CHAPTER 1

INTRODUCTORY PERSPECTIVE AND PROBLEM STATEMENT

Ever since the earth was formed, natural disturbances on a geological scale - ranging from meteor strikes, volcanic activity and earthquakes to floods and ice ages have been frequent and varied, resulting in ecosystem disturbances. These changes have occurred both in time and in space and their characteristics have been inferred from several types of scientific studies. Thus, an ecosystem disturbance can be defined as an event, or series of events, that result in changing the relationship between organisms and their habitats from their natural state, both temporally and spatially (Wali, 1992).

Presently the concern lies with disturbances that are anthropogenic and whose impact have resulted in scales that are temporarily narrow but spatially wide. Several events have created these disturbances: (1) extensive clearing of natural vegetation for agricultural and other purposes; (2) selective harvesting of desirable species and the introduction of alien species to a given area; (3) soil erosion and desertification; (4) abandonment of unproductive agricultural land; (5) mining and improper reclamation of mined lands; (6) drainage of wetlands for agricultural or fuel usage or for the control of diseases (eg. Malaria); (7) introduction of biocides and pesticides into the environment; and (8) creation of war impacted ecosystems by bombing, defoliation, and movement of men and material (Owens *et al.,* 2002). However, over the years technology and practices have been developed to rehabilitate some of the areas affected by such disturbances.

Rehabilitation includes the development of management strategies to restore and maintain physical, chemical and biological ecosystem processes in degraded environments. Rehabilitation of disturbed areas has been conducted for centuries; with the ultimate success thereof being largely dependent upon the prevailing environmental conditions, the characteristics of the site, and the inclination of and resources available to those undertaking the rehabilitation process (Risser, 1992).

Metalliferous and coal mine site rehabilitation has been subject to demands for increasingly higher environmental standards in recent years. Techniques for dealing with abandoned as well as operating mining sites which could cause soil, water and air pollution have kept pace with these demands. Surface mining (utilizing open pit or open cast mining methods), has

been especially guilty of environmental disturbances, giving rise to calls for extensive rehabilitation in a sustainable manner.

Surface mining is normally used for the extraction of ore bodies that occur on the surface or close to the surface with shallow cover. Surface mining normally affects the surrounding area and the environment more drastically than underground mining used for deeper and more complicated ore bodies.

- Open pit mining is normally used for shallow, steep dipping beds or veins; or for massive irregular deposits close to the surface. In open pit mining, overburden (non-mineralised soil/rock that covers an orebody) and waste rock (poorly mineralised or very low grade soil and rock that are within the ore body or surrounding it) are first removed from the entire area of the final planned pit, often in very large quantities. The mine shape is then formed by a series of benches and terraces arranged in a deepening spiral or in levels with interconnecting ramps. The pit is then deepened in a sequential manner using benches that also serve as haulage roads for the removal of ore from the pit. Rehabilitation at the end of the mining process is usually very expensive, particularly if it involves backfilling, as the wastes are often dumped at some distance to avoid obstructing the removal of economic ore (Warhurst, 2000).

- In open cast mining, on the other hand, extraction proceeds laterally rather than vertically and this method is therefore more suitable for shallow and laterally extensive deposits. A "strip" of overburden is first removed to expose the underlying economic ore deposit whereafter the deposit is then worked out. Rehabilitation normally takes place as part of the mining process and also involves backfilling, revegetation and maintenance in a sustainable manner.

Both mining methods are commonly practiced in South Africa and more often than not result in large open pit excavations and remnant waste rock dumps producing vast land disturbance and other associated environmental problems.

This study deals with the evaluation of the cost effective nature of a sustainable approach to the rehabilitation of an open cast chromite mine – Rustenburg Minerals Development Company (Pty) Limited – in the North West Province of South Africa.

1.1 Disturbed Land: An international problem and associated legislation

Judging from the various sources which were investigated during this study, it became clear that the first serious attention given to disturbed land and its associated problems - especially with regard to disturbance as a result of mining activities - occurred during the early 1960s.

According to Bradshaw *et al.* (1980), **British** legislation during 1944 in terms of local government policy, decreed that disturbed and derelict land should be made available for alternative land use and practices. This was the Town and Country Planning Act of 1944 (Harris *et al.*, 1998). It enabled local authorities to acquire disturbed and derelict land, and bring it back into use for industry and development activities. This Act was later replaced by the Town and Country Act of 1947 which stipulated that district councils could launch actions and initiatives to restore and reclaim such disturbed areas thereby improving the state of the land for the future. However, at the time very little attention was given to the restoration of land for agricultural or pastoral use. The first case to do so was reportedly in 1973, when the Town and Country Planning and General Development Order gave planning authorities the power to demand that mineral extractors provide for adequate disposal and reclamation of spoil materials (Harris *et al.*, 1998).

