# MINING FOR CLOSURE

A mine in Australia was in need of a solution to produce a 3D visual landform which, while reducing costs, could also achieve desired rehabilitation objectives for eventual mine lease relinquishment. **Ian Neilsen, Deswik, Australia,** discusses the modelling techniques tried and tested at the site.

Glencore-operated Newlands coal mine in Queensland (Australia) required a solution to tackle the challenge of producing a 3D visual landform which, while reducing costs, could also meet or exceed final land use and other environmental objectives.

The challenge: design a rehabilitation surface that was compliant with the rehabilitation criteria, as the particular pit (Pit A) was destined to be rehabilitated in the near-term.

A secondary objective was to develop a high level landform for the remainder of the site. This covers a large disturbed area, mostly a mix of rehabilitated areas, pits and irregular shaped spoil dumps.

Deswik applied the standard method of cutting a 2D cross-section per pit area to estimate reshape efforts. The detailed planning for Pit A created evenly spaced sections along the strike of the pit. A number of versions were completed over several days to balance cut and fill and calculate total volume.

To complete the site-wide estimate, this traditional method was going to require a minimum of 20 sections across seven areas, the equivalent to two weeks of planning to construct the sections and report the outcomes.

## The light bulb moment

The manual process of repeating 2D cross-sections for Pit A to find a satisfactory cut and fill balance was painful and slow. Much time was spent maintaining an acceptable 3D grade (between sections). Rather than continue this inefficient method, improvement ideas were investigated.

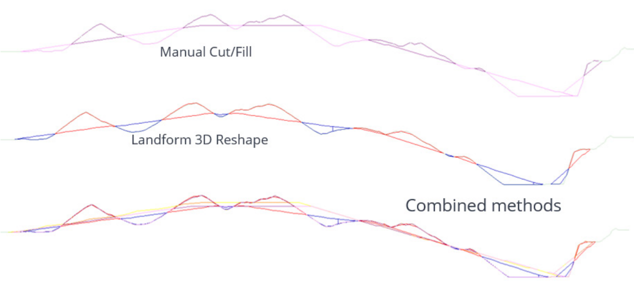


Figure 1. Initial method comparison.

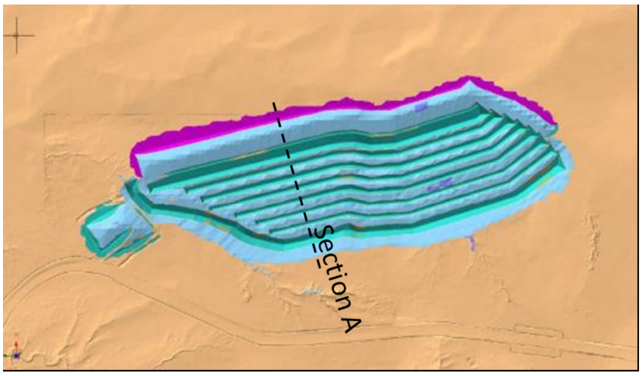


Figure 2. Dozer push modelling enhancement at Pit B.

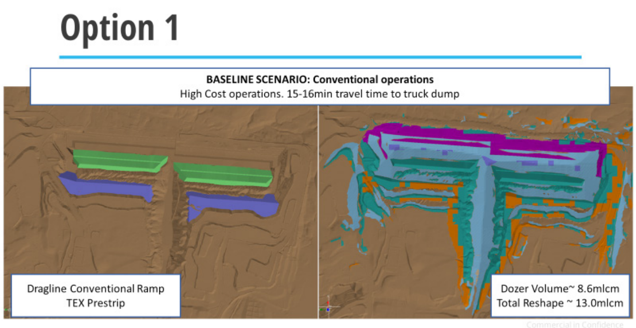


Figure 3. Baseline scenario: conventional operations.

3D mathematical modelling was identified as the best method to deliver fast, grade-compliant surface balance for cut and fill. The concept was used to experiment and develop a modelling technique, which was then used to re-process the work for Pit A. The 3D approach for the reshape of Pit A delivered the following:

- A 7% volume reduction was identified using 3D modelling to achieve the same grade constraints, translating to significant cost savings.
- Reduced planning time from three days to 4 hours.
- Shorter timeframes for the testing and quantification of multiple rehabilitation landform scenarios, which allowed the site to assess different criteria and rehabilitation cost-effectiveness.
- Improved visual output, providing a 3D reshaped surface that can be easily reviewed.

