

SAVAGE RIVER MINE - PRACTICAL REMEDIATION WORKS¹

Bruce J. Hutchison,² and David Brett³

Abstract. Australian Bulk Minerals purchased the Savage River Mine in 1996 from the Tasmanian government. The mine operates in a wet temperate environment in steep terrain and has an historic environmental legacy of acid rock drainage. Mining personnel have worked with the government to remediate the historic legacy and along the way have developed simple mine planning and mining techniques to maximize the cost effectiveness of the operation. This paper outlines several of those techniques, including ore and waste handling procedures, alkaline flow-through construction, waste dump construction and remediation of an historic acid producing waste dump by construction of combined water shedding and alkaline side covers.

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² Bruce J. Hutchison is Principal Engineer, Australian Bulk Minerals, Burnie, Tasmania, 7325, Australia, ³ David Brett is Principal Engineer, GHD, Hobart, Tasmania, 7000, Australia
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Introduction

Australian Bulk Minerals (ABM) operates the Savage River Iron Ore Mine on the west coast of Tasmania, Australia. The west coast of Tasmania is characterised by steep hillside terrains with a wet temperate climate with an annual rainfall in the order of 2 m. ABM purchased the mine from the Tasmanian government in 1996. The mine was originally opened in 1966 and mining occurred through to 1995. The original operation has left a major environmental legacy of acid rock drainage (ARD), emanating from the oxidation of pyrite, found both in the magnetite ore and adjacent wall rocks. In a cooperative legislative agreement (the Goldamere Act) ABM works closely with the Tasmanian Department of Primary Industries, Water and the Environment to mitigate the effects of the acid rock drainage. The Savage River Rehabilitation Project (SRRP) is the administrative/technical vehicle through which the remediation work is carried out. The effects of the historic ARD are expected to continue for decades and as it is almost impossible to segregate the historic and ABM's new rock waste dumps the government has accepted the long term environmental liability of the mine site, as long as ABM use Best Practise of Environmental Management (BPEM) to dispose of their waste materials.

ABM and the SRRP have developed a remediation plan (Brett, 2006) that is based on a combined encapsulation of historic waste dumps and active/passive treatment of collected ARD seepage. ABM's own waste management plan is based on the encapsulation of potentially acid forming waste rock. All of these strategies are based on the identification and management of a series of different rock and soil types. The segregation of the different types of waste allows for practical remediation of the historic ARD and/or the cost effective disposal of ABM's waste materials.

Waste Designation and Mine Planning

The magnetite ore body and adjacent rocks at Savage River are a vertical sequence of ultramafic rocks (mainly schists and intrusives) approximately 500 m wide, located along a major fault zone. As noted previously pyrite is the main mineral responsible for the formation of the ARD through oxidation processes. The management of the waste rock is based on the identification of the acid forming potential of the rocks. The presence and percentage of pyrite is not necessarily a direct measure of the acid forming potential due to the existence of carbonate minerals (particularly calcite, magnesite and dolomite) within some rocks, which can neutralise the potential effects of the pyrite or make the rock alkaline in nature. The geologists rely on standard acid base analysis/accounting and static net acid generation tests to assist in classifying the rock types into four main groups:

- “A-type” Alkaline material used in hydraulic flow-throughs to add alkalinity into water courses, as an armouring material around clay encapsulated potentially acid forming rock (D-type) dumps, or co-mixed with neutral or low acid forming potential rock (B-type).
- “B-type” Rock having low acid forming potential or being neutral. Requires no special disposal technique but is usually co-mixed with A-type rock.

- “C-type” Fine grained soils or highly weathered rock of a silty to clayey nature. Used for rehabilitation and to encapsulate the potential acid forming rock (D-type).
- “D-type” Rock having significant acid forming potential. [Note that this material is more commonly referred to as “Potentially Acid Forming” (PAF) rock and this term will be used throughout this paper.]– Needs segregation and encapsulation with C-type material and then armoured with A-type.

The identification and classification of the different waste types begins during the initial exploration drilling phase and continues through the various planning and production phases, as outlined in the flow chart of Fig. 1. This process has proven to be quite simple and effective. Quality checks are carried out by senior geological and geotechnical staff on a continual basis. Geochemical audits by consultant geochemists are carried out every couple of years or more often if the geologic staff undergoes significant turn over.