Subsequently legislation in the United Kingdom went through drastic changes over the years. The period between 1989 and 1995 saw considerable changes regarding legislation and regulation governing derelict and contaminated land. This change was motivated by European Commission directives and increased popular environmental awareness influencing politicians and governments (Harris *et al.*, 1998). Principal legislation passed in the United Kingdom included the Environmental Protection Act 1990 and the Water Resources Act 1991, both of which brought together a number of previous acts and also incorporated new legislation and regulations. In the United Kingdom, rehabilitation and reclamation legislation are also directed at active mining activity, which is then governed by mineral planning and environmental assessment legislation and guidance. Mining activity is not permitted to proceed without planning and budgeting for rehabilitation - much like the situation in South Africa. This has resulted in an ideal situation where many other mining practices within the United Kingdom carry out rehabilitation and restoration of land as the mining progresses - thus substantial amounts of land are returned to beneficial use whilst the mine is still in operation.

Evidence of such efforts in the **United States of America ("USA")**, as mentioned in van Wyk (1994) dates back to 1930 when attempts were made, at the rehabilitation and revegetation of iron ore waste dumps in Minnesota. The first serious research was only completed at the University of Minnesota in 1948, although some research was conducted at the Hanna Mining Company in Minnesota during the original attempted rehabilitation effort. At that stage it had already been determined that chemical soil stabilisers were effective, albeit only in the short-term.

Some of the first definite evidence of legislation attempting to implement and force the control of erosion and sedimentation in the USA, was enacted in the State of Maryland in 1970. By 1975, thirteen other states had followed this example (van Wyk, 1994). During 1977 the Federal Surface Mining Act created overall regulations for reclamation and restoration on coal-mined land. This introduced minimum standards with regard to the replacement of contours, segregation and replacement of topsoil, the establishment of vegetation and hydrological protection. Similar to the South African requirement where a trust fund is established for rehabilitation purposes at the end of a mine's life cycle, a bond is paid by the mining company and is not repaid until the land is satisfactorily restored. There is also a levy on coal production to allow for previously unrestored land to be reclaimed and to alleviate off-site impacts (Harris *et al.*, 1998).

One of the earliest rehabilitation efforts on goldmine tailings and waste dumps in **Canada** was carried out at McIntyre Porcupine in 1932. During the 1940s similar rehabilitation work was carried out on uranium-tailings dumps at Inco Limited in Sudbury. Due to low pH conditions no vegetation could be established and other methods such as chemical soil stabilisation was tested. These methods turned out to be very costly and ineffective. During the 1950s investigations and research into the establishment of vegetation on such parent material was carried out for the first time (van Wyk, 1994).

According to Harris *et al.* (1998), the former **West Germany** exercized tight control over mining reclamation with detailed consultation and planning in the Ruhr Valley as overseen by the *Siedlungsverband Ruhrkohlenbezirk*.

According to research done by van Wyk (1994), rehabilitation and restoration ecology enjoys high preference in the former **USSR**. The first research and attempts at "recultivation" - as

defined by the former USSR, were initiated in the vicinity of the Moscow Basin during the early 1960s. Due to the topography of the former USSR, of which only 10-13% is flat, there was an urgent call for effective rehabilitation and reclamation so that the land could be put to its most beneficial use after rehabilitation had been completed. Environmental legislation stipulates that the production capacity of rehabilitated areas should be no worse off than what it was before mining activity had commenced - hence calling for full restoration of land, as defined in Chapter 6. This attitude has resulted in 60% of operational budget commitment being dedicated to ecological rehabilitation.

It can be said that the ultimate rehabilitation end use and type of reclamation practice in any region would be fundamentally defined by the manifest legislation and regulations applicable to that particular state or country.

This is especially the case in **Australia**, according to van Wyk (1994), where each state has its own legislation and regulatory body, and the mineral rights belong to the relevant state. In Western Australia use is made of the "Agreement Act" whereby a developer and the regulatory body institute a legal agreement which entitles the developer to commence the respective activity - provided that the terms and conditions agreed to in the contract are adhered to.Initially the requirements were very simple, and only required mining companies to leave the mined-out areas "neat and tidy." During 1972, legislation was passed that directed mined-out areas to be restored in terms of vegetation establishment and the prevention of erosion. Currently these directives have evolved to be far more complex, requiring continuous monitoring and research to determine parameters whereby the effectiveness of a rehabilitation attempt could be assessed - thereby establishing a type of industry benchmark or standard, which could aid in the establishment and implementation of appropriate legislation. As is the case in South Africa it is a legal requirement to submit an Environmental Impact Assessment and an Environmental Management Plan including a rehabilitation plan. All of the above documented terms would eventually be regarded as part of the "Agreement Act" contract instituted between the regulatory body and the developer.

