DEVELOPMENT OF A MODELING FRAMEWORK FOR DESIGN OF LOW-COST AND APPROPRIATE REHABILITATION STRATEGIES FOR NYALA ABANDONED MINE

Name : Mhlongo Sphiwe Emmanuel
Student number: 11542669

Supervisor : Dr. F. Amponsah-Dacosta
Co-supervisor : Dr. N.F. Mphephu

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ABSTRACT

The issue of abandoned mine sites is a major environmental and social problem for the mining industry, communities and governments. A legacy associated with historical mining is significant degradation of the environment since these operations were not subject to current environmental protection laws. The impacts of abandoned mines include a range of health and safety problems, and extensive economic impacts due to resource degradation and water pollution. So far, there are only a small number of systematic programmes to deal with the issue and in many instances there is a rapidly growing population encroaching on areas of historic mining activities thereby creating a greater potential for adverse effects to human health and the environment.

The main purpose of this research was to develop a modeling framework for the design of inexpensive and suitable rehabilitation plans for the abandoned Nyala Magnesite Mine. The specific objectives were to conduct a detailed site characterization of the abandoned mine site, create surface terrain models for the development of different rehabilitation landforms, design low-cost and appropriate rehabilitation plans for addressing the problems at the mine site, and estimate cost of alternative rehabilitation strategies. The research approach used involved site examination and characterization to establish the environmental conditions of the mine. Hazards at the mine were identified, scored, and rated using modified Historical Mine Site Scoring System. Terrain models were generated using RTK-GPS data and this assisted in developing rehabilitation design alternatives ranging from doing nothing to rehabilitating various sections of the mine to approximate original contour. The alternatives were evaluated for expense, attractiveness in terms of site stabilization and aesthetics, and mitigation of public safety hazards. A comparative economic evaluation of the three most promising rehabilitation alternatives was conducted in order to select the most suitable option for the abandoned Nyala Mine site.

The mine site characterization assisted in determining the nature and extent of environmental problems at the study area. The site was found to be extremely degraded with most surface alterations resulting from extensive diggings, tailings material and overburden spoil dumps. Dangerous abandoned highwalls, exploration trenches, deep erosion gullies and dilapidated ore bunker were identified to be major physical hazards

in the area. In addition, the pit lake presents a drowning hazard and the exposed and rusted empty metal containers, drums, scraps, and nails represent safety hazards. The conceptual site model developed for the abandoned Nyala Mine has provided an increased understanding of the physical features of the site, a description of chemical migration pathways, and an outline of human and ecological populations that may be exposed to identified hazards at the mine.

The results of the physical characterization of the mine waste showed that both tailings and spoil materials are generally well-graded sands and are suitable for engineering purposes. The different surface models generated for the mine site assisted in making informed decisions with regard to the area of the terrain to be cut and the voids to be filled. Based on Strengths, Weaknesses, Opportunities, and Threats (SWOT) and Quantitative Strategic Planning Matrix (QSPM) analysis and cost estimates the three most promising rehabilitation options were evaluated. These options were scenario I which focused on developing the mine site for crop farming; pit lake and construction of inert landfill site with an estimated cost of R68.8 million, scenario II aimed at developing the mine site for settlement and industrial purposes; pit lake; livestock grazing site and pit lake associated with the picnic site and the estimated cost was R72.6 million, and scenario III with the estimated implementation cost of R47.6 million. The lowest cost and the most appropriate rehabilitation option was scenario III. This plan focused on rehabilitation design for residential area, development of BMX dirt park, and construction of landfill site for inert waste and pit lake.

The cost estimates and the escalating costs will assist in budgeting for the rehabilitation of the abandoned mine site. This research has revealed that site characterization and terrain modeling are robust scientific techniques for making sound decision on selection of economical and appropriate rehabilitation plans for abandoned mine sites. The modeling framework developed in this study will serve as a blueprint for developing low-cost and appropriate rehabilitation strategies for other abandoned mines within the province and/or the country.