Once the various waste types have been identified and loaded into the trucks the mine plan dictates the waste dump in which the material is to be disposed in, or for what specific remediation project it is to be taken to. Scheduling of the waste dump and remediation projects is essential to ensure the materials are put to the best use. It is imperative that the mining production staff and the people responsible for the remediation projects work closely together to achieve acceptable outcomes. At Savage River this has been achieved due to the total commitment of upper management. Flow-Through Dumps

One of the major rock types is a calcite chlorite amphibolite (referred in the geological classification as MXR) that has proven to be a very useful waste type. The calcite content makes the MXR an alkaline rock with an A-type designation. This rock material is generally quite blocky and very competent, although at times a significant amount can be finer.

During the previous operations waste dumps were confined to ridge top or hillside dumps, the latter that at times encroached on the streams and riverbeds around the lease. During ABM’s operations the blocky MXR has been used to create a major flow-through in Broderick Creek (Brett and Hutchison, 2003). In essence this is a 20 m high by minimum 50 m wide coarse rock dump that extends for over a kilometre up Broderick Creek. The top of the flow-through, and in some places the sides, are covered by a 5 m thick layer of the C-type “clay” (e.g. Fig. 2).

The benefits of the flow-through are two-fold. Historically the dumps were confined to ridge top dumps that required long uphill climbs or to much smaller hillside dumps. Following the construction of the flow-through, large dumps have been formed across the complete valley. Clay encapsulated cells of D-type material or co-mixed A and B-type dumps can be formed on top of the clay capped flow-through (e.g. Fig. 2). This has led to significant cost savings in haulage of waste materials.

The second benefit has been the addition of alkalinity to the ARD-affected Savage River. ARD from the historic waste dumps has lowered the pH of the river. Fresh water flowing down Broderick Creek enters the flow-through and picks up alkalinity as it passes through the calcite rich rock. The amount of alkalinity is dependent on the seasonal flow as shown in monitoring

results in Fig. 3. The Tasmanian government gives ABM credits for achieving the minimum and bonus target levels of alkalinity also shown on Fig. 3.