Strict legislation being implemented the world over, has incorporated responsible resource management with financial implications for failure to do so. This would ensure that the developers and extractors involved in especially the mining industry, are forced to conform to environmental best practice, thus minimising the ultimate disturbance and pollution of the

environment. However, implications could also be that the methods applied during such processes are such that the costs of rehabilitation combined with mineral extraction are in balance with the results achieved aesthetically while total costs are kept as low as possible.

1.2 Disturbed Land: A South African problem and associated legislation

The first pioneering work conducted in the area of rehabilitation, was done by Professor J. Phillips of the University of the Witwatersrand during 1932 (van Wyk, 1994). The main aims of these early attempts was dust suppression from the tailings and slimes dams of the gold mines and not necessarily environmental conservation. By 1953, no further progress had been made in this regard, and even dust suppression testing and research had not lead to any significant advances being made. These dust suppression methods included the use of waste rock covering slimes dam walls, spraying of salt water and silt on these walls, as well as mixtures of mud composed of neutralised acid mine drainage water with CaO, mixtures of oil and water as well as mixtures of molasses and water to bind the dust.

Van Wyk (1994) found that after due consideration the South African Chamber of Mines ("Chamber") along with the South African Council for Scientific and Industrial Research ("CSIR") came to the conclusion in 1956, that the best way to limit and control dust was through the establishment of vegetation on the slopes of the slimes and tailings dams. Further research and testing was done by Phillips, Walker and Grant during the early 1980's.

With the rise of a worldwide environmental awareness during the 1980s, stricter legislation and regulation of environmental issues lead to the establishment of the Research Institute for Restoration Ecology ("RIRE") at the Potchefstroom University for Christian Higher Education in South Africa, which had at that stage already been involved in numerous projects throughout South Africa relating to restoration ecology and rehabilitation of disturbed land within the mining and agricultural sectors (van Wyk, 2003; Personal Communication).

Legislation applicable to the rehabilitation of ecologically disturbed land areas as a result of mining activities, was re-evaluated for the first time in 1980 as part of the revision of Chapter 5 of the Mines and Works Act, 27 of 1956. Even though this piece of environmental legislation was already promulgated in 1957, it was not implemented until the increased environmental awareness of the early 1980's. This legislation was also only applicable to

open cast mining activity or in cases where more than 12 000 tonnes of ore reserve including topsoil, had been removed.

Currently, within the mining industry of South Africa, the following legislation is, inter alia, relevant in terms of rehabilitation and restoration ecology of disturbed land:

- Minerals Act, No 50 of 1991 – *Sections 1, 5, 9, 38, 39, 40, 47, 61, 63 and related regulations;*
- Nuclear Energy Act, No 131 of 1993 – *Controls radioactive substances from mines as well as management of radioactive wastes;*
- Water Act, No 36 of 1998 – *Sections 1, 2, 5, 6, 8, 9, 10, 11, 12, 20, 21, 22, 23, 24, regulations and all other related regulations and mineral legislation applicable to water usage and treatment;*
- Health Act, No 63 of 1977 – *Sections 37, 38 and related regulations;*
- Conservation of Agricultural Resources Act, No 43 of 1983 – *Sections 6, 7, 25, and related regulations;*
- Atmospheric Pollution Prevention Act, No 45 of 1965 *(*Soon to be replaced by the new Air Quality Management Bill) - *Part II, III and IV and related regulations;*
- Environmental Conservation Act, No 73 of 1989 (Certain sections replaced by the National Environmental Management Act);
- National Environmental Management Act, No 107 of 1998 – *Entire Act;*
- National Forest Act of 1998 - (Updated from Act 122 of 1984) - *Sections 24, 25, 26, and related regulations;*
- Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, No 36 of 1947 – *Sections 3 - 10* ;
- Advertising on Roads and Ribbon Development Act, No 21 of 1940 – *Section 8;*
- Fencing Act, No 31 of 1984 – *Sections 1, 10, 11, 17, 18, 23, 24, 26, 29 and related regulations*; and
- Physical Planning Act, No 125 of 1991 – *Sections 1, 4, 22.*

Applicable environmental policies such as the policy concerning financial provision for the rehabilitation of land disturbed by mining activities (1996) and the National Environmental Management Policy (White Paper, 1998) play a large role in the evolution and implementation of a rehabilitation model and plan. According to van Wyk (2001a) the term

"rehabilitation plan" as defined in the regulations of Chapter 5 of the Mines and Works Act, No 27 of 1956 as promulgated in March 1980, inter alia implies the following:

- An environmental assessment investigation needs to be carried out to establish and ensure effective future land usage;
- Land needs to be rehabilitated to a level of productivity as stipulated in the initial land use plan before mining activity had commenced;
- The amount of environmental disturbance will ultimately be limited;
- Where possible, the land would be returned to the its original state prior to disturbance;
- That the eventual rehabilitated site would be aesthetically pleasing;
- Rehabilitation should ultimately be flexible to ensure that land can be utilised for multiple land uses;
- Disturbance, if any, should be kept to a minimum; and
- Environmental protection and conservation should not be a mere afterthought but form an integral and integrated part of the mining process.

