

EXECUTIVE SUMMARY

The Water Research Commission (WRC) awarded a contract in 2004 to Golder Associates (in partnership with a number of organisations) to develop a first order Decision Support System (DSS) for the sustainable design, operation and closure of mine residue disposal facilities. It was foreseen that this project would represent the first of three phases, with the first phase focussed on the development of a first order DSS.

The first phase of this research programme was completed in 2008 and documented in WRC Research Report No 1551/1/08. The Phase 1 research identified 3 research objectives for phase 2, which was aimed at the refinement of the first order DSS. Phase 3 of the research project was envisaged to be the development of a comprehensive DSS covering all aspects of sustainability.

The research objectives for Phase 2 focussed on the refinement of the DSS and included:

1. Develop a performance demonstration protocol, i.e. procedure or guidance that can be used to demonstrate the acceptability of particular technique, technology or approach;
2. Alignment of the DSS to current legislation;
3. Undertake specialist studies of specific knowledge gaps identified during the development of the first order DSS in order to better understand the aspects and to provide better guidance in the DSS for users. Specialist studies included water and surface stability related studies. The water studies included mine residue disposal facility water balances, depth of oxidation zones, pore water quality evolution and protocols to handle uncertainty in the prediction of mine residue disposal facility impacts. The surface stability studies related to erosion rates and the effectiveness of cover technologies, the effect of slope geometry on surface stability and protocols to monitor surface stability during the post closure phase; and
4. Identify and assess new and promising technologies and approaches that could be used as supporting guidance in the DSS and that could further play a role in managing water resource degradation caused by mine residue disposal facilities.

The second phase of the project was awarded to Golder Associates in association with the same organisations that were involved in the development of the first order DSS. This research report details the outcomes of Phase 2 – Refinement of the first order DSS.

A summary of the outcomes of the various components of the Phase 2 research is provided below:

Development of a demonstration protocol

Fundamentally, the DSS is designed to lead to a decision and is captured in final questions that are posed in such a way that if answered, it will lead to a decision higher up in the DSS hierarchy. This final or end-of-line question can either be answered by providing the necessary technical requirements, or comply with said standards, or by following a demonstration protocol in support of answering the question.

A demonstration protocol was developed to provide a mechanism for when a question cannot be answered in the positive using existing knowledge and predictive models, to demonstrate the applicability and acceptability of using a particular technology, approach or technique. The demonstration protocol, although developed for surface stability applications, can also be applied for water related aspects. The demonstration protocol includes guidance to the regulator, the proponent and consultants on:

- Selecting and prioritising potentially feasible solutions or technologies;
- Comparing the potential solutions to predictive models;
- Undertake appropriately scaled field testing; and
- Documenting the results in support of using the particular technology or technique.

The demonstration protocol will form a key characteristic of the comprehensive DSS.

Alignment of the DSS with current legislation

The following bullets summarises the key outcomes of assessing the alignment of the DSS to current legislation which is particularly relevant for the development of the comprehensive DSS:

- The DSS has no legal standing. However, it has been developed to be aligned with the national environmental management principles and to support applications by proponents for current or new mine residue disposal facility schemes.
- The DSS will, based on the preliminary DSS and once developed, provide for the procedure that covers the scope of investigations to define and quantify the environmental risks associated with a current or proposed scheme.
- It is recommended that once the comprehensive DSS is developed that the DSS be converted to guidelines in terms of regulation 73 and/or 74 of Government Notice R385 to the National Environmental Management Act in order to attain official recognition in both the Basic Assessment and Scoping and Environmental Impact Assessment procedures which forms the core vessel for application of the DSS.

It is expected that the development of the comprehensive DSS will include specific legal requirements as recommended by the outcome of the phase 2 study and that it, in principle, will comply with the requirements of Administrative Law and the National Environmental Principles.

Progress on specialist studies related to water and geochemistry

Four specialist studies related to water and geochemistry were recommended for phase 2 of the DSS research project, including (1) depth of the oxidised zone, (2) tailings water balances, (3) pore water quality evolution and (4) protocols to handle uncertainty in model predictions.

The aim of the studies were specific to the development of the comprehensive DSS in that it assessed whether enough information/understanding existed to develop the necessary guidance to the user of the DSS to answer a particular water related question in the DSS or not. Should not enough

information or understanding be available, the studies had to recommend using either a demonstration protocol, or a research project for Phase 3, to address the particular knowledge gap.