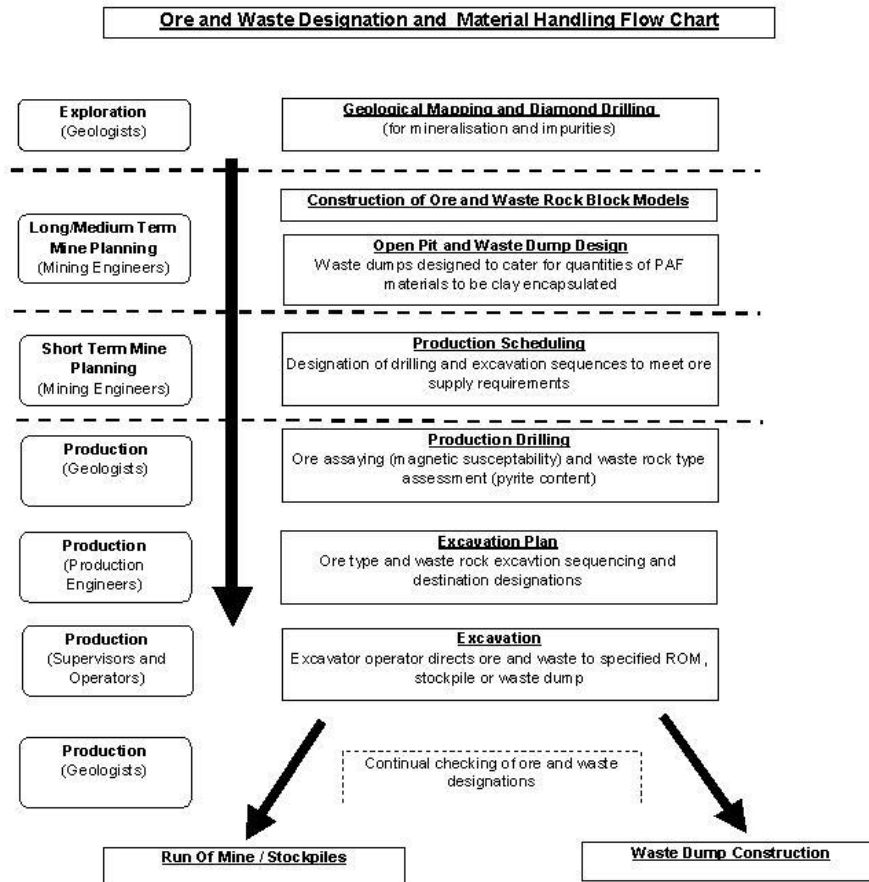


Figure 1. Waste Rock Designation and Management Flow Chart

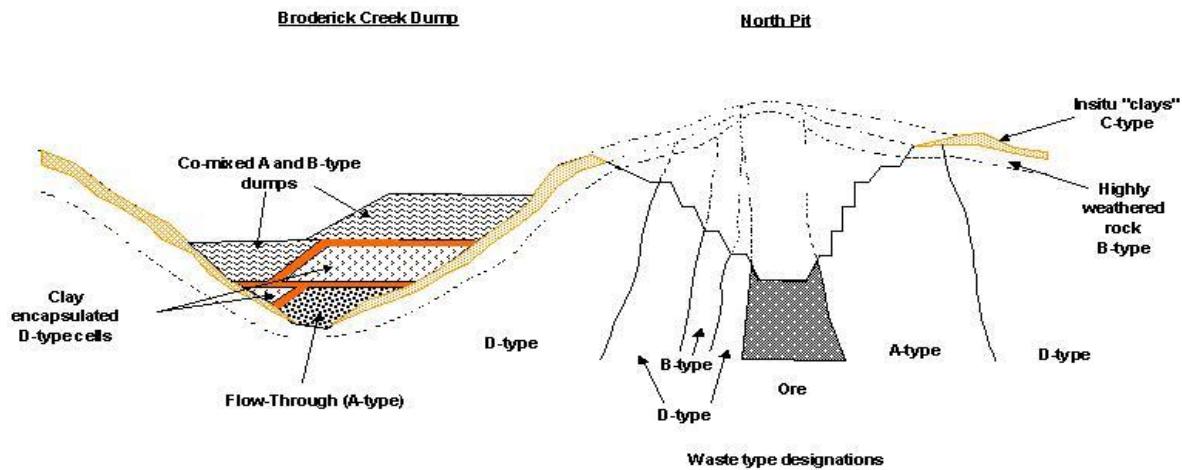


Figure 2 Typical Cross Section of Open Pit and Waste Dump

The key construction techniques adopted include:

- Initial selection of competent blocky rock (carried out by the excavator operators or geotechnical staff).
- Maintaining a dump tip head of at least 20 m in height to segregate coarse material at the toe.
- Maintaining the tip head either parallel to the creek bed or at a maximum of 45° to the course of the stream.

The latter recommendation allows for water to flow more freely along the inherent “layering” that occurs as the end tipping occurs. If a tip head is formed perpendicular to the stream flow then there is a greater chance that unwanted finer materials could block the flow, as was once the case during our early development of the flow-through.