It was clear from these results that 2D methods were not suitable for accounting for (3D) surface variances between sections. Sectional methods also require engineers to align sections with the final rehabilitated surface to achieve correct gradients. This is difficult when the final rehabilitated surfaces are not yet designed.

The return on investment for this new approach has been substantial, due to material movement cost savings and improved planning efficiency. Deswik has continued to invest in the value and potential shown by this initial process innovation, and it now forms the foundation of a new suite of tools that integrate mine production, rehabilitation and closure planning.

## Optimising reshape for Pit A

In just under two weeks, the new 3D modelling process delivered robust reshape volumes for each pit, and tested several rehabilitation scenarios. Outputs included rehabilitation surfaces, cut and fill solids for volume estimates and scenario comparisons and analysis.

The speed of the 3D modelling process enabled the site to revise mining forecasts and develop confidence in rehabilitation plans supported by robust costings. A rehabilitation sequence was then drafted, allowing for assessment of equipment requirements and water impacts. Additional work has now been conducted over the subsequent three mine planning cycles, ensuring alignment of rehabilitation objectives with the mine plan.

Since the original prototype, Deswik has enhanced its tools, which have been used to optimise landform reshape by several other mines and companies. The improved process can now:

- Reshape landforms to honour rehabilitation grade constraints and minimise cut and fill.
- Account for exclusions and fixed surface requirements (for example, forcing reshape to conform to a required surface).
- Dozer push modelling to improve cost estimation of push vs other material movement methods.

- Model surface water drainage paths and catchments.
- Run across regional-scale datasets, e.g. a large opencast coal mine lease.

The design surface was provided to site operations personnel for execution. Guidance was also provided as to the direction of dozer push, as this is critical to ensuring the volume balance (cut/fill) is maintained. When Pit A reshaping was done, Deswik reconciled to assess the accuracy of the modelled prediction of volume. Using the latest version for modelling, the resultant surface predicted a volume within 2% of the actual result. Therefore, with the correct grade constraints and good operational survey control, the modelled surface can produce results that are well within most mine design tolerances.

## Integrating rehabilitation and mine planning

Planning for pit area extensions now integrates detailed rehabilitation planning, scheduling and costing. Once conceptual mine designs have been completed, dump modelling is conducted to simulate the completed mining surface.

The post-mining surface is then modelled for rehabilitation and estimations are made of reshape volumes and costs. The minimum requirements for a reshape model are:

- The surface to be regraded, e.g the predicted post-mining surface.
- Gradient and reshape extent constraints using polygons to define domains.

Optional model input extras are as follows:

- Minimum backfill surface – the final surface should not be below this surface.
- Maximum dump surface – the final surface should not be above this surface.
- Exclusion areas – similar to rehab or no disturbance areas.
- Sub areas – smaller areas to balance cut/fill volumes. These are used to minimise material transport costs when reshaping large areas.

The outputs from the model include the following:

- Reshaped surface balanced for cut and fill within a stated tolerance.
- Cut/fill solids used for dozer push simulation.
- Contours, cross sections, plots (optional).

Now that the final stages of the pit can be simulated within reasonable planning timeframes, the total cost of operations can be estimated. This process minimises rehabilitation costs by identifying high cost areas during the planning phases then adapting the mine plan to reduce these costs. Deswik Enviro has been extended to include surface water catchment and drainage paths, enabling integrated consideration of water management strategies.

These outputs can also be used to create the rehabilitation schedule, which, in combination with other Deswik models, can deliver an integrated production and rehabilitation plan, including equipment schedules and detailed costings.

## Mining for closure

A key driver for mine closure is to achieve a set of rehabilitation objectives and to align mining operations. The approaching closure drives an increased cost focus, of both the mining operation and rehabilitation reshaping. Reshaped surfaces may require expensive rework if rehabilitation objectives are not achieved early within the mining operation. Effective planning should adhere to rehabilitation objectives to ensure that opportunities are identified. Using Deswik integrated planning tools quickly provides both mine production plans and the total cost to rehabilitate, enabling value-driven operational decision making.

