline for the rehabilitation of processing waste deposits is composed of, is the placement of an armour covering over the reshaped and sloped dump. This process involves placing a cover of rocky material over the dump (usually around 150mm thick) and shaping it to merge with the profile of the underlying dump (now properly smoothed) and then compacting that layer to a given specification.

Placing a topsoil cover of 300mm (4.3.4 (d), Page 57)

The placement of an evaporative cover (soil layer) forms another component of the master rate in the DME guideline for the rehabilitation of processing waste deposits. This step involves placing a layer of soil material (usually about 300mm thick) over the rock layer placed before to establish a suitable medium for vegetation in the following step.

Vegetation (4.3.4 (e), Page 58)

The final individual cost component that comprises the master rate in the DME guideline for the rehabilitation of processing waste deposits is vegetation of grassing. This process involves the placing of grass of a specified species mix, adding fertiliser and generally ensuring that the grass cover has every physical opportunity to establish over the dump. The rate is indicated per hectare of grass cover required (1ha = 10,000m^2).

The establishment of a borrow pit to obtain cover and topsoil material near the dump (4.3.4 (f), Page 58)

The DME guideline rate provides for the establishment of a borrow pit to obtain material to place on the dump. This is a very specific rate component as it assumes that the borrow pit will be established on the project site itself. This borrow pit will not require further licensing as it is part of an existing mining right if the mine rehabilitates concurrently to its operations. However, in the case of an abandoned mine, the borrow pit cannot be assumed to exist and the rock or aggregate material must be obtained from commercial, licensed sources. Where these are located far away from the mine, the transport costs increase the price of sourcing these materials dramatically. It is simple yet practical considerations like these that require very careful consideration of the third-party rehabilitation assumption. It must always be borne in mind that, if any mine fails to rehabilitate themselves, and the State must take over and fund rehabilitation, the process of obtaining a mining right just to source borrow pits material might be too onerous for a short-term rehabilitation project. These legal technicalities, e.g.: not having a mining right to exploit borrow pit material on site and thus having to source commercially, has significant cost implications. One of the specific material cost components included in the master rate in the DME guideline for the rehabilitation of processing waste deposits is the sourcing of aggregate for the covering of the dump and placing that material over the dump. In this instance, the master rate allows for the opening of a borrow pit close to the dump while the practical implementation is that this material is usually rather sourced from commercial sources.

Geotextile (Page 59)

Another specific material cost component included in the master rate in the DME guideline for the rehabilitation of processing waste deposits is the purchase and placing of geotextile used in the covering of the dump and stabilisation of the soil for protection against erosion. This material is a specialised membrane used to stabilise soil and protect against erosion and several standard varieties are available from suppliers.

Master Rate (10): General surface rehab and grassing (4.3.5, Page 60)

While the master rate for item 8C already includes most of the cost elements that constitute the majority of the work on a typical asbestos rehabilitation project, general surface rehabilitation and grassing is a rate addressed in item 2.7 of the generally accepted closure methods in the DME guideline for areas which are not covered elsewhere. The generally accepted closure methods, in 2.7, prescribe that this work should ensure surface topography that matches the surrounding areas, landscaping to ensure proper surface water runoff, removal of unnecessary surface infrastructure and provide for a suitable landscape for vegetation. The master rate allows for shaping to a depth of 500mm and includes removal of concrete slabs or other surface features which could have been built temporarily to establish plant and maintain the project site. In the terms of practical implementation, this item can be compared to the rehabilitation, usually close to project completion, of the site establishment areas, site decommissioning and closure and general repair of the lay-down areas, clearing of temporary site offices and infrastructure, ripping up of the temporary access roads, etc. The intention of this category of unit rates is not bulk earthmoving but generally shallower general surface workings to achieve a final surface topography that is free-draining and aesthetically merges with the surrounding landscape. The master rate for surface rehab and grassing in the DME guideline involves general levelling of the surface and compaction where required as well fertiliser application and the planting of grass species selected for the area.

Master Rate (12): Fencing (4.3.6, Page 61)

The final master rate in the DME guideline and considered in this report is the erection of fencing to protect the works and restrict access after rehabilitation is completed. The fencing standard is as specified for stock fences in the ARC guideline.