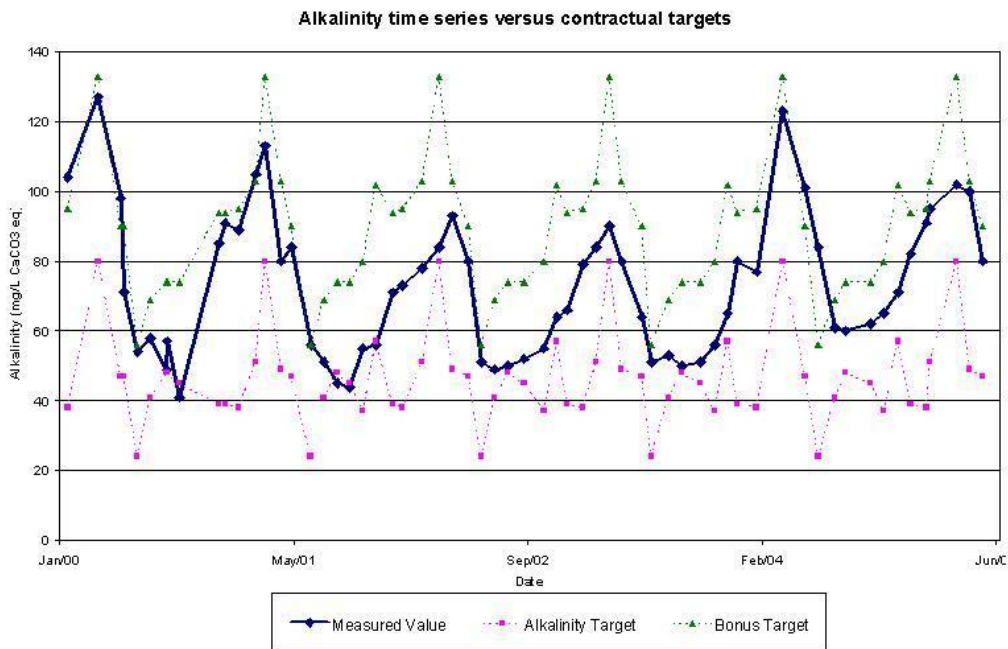


Figure 3 Broderick Creek Flow-Through Alkalinity

PAF Waste Dump Construction

The construction of the Broderick Creek Flow-Through solved a major problem with waste disposal around the North Pit. Mining however has and will continue to occur adjacent several other open pits on the lease. In these areas long uphill climbs to ridge top dumps and the restricted space on the ridges still required the use of hillside dumps. BPEM BPEM what does this stand for? has dictated the use of highly compacted clay encapsulation techniques to dispose of the PAF what does this stand for? PAF waste. The adoption of the ABM's waste designation strategy significantly reduced the volume of waste needing special treatment, as PAF-PAF materials usually comprise only about 15% to 30% of the total waste in any one pit. Despite this reduction, further problems were encountered during a construction trial carried out on B-type waste in the South West Dump (eg-Fig. 4). Construction procedures were developed and refined but the costs were very prohibitive due to the extensive spreading and compaction of a series of relatively thin clay layers needed to produce the desired effect. In addition it was discovered that the majority of "clayey" material available was actually highly to extremely weathered rock with clayey silt or silt matrices. This made the compaction criteria (permeability $<10^{-8}$ m/s) extremely difficult to achieve to prevent oxygen penetrating the cover.

It can also be seen in Fig. 4 that the overall slope angle required to carry out the compaction and to keep the slopes stable is very shallow, in the order of 20°-22°. This severely restricts the locations of hillside dumps and the amount of material that can be placed in them.

During a technical visit from our geochemical consultants, Environmental Geochemistry International (EGI), this problem with the compaction of non-clay materials was mentioned.

EGI presented some work they had been carrying out on the relationship between the Acid Sulphate Generation Rate (ASGR) versus the degree of saturation of fine-grained materials (e.g. Fig. 5). From this work an alternative construction technique was developed that is suited to the high rainfall environment and variable nature of the fine-grained materials of the mine site.



Figure 4 South West Rock Dump – compacted clay encapsulation and re-vegetation

Rather than placing “clay” in compacted low angled layers the readily available highly weathered waste material is end dumped over the edge of 15-20 m high tip heads of PAF materials. Three to five metre thick layers are used to encapsulate the side of the PAF dump and then a variable thickness of A-type material is end-dumped over this to armour the encapsulation material and to provide a mulching effect. The thickness of the required armouring is dependent on the ultimate height of the dump taking into account stability considerations. For a single 20 m high dump lift only 5-7 m of armouring is required; but for a series of four or five 20 m lifts then up to 60 m of armouring may be required in front of the lower lift, reducing in width as one proceeds to the upper levels.

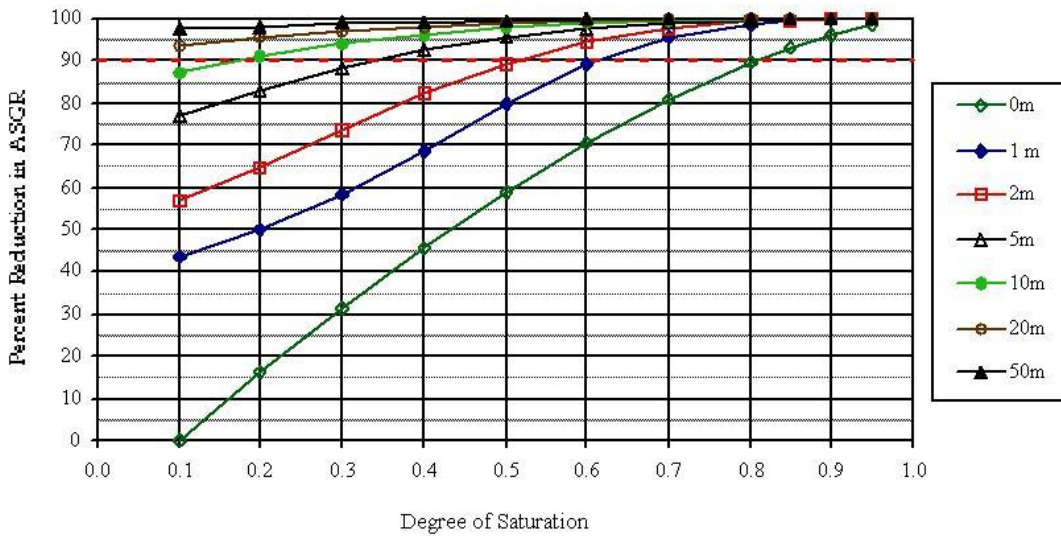


Figure 5 Percent Reduction in ASGR as a Function of Moisture Content and Cover Thickness

