

Gullies and Waste Dumps

In the last 18 months, various Landloch projects have involved inspections of approximately 40 waste rock dumps on minesites across Australia. On almost every dump, gullying was observed to be the major and quite dominant erosion mechanism. This has prompted two questions:

- (a) why is gullying so predominant (can changed waste dump designs reduce gullying)?; and
- (b) what can be done to manage existing gullying?

Causes of gullying

Gullies involve incision to depths often well in excess of a metre, and remove large quantities of soil. The incision may be achieved via:

- tunnel erosion in dispersive or unstable materials, with the tunnel eventually collapsing to form a gully;
- large erosive forces applied to the surface by large overland flows; or
- wetness zones where positive pore pressures at depth reduce soil cohesion.

On minesite waste dumps, the first two mechanisms appear to account for all of the gullying observed.

Tunnel erosion

Tunnel erosion may develop as a network of tunnels under a batter slope, but is often also seen as a “piping failure” of a berm. The former mechanism forms gullies under the soil initially. The second mechanism forms gullies when large concentrated flows from a failed berm are discharged onto the batter slope below.



Tunnel collapsed to form a gully



Tunnelling through a berm

Tunnel erosion is commonly associated with dispersive materials, with high levels of exchangeable sodium being the causal factor. It should be borne in mind that there is an interaction between sodicity and salinity, so that a saline/sodic material may be stable, whereas a non-saline sodic material is typically very unstable. In practice, the difference

between the two is often a matter of leaching and time, and structures that pond water clearly hasten that process.

However, not all materials that tunnel are dispersive. Some fine, silty spoils tend to have a low bulk density when dumped, and such materials may also tunnel, probably due to high rates of water flow transporting particles through their high pore space, thereby enlarging and weakening pores in the spoil.

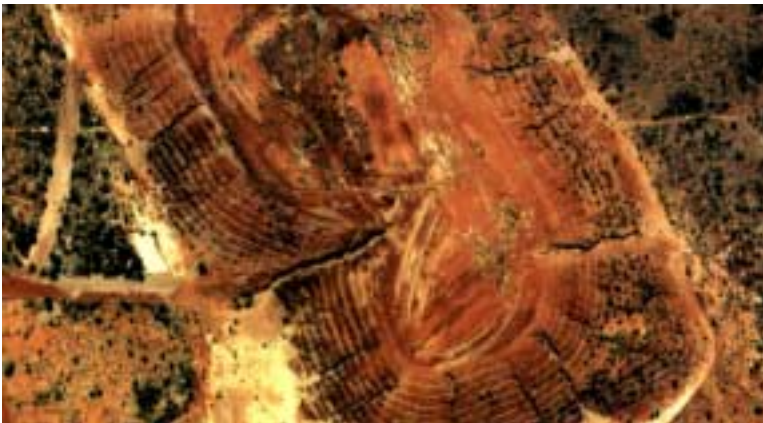
Creating large erosive forces

Large concentrated flows on outer batter slopes of waste dumps are usually due to one or more of the following factors:

- (a) uncontrolled discharge of runoff from the dump top;
- (b) large cross-slope rip lines which, when they overtop, discharge flows that have been accumulated across considerable widths of batter slope; and
- (c) failure of level or graded berms designed to pond or “manage” runoff.

The first of these factors is typically the result of some oversight during construction, and may include:

- inadequate quality control of earthworks; and
- failure to appreciate the prevailing physical environment.



Aerial view of gullies developed due to flow from the top of a dump spilling onto steep outer batters

Berms (either level or, alternatively, graded and drained by rock chutes) and cross-slope ripping are generally considered good practice in waste dump construction in Australia.

However, there is a considerable **likelihood** that rip lines or berms will overtop, due to one or a combination of:

- a large storm event exceeding their storage capacity;
- inaccurate construction;
- material properties that make such structures relatively unstable;
- gradual loss of capacity through sediment deposition over time; and
- faunal impacts such as animal tracks.

The **consequences** of that overtopping usually include formation of large active gullies, and complete loss of the effectiveness of the runoff management system that has been constructed.

Therefore, the **risk** of erosion is often unacceptably high when berms and large rip lines are part of the waste dump design. Although cross-slope ripping is seen to be important to trap water and improve vegetation establishment, the practice also carries significant risk of accelerated erosion.



Gullies associated with berm overtopping



Waste dump with small rip lines and little erosion on left, large rip lines and gullies on right.

Basic information

Gully development is highly dependent on contributing area, and strongly affected by gradient and material erodibility. It tends to be independent of the level of vegetation on areas outside the gully. Gullying is prone to periods of intense activity and relative quiescence.

Responses and alternatives

Consistent with our perception that gullying is a major issue for minesite waste dumps, Landloch has:

- (a) initiated a project studying identification and management of dispersive minespoils;
- (b) developed methods for designing slope profiles that do not rely on berms; and

- (c) begun to develop a methodology to not only assess gully activity, but also classify gullies in a way which also specifies appropriate repair methodologies.

Information on gully activity will provide minesites with an objective method for deciding whether gullies can either:

- i) be left alone;
- ii) be monitored, or
- iii) receive some remedial action.

Gully repair is potentially costly, and generally unsuccessful. Landloch's current work aims to produce guidelines for gully repair that remove the circumstances driving gully growth.

Following technical articles

Subsequent articles will consider the role of surface roughness and ripping in stabilising steep slopes, and issues for slope profiles and berms.