

Dump design and management

IM looks at some of the essential criteria in dump design and construction, essential tools and the overarching need to avoid acid rock drainage (ARD)

The name of Australia's DumpSolver Pty gives a very good clue to its activities. This Perth-based company that was formed in 2002 to provide a service to optimise the economic design and sequencing of waste dumps for open pits. It was named after its proprietary software program, which is designed to do for waste dump design what pit optimisation programs like Whittle Four-X™ have done for open pit design.

Dumpsolver's Mike Russell presented an interesting and very useful paper¹ at the Rock Dumps 2008 conference in Perth. He says a waste rock dump should be designed and developed at the lowest possible cost, with the least impact on the external environment and be acceptable to the future community. He lists the site specific constraints on rock dumps as including:

- Climate and environment
- Dump material
- Surface requirements
- Locations
- Mining economics
- Waste scheduling.

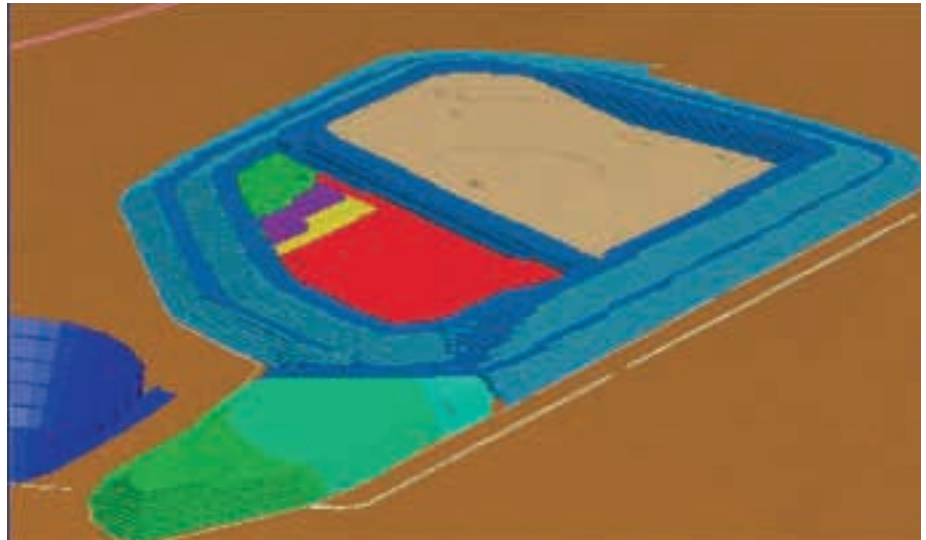
He notes that "they are very much interrelated and must be considered as such."

Three of the ultimate aims for the waste rock dump will be for it to be safe, stable and able to assimilate into the wider environment. As Russell says, "the first two points are mandatory with the latter point being implicitly included. Climate and environment determine the pre-existing productivity and communities of flora and fauna which in turn suggest maximum possible levels for the post-rehabilitated landform."

The most crucial period in the life cycle of a waste rock dump is generally seen as during and after construction. During construction "final slopes and water control methods are generally not in place and deleterious material is exposed to the environment." Insufficient attention at this stage can "result in off site damage even before completion."

Work is required at the end of the mine life to complete the dumps. "At that time all major movements of material have ceased and the dump is being finished. The finishing work that is required will be largely determined by the climate.

"There needs to be a good understanding of the environment in which the dump is to be placed."



Dump being scheduled after economic optimisation. Several material types needed specific placement based on their deleterious and beneficial physical and / or chemical properties



Same dump as above during construction. Different material types identifiable

The fixed criteria for dump material are generally:

- The volume of material to form the dump
- The characteristics of that material
- The sequence and timing of that material entering the dump.

"However, it is uncommon for there to be a complete and adequate understanding of the materials." In particular Russell singles out a lack of understanding in waste geology, waste volume and sequence of mining.

An additional complication could be the need to stockpile low grade ore for an indeterminate period of time pending possible future processing. "Clearly storage should be at least possible cost but it should preserve future options for the operation. The geochemical characteristics of the low grade ore may also determine the need to be encapsulated to prevent possible environmental impacts.