The Upper South West Dump has been used as a trial for this new technique. A series of soil moisture and temperature instruments were placed in the dump to monitor the effects. Fig. 6 shows the dump, the weathered rock wastes utilized and the instrumentation installation during the construction phase. This alternative encapsulation technique has had four main advantages:

- Reduced supervision of the dump encapsulation process.
- A much greater variety of acceptable encapsulation material
- Increased volumes of waste over the same hillside footprint
- Greatly reduced costs.

The moisture monitoring results (e.g. Fig. 7) have consistently measured soil saturation levels above 60% and typically above 75% at lower levels of the cap. Based on the ASGR chart presented by EGI these levels would reduce the ASGR by in excess of 95%, confirming the effectiveness of the cover system. The monitoring of volumetric moisture levels over time will be used to confirm that the cap layer maintains adequate saturation levels.

Remediation of a Historic Acid Producing Waste Dump

At Savage River there are several catchment areas polluted by acid rock drainage emanating from historic waste dumps. The Main Creek catchment produces approximately 40% of the total pollutant load (based on copper loads) of the mineral lease. The B Dump Complex is a significant contributor, along with the Emergency and Main Creek Tailings Dams, to the



Figure 6 Upper South West Dump Construction and Instrumentation

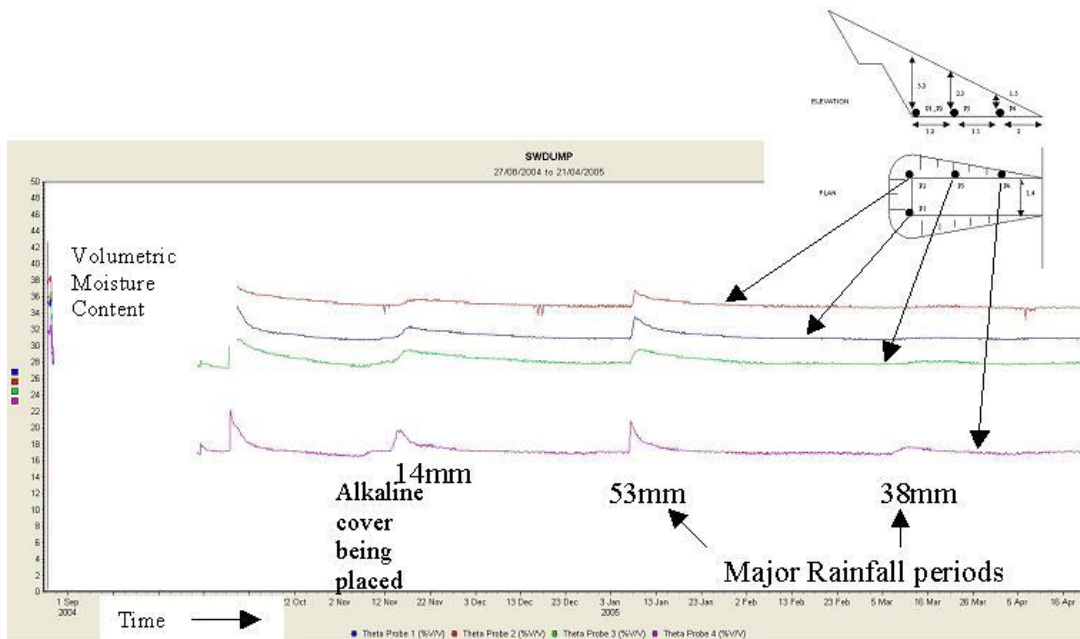


Figure 7 Upper SW Dump Soil Moisture Monitoring Results

pollutants in Main Creek. As part of the SRRP ABM have begun remediation of the B Dump Complex (e.g. Fig. 8) using a combination of active and passive treatment. The passive treatment is comprised of:

- An alkaline side cover above the eastern Main Creek side of the dump.
- A clay encapsulation cover on the western side of the dump.
- A water shedding cover over the top of the dump that discharges to an alkaline flow-through on the southern end of the dump.