The generally accepted closure methods in the DME guideline did not prescribe any specific methodology or approach for constructing fences on rehabilitated mine lands. In this instance, the norm is to provide standard stock fences as specified in the publication “Farm Fences” by J.F. la G Mathee and revised by W.G.S. Grobler. This ARC Agricultural Research Document was published by the Institute for Agricultural Engineering in 2005 with ISBN no.: 1-919849-81-5. This specification is referenced in all asbestos rehabilitation projects where fencing is required. Because the generally accepted methods published in the DME guideline does not provide specific details about these fences, it is assumed that the master rate includes material and labour to erect these fences.

The rates for provision of the material and labour to erect these fences are readily available from the tendered values and are used to analyse trends over time for this item to compare with the master rate. The unit of measurement in DME guideline for the erection of fences is the metre (m) and this correlates directly to the units used in the tender specification.

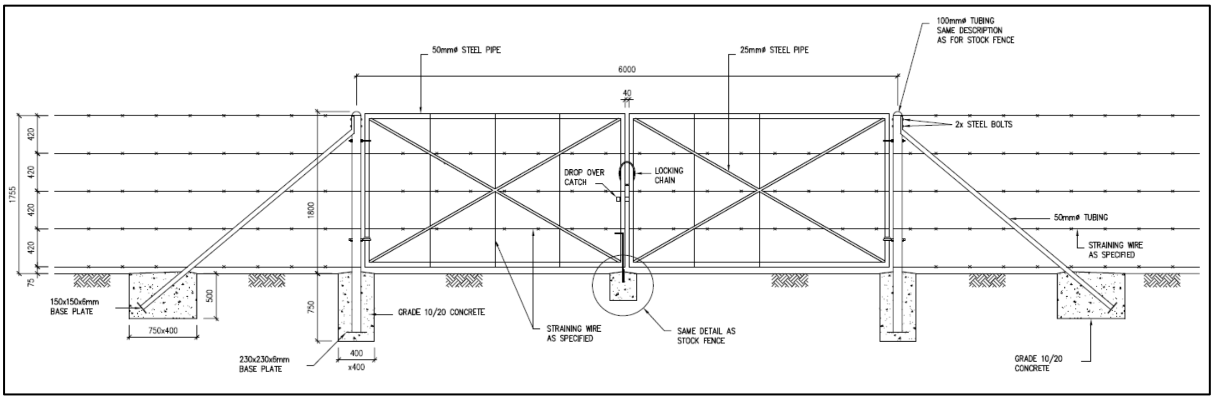

Figure A-3.9: Typical detail of stock fence installed after rehabilitation projects (Source: Mintek)

ANNEXURE D: PERMISSION TO USE MINTEK DATA IN RESEARCH REPORT

MINTEK
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In your reply please quote: SP Cornelissen HS

The Dean of the Faculty
Faculty of Engineering
University of the Witwatersrand
Private Bag
WITSPOST

26 February 2018

Dear Sir

PERMISSION TO USE DATA HELD BY MINTEK FOR THE PURPOSES OF A RESEARCH REPORT SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF M.Sc. Eng. Mr H Cornelissen

I confirm that Mr Hermanus Cornelissen (Wits student number: 813837) currently holds a Mintek bursary and is studying towards his M.Sc Eng degree at the School of Mining Engineering in the Engineering Faculty at Wits.

Mr Cornelissen is in the process of completing the research report that is a requirement of this course. His research report titled: "An analysis of actual cost data for surface mine rehabilitation projects in South Africa and comparison with guideline values published by the Department of Mineral Resources" is based on data that he has extracted from tenders that were published by Mintek.

The source data has been altered to remove the names of projects and bidders. The manner in which the data is presented in the research report therefore constitutes no business or reputational risk to Mintek or its service providers. I confirm that he is using this data with Mintek's permission.

Any further queries in this regard may be directed to my office.

Yours faithfully

Dr. D. Powell
General Manager: Business Development

"Your partner in unlocking mineral wealth."

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