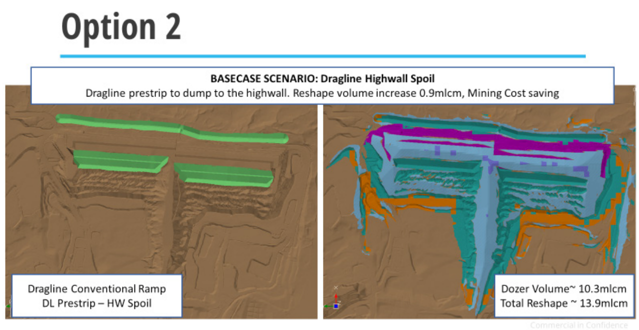


Figure 4. Baseline scenario: dragline high wall spoil.

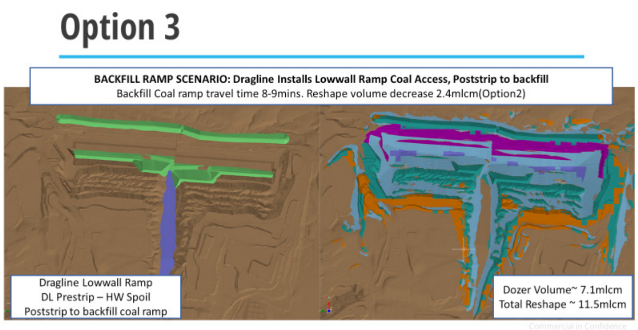


Figure 5. Backfill ramp scenario: dragline installs low wall ramps coal access, poststrip to backfill.

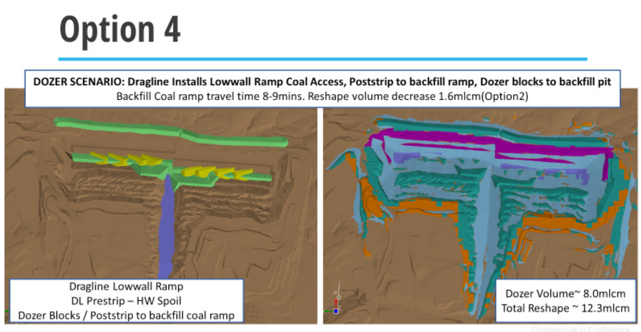


Figure 6. Dozer scenario: dragline installs low wall ramp coal access, poststrip to backfill ramp, dozer blocks to backfill pit.

The escalation of reshape costs can now be accurately modelled. As mining margins decrease support, 'mining for closure' strategies maximise remaining value and deliver rehabilitation objectives. As a pit advances over time, the reshape cost continues to increase until the final year where reshape reduction measures in the mining operation reduce the reshape effort required for rehabilitation.

Creating a 'mining for closure plan' requires visibility of total costs, then allows engineers and management to optimise by:

- Modifying the mining plan.
- Modifying the dump plan.
- Modifying the rehabilitation strategy.

As illustrated in Figures 3, 4, 5 and 6, several mining scenarios were tested and a number of instances of reshape modelling were completed to assess the best operation to deliver the desired final landform.

## Optimising final landform criteria

What does good mine planning look like? The following are some of the key criteria:

- Landform planning allows good understanding of post mining use and criteria so that if the foot print changes it does not necessarily change the landform criteria.
- Allows constructive discussion/opportunities to be developed.
- Longer-term view of value and opportunity is required – a separate data review indicates a required lead time of at least four strips to maximise value add.

Final landform development can be optimised by assessment of rehabilitation criteria at a high level to:

- Identify opportunities to reduce the cost of rehabilitation. For example, assessing areas that contribute to high costs and explore alternative mining measures.
- Modify any future mining works to ensure that the total mining cost is reduced.
- Prioritise areas of lower rehabilitation cost for completion to reduce total disturbance.
- Provide input into environmental modelling, such as water balance models.

These planning measures improve the ability of the site to perform effective rehabilitation. High standards of rehabilitation can be maintained by planning the work to reduce wasteful rework and achieve desired rehabilitation objectives to support successful mine closure and eventually, mine lease relinquishment. GMR