The active treatment component consists of the collection of the reduced seepage (due to the water shedding cover) and the treatment of the seepage hopefully utilizing dolomite-magnesite rock from the site. Development of the treatment process is currently underway.

Summary

This paper presents several examples of practical mine site remediation and waste rock disposal techniques currently ongoing at the Savage River Mine. Many of these techniques would be applicable to mines located in similar high rainfall temperate climates. The majority of these works are dependent on the identification, segregation and utilization of a variety of rock waste materials, based on their environmental and construction related properties.

Literature Cited

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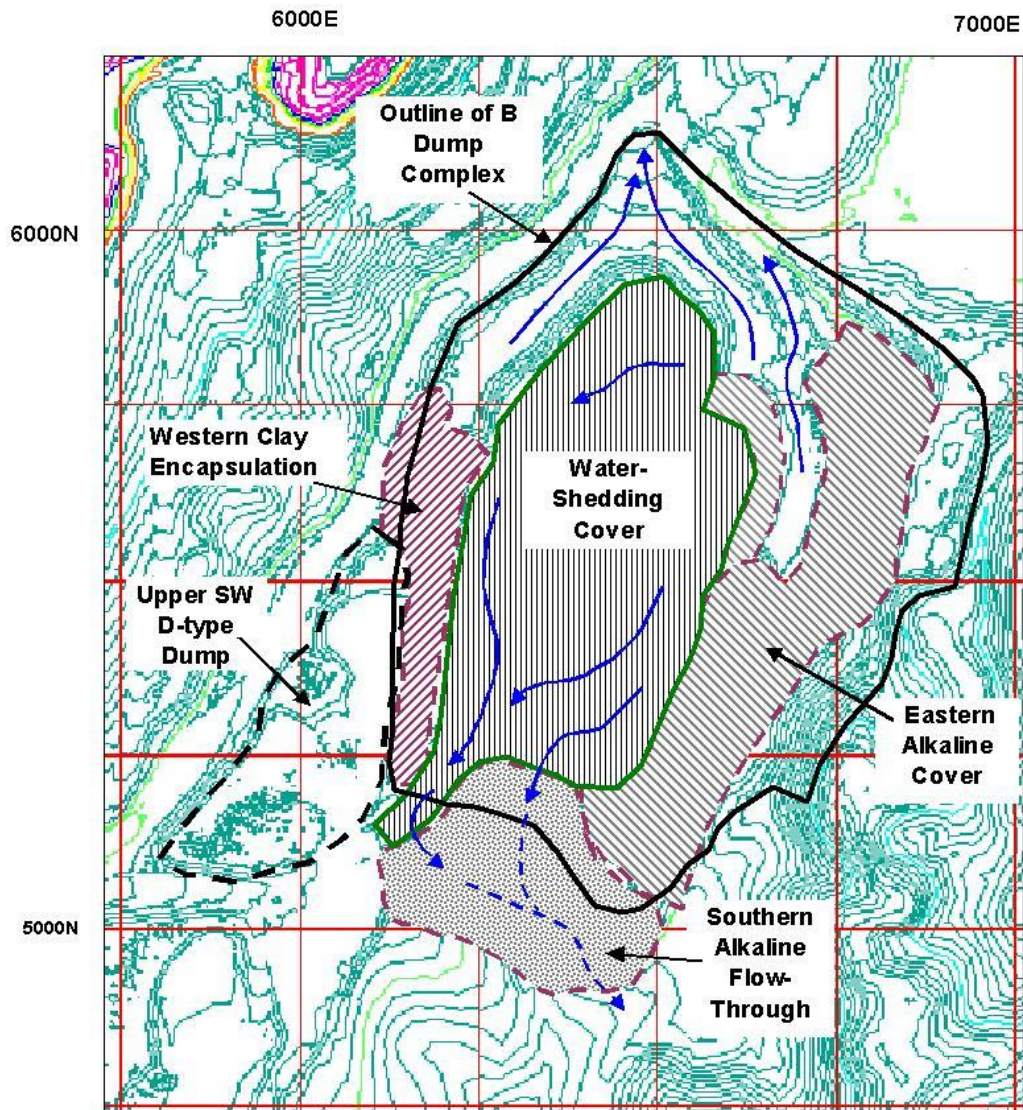


Figure 8 B Dump Complex showing remediation and surface runoff directions