The rehabilitation of mine dumps gained momentum only after regulation 537 of March 21, 1980 an amendment of the regulations in the Mines and Works Act No 27 of 1956 was accepted. This amendment stated that restoration of ecology and revegetation formed an integral part of mining activities (van Wyk, 2001a).Responsibility for such rehabilitation was only formally assigned to mining companies in the Minerals Act which was promulgated in January 1992.

The Minerals Act was amended in July 1993 to become Act No. 103 of 1993. This Minerals Act has since been replaced by two other acts, *viz.* the Mine Health and Safety Act No. 29 of 1996 and the Mineral and Petroleum Resources Development Act No. 28 of 2002. However, it is important to note that even though new regulations have been added to the initial Mines and Works Act (No 27 of 1956) the original regulations still stand and are being enforced and applied to this day in South Africa.

1.3 Specific Problem Statement

In the previous sections of this chapter an attempt was made to indicate the level of land disturbance within the South African open cast metalliferous mining industry. Associated

problems were identified and will be discussed in full in later chapters. Despite the problems already mentioned other side effects such as noise-, air-, water- and other associated forms of pollution were not discussed but do inherently form an integral part and is often closely associated with land disturbance.

The quantification of the effects of revegetation in terms of a successful rehabilitation model, i.e. eliminating some and limiting all of the associated problems relating to land disturbance, has not been attempted by other authors in much detail.

Van Wyk (1994, p 15) states that: "there was a drastic decrease in water pollution after the establishment of vegetation on mine dumps. On location at Gedulddam near Springs the sulphate concentration varied between 2000 and 3000 ppm before 1970 and in 1973 it decreased to less than 200 ppm. In the same dam the total dissolved solids before revegetation was 1000 to 5000 ppm, while this number decreased significantly to between 400 and 700 ppm after the establishment of vegetation."

After researching and referencing various sources it became clear that during the early efforts at rehabilitation and restoration ecology, the mining industry especially, focused its attention more on the suppression and remediation of symptoms rather than the elimination and remediation of the actual causes of the problem.

Aided by years of research and an ever increasing worldwide environmental awareness, policy makers and regulatory bodies have been evolving and implementing practices to accommodate modern scientific findings and to eliminate the problems associated with land disturbance.

From the sources referenced for this study it became clear that the industry suffers from confused terminology and a lack of practically applicable solutions. No investigations have been conducted, to develop and establish a successful strategy by which to address rehabilitation issues associated with open cast chromite mining in South Africa. Although this study includes the use of techniques such as revegetation, reclamation and restoration to develop a successful and self-sustaining rehabilitation model; it focuses more on the investigation and evolution of strategies which could incorporate the industry standard

practices into a model –a model which could serve as the basis for the cost effective and sustainable rehabilitation of open cast chromite mines and dumps in South Africa.

The case study used for the purposes of this exercise is an open cast chromite mine Rustenburg Minerals Development Company (Pty) Limited ("Rustenburg Minerals"), situated in the North West Province – Pilanesberg Region – of South Africa. Rustenburg Minerals is a wholly owned subsidiary of Assore Limited, a company listed on the Johannesburg Stock Exchange.

African Mining and Trust Company Limited ("African Mining") another wholly owned subsidiary of Assore Limited, the technical advisors to and operating company responsible for Rustenburg Minerals, was faced with the problem of rehabilitating old open cast mine workings at their Rustenburg Minerals operation which had been mined since the early1960s (first by SA Minerals and then by African Mining) and now approaching the end of its economic life. The mining operation was conducted by two mines, Clementine Mine on the farms Tweelaagte and Vogelstruisnek; and Makgope Mine on the farm Groenfontein, all of which had been and continue to be used by landowners of neighbouring communities and properties as grazing land for cattle.

The main objective of this study is to evaluate the approaches followed and the aspects relating to the evolution of a rehabilitation model used by Rustenburg Minerals, specifically aimed at cost effective open cast chromite mine rehabilitation of which the eventual target is self-sustainability.

It will be shown in this study that the re-establishment of vegetation is fundamental to any post-mining land use and that alternative methods of "landscaping" can result in cost effective rehabilitation, without necessarily having to resort to complete backfilling of the pits which could be prohibitive from a cost point of view.