"For quality planning to occur, a good understanding is needed of the following:

- Material characteristics – the physical and chemical characteristics of the waste rock units
- Material positioning in the dump – in an ideal case there will be no deleterious physical or chemical characteristics that require special consideration. However, material characteristics should determine the required positioning of material within the waste rock dump. This may be encapsulation or to create a suitable growth medium on the external surface
- Waste material flow by rock type – the timing of the flow of waste rock, by specific material types, then becomes the primary input data to the effective waste dump construction scheduling.”

The dump surface is one of the most critical structures within the dump, i.e. the thickness and nature of the outer skin.

Russell explains “the conundrum for designers of waste rock dumps lies in the outer slope. The angle of the slope and particularly the behaviour of water on the slope will have a direct and major impact on the stability of the dump. The extent of surface erosion is controlled by the speed and volume of water passing over the material of the slope which in turn depends on the length and steepness of the slope. For a given fall in elevation (waste dump bench height) the steeper slope is shorter and so, to avoid excessive erosion, must minimise the amount of water on it, i.e. be positioned near the top of the dump. Where water volumes increase, towards the bottom of the dump, the slope should be lower to reduce the velocity. This implies that the concave slope system is potentially superior in terms of surface stability to the conventional batter and berm approach to dump slopes. This may be the case since berms can ultimately deteriorate to become structures that actually concentrate water flow rather than control it. However, since there is no hard cap protecting the crest of a concave slope upper face there will be increased erosion. In all cases great care must be taken to ensure that the water does not over-top the face of the dump.

“The following should be considered when evaluating dump locations:

- Proximity to the pit exit - economics obviously favour waste rock dumps positioned close to the pit exit (though the selected pit exit location should be incorporated with the overall dump economics)
- Gradient – slopes that allow drainage back into the pit ameliorate some of the potential risks particularly if potentially acid forming materials are present

- Drainage – care must be taken to ensure that water courses are not blocked by the development of the dump. As needed it may be appropriate to consider flow-through drains below the dump though these should only be used after careful consideration and require precise construction. When rock dumps are tied into topography, special consideration should be given to prevent / control the runoff from the surrounding area damaging the dump structure
- Topography – aiming to get the waste rock dump to complement the local topography
- Stability – the stability of the dump itself relies on the stability of the underlying material. It may be necessary to relocate weathered rock to provide a firm footing

particularly where these are deep, or where there is a slope and water is present.

“Whilst not specifically covered in this work there should be a preference for using existing pit voids for the disposal of rock waste. Second hand holes in the ground do have a value.”

Two considerations should be adhered to in keeping costs to a minimum. This is to minimise dump construction costs and closeout costs, by ‘getting it right first time’.

“The cost of developing a rock dump is largely controlled by:

- Haulage economics, i.e. the cost of moving the waste material around the site
- Land costs, those associated with the pre and post mining activities
- Ancillary equipment costs, those associated with keeping the haul trucks operating on

Essential tools

Laser scanning is used to quickly create 3D surface models of mining bulk-earthworks operations. Periodic scans of mine excavations and ROM stockpiles for example, allow surveyors to accurately calculate volumes of material moved while mining engineers are able to monitor site productivities, accurately reconcile the movement of materials, and assess features such as the condition and grades of dumps, ramps, benches, and haul roads.

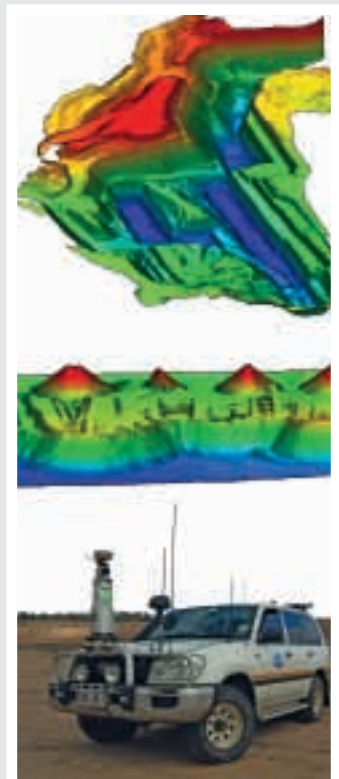
This rapid-mapping technology promotes ‘out-of-pit’ survey activities as the laser system measures surfaces through the natural reflectivity of materials. Riegls reports laser scanning can be used in situations where ground access is limited, prohibited to field crews, or where continuous subsidence monitoring or productivity applications are required.