In all four cases, enough information was available to develop guidance on how a particular question can be answered in order to make a decision based on the technical studies conducted in support of the answer to the question. However, in all four cases, although the technology exists to predict future behaviour, there is a requirement to follow a demonstration period in order to calibrate and verify future predictions. Guidance is provided to the regulator on how the monitoring should be done and for how long. Furthermore, since prediction can never be an exact science, guidance was also developed for the assessment, quantification and documenting uncertainty associated with the assessment of the development of the oxidised zone on mine residue disposal facilities, tailings water balances and the evolution of pore water quality in the mine residue disposal facilities. The principles on which these protocols were developed are also applicable for other water and geochemistry related aspects as well as the surface stability aspects.

Progress on specialist studies related to surface stability

Surface stability (defined as the stability of the outer surface of the mine residue disposal facility against erosion caused by wind and water) specialist studies focussed on the erosion rate and effectiveness of cover technologies as well as the development of monitoring protocols to monitor and check surface stability during the post closure phase of a mine residue disposal facility.

In the evaluation of erosion rates, slope geometry and engineered erosion mitigation on mine residue disposal facilities were divided into geotechnical and bio-engineering aspects with some overlapping between the two aspects.

In terms of the geotechnical approach, benchmark erosion rates, measured on analogue sites in the Witwatersrand area, were established. Erosion rates are sensitive to slope angle and length, with overall erosion rates increasing linearly with slope angle. Optimum slope angles are proposed and rock cladding is proposed as an effective mitigation measure against erosion.

From a bio-engineering perspective, only the height, slope lengths, slope gradient and slope geometry of the mine residue disposal facilities can be optimised in the design phase which will also be dictated by the type of protection cover and end land-use. The end land-use dictates the first level of cover selection. The second factor determining cover choice is the presence or absence of sulphide minerals in the tailings. The third level of cover selection requires modelling and is dictated by the availability and type of cover materials and the slope length and slope gradient of the mine residue disposal facility. The main knowledge gaps with respect to bio-engineering approach still remain with vegetation issues which are strongly interrelated with the above mentioned support guidance.

In both approaches, monitoring protocols were developed in order to follow a demonstration approach as support for using particular slope geometry design and/or cover technology for a current or proposed mine residue disposal facility.

Identify new and promising technologies

The identification of new and promising technologies was addressed largely as part of the specialist studies and included in the specialist reports (appendices to the main research report which appear on the CD found at the back of the report). The approach that was followed in this task was to contact relevant stakeholders/role players (regulators, practitioners, technology providers) and document new and promising technologies. The team engaged with specific technology providers to assess new technologies.

In addition, a separate study focussed largely on a literature review of papers and conference proceedings recently published and categorised technologies in four categories; (1) modelling, (2) process/chemical related, (3) vegetation and natural interventions and (4) laboratory and field trials. Discussions with practitioners also yielded new technologies. Many new and promising technologies were identified and evaluated against criteria that were developed to identify the technologies that should be considered in the future, resulting in seven technologies proposed for further research. The technologies proposed for further research are:

- Natural analogues
- Metallophites and Phytomining
- Apply old technologies with more precision
- Design and construct mine residue disposal facilities with flatter slopes
- Designing scalloped slopes
- Paste rock
- On-site rainfall simulations.

Conclusions

In conclusion, the main objectives of Phase 2 (refinement of the first order DSS) of the development of a comprehensive DSS have largely been achieved and incorporated into the current first order DSS. The current DSS is now developed to a point where the methodologies and protocols have been developed and established for the development of the comprehensive DSS (Phase 3).

Recommendations for Phase 3 of the Research Programme

As mentioned at the start of this executive summary, Phase 3 of the main research programme is the development of a comprehensive DSS that builds on the experience of the preliminary DSS and the findings of Phase 2. Although Phase 3 is defined as one phase, it will consist of a number of project steps that will lead to the development of the comprehensive DSS. Furthermore, due to the dynamic nature of knowledge developed around the various topics in the DSS, it is envisaged that the DSS guidance components (decision and technical guidance) will change in future as more knowledge becomes available, requiring the DSS to be a dynamic tool. Recommendations are provided for the development of the comprehensive DSS in Phase 3 of the research programme.