The main factors are high speed data-acquisition in combination with the high accuracy of the acquired data. Results can be delivered as written reports or as map-plots. Riegls RISCANPRO software offers tools to automatically extract noisy data like vegetation, vehicles, etc. After removing these wrong measurements, the point-cloud, consisting of millions of points per data-set, is triangulated to get a closed surface-mesh. Based on highly accurate 3D surfaces, contour-lines and profiles of any orientation are extracted automatically. A tool for semi-automatic extraction of break-lines is also available. The resulting 3D-polylines can be exported in dxf-format to any CAD-system or special mining-software.

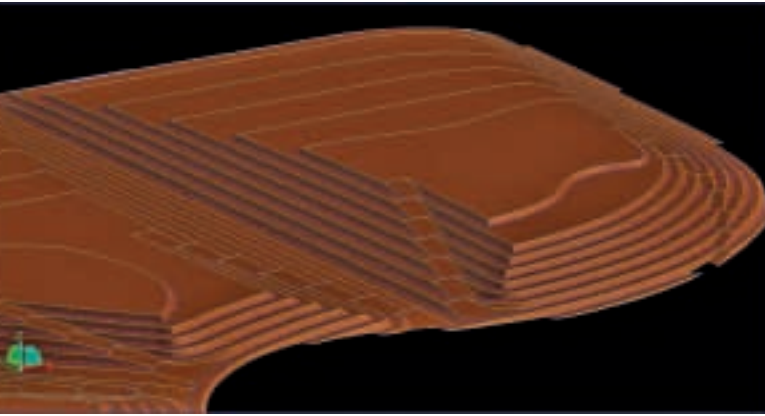
Volume calculation between different 3D surfaces is another important feature. The results are shown in numbers as cut- and fill-volume, and can be also visualised by colouring the 3D-surfaces according to height differences.

Geotechnical analysis can also be achieved on the 3D surfaces. Geotechnical analysis, dip-angle and dip-direction of faults, joints and beddings are essential as input for this. These parameters mainly determine the mechanical behaviour of rock masses. This avoids people having to climb into dangerous areas to measure these values by hand, which is hazardous, difficult, and time-consuming.

Through laser scanning technology 3D data is being used more than ever. Riegls says: “Terrestrial laser scanning equipment is changing the way we control and/or manage work in mining and will in the future be adopted and utilised as a key tool to support operations.”



ROCK DUMPS



Apache Pass system at design stage, prior to dump closure design

the waste landform safely and efficiently.”

The final consideration is scheduling, “unless the waste dump is to be constructed with a single benign material a detailed understanding needs to be gained of:

- Required / preferred and alternative locations for all materials.
- The timing of the material flow by type.

“These need to be combined in a detailed schedule, by period to ensure that a dump plan can be achieved.”

Another of Dumpsolver’s consultants, Nick Journet considers a specific project² in which they “selected the most likely operating scenario and used the results to prepare a detailed dump sequence which will be used to guide the mining operation and progressive construction of the waste landform. The detailed designs incorporate ‘Apache passes’ which show how semi-permanent access can be maintained to all dump lifts throughout the majority of the life of the waste dump thereby providing opportunities to fill the cheapest blocks first in a waste landform and maximise the project’s NPV. In addition, maintaining access to all dump lifts over the life of a waste dump eliminates the need to develop excessively high tip-heads and presents the following benefits:

- Safer operating environment
- Limits potential energy losses and saves fuel
- Reduction in overall haul cycle times
- Individual bench heights are significantly more stable, easier to doze down and rehabilitate.

In his conclusion, Russell says “the construction of good waste rock dumps cannot be simply planned at the start and then assumed that it will be completed appropriately. Periodically formal audits should ensure that the rock dump development and rehabilitation is on track and that, with potentially differing material types and volumes from updated information, the waste rock dump will get to the desired end point, namely a waste rock dump that is lowest possible in cost and has the least possible environmental impact.” **IM**

References:

1. Russell, M. So You Want to Have the Best Possible Waste Rock Dump
 2. Journet, N.C. Conceptual Analyses of Waste Dump Options Used to Prepare a Detailed Progressive Waste Dump Life-of-Mine Plan
- Both from *Rock Dumps 2008*, Australian Centre for Geomechanics, Perth, ISBN 978-0-9804185-3-8

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