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Commitment, Experience and Teamwork — The Key to a Successful Mine Closure Works Programme at Tanami Mine Site

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Abstract

Tanami mine site, located in one of the most remote and inhospitable locations of Australia, is undergoing one of the largest mine closure works programmes seen in Australia over the past five years. The mine area and its satellite pits are scattered over an area of 100 km in length and 1800 km^2 within the Tanami Desert of the Northern Territory, approximately 670 km north-west of Alice Springs, and is one of the most remote mines in Australia. The majority of the project area occurs within the Central Desert Aboriginal Land Trust, administered by the Central Land Council (CLC).

The site is a historic mining area which was mined for gold from the early 1900s and, most recently, from the mid 1980s, up until 2004. The site comprises 45 open pits, eight backfilled pits, 11 in-pit tailing storage facilities, 24 waste rock landforms, two above-ground tailing storage facilities (TSFs), a processing plant and on-site village accommodation. The site is in the final phase of closure works after five years of investigation work, planning and earthworks. Consultation with local indigenous groups, government departments and other key stakeholders has facilitated a transparent closure process towards the agreed return to traditional land-use. The final land-use objective for the Tanami Mine is for rehabilitation of the mined environment to occur over the long term to promote the establishment of sustainable ecosystems. Following the demonstration of rehabilitation and the achievement of lease relinquishment, the area will be returned to the site's traditional owners for traditional uses.

The harsh environmental conditions of cold winters, extreme summer temperatures, highly variable rainfall (from occasional drought to intensive, short duration cyclonic rainfall), frequent wildfires and remoteness are some of the many challenges faced during the closure process. The size of the site and array of landforms, some composed of highly unstable and dispersive waste material, further complicated the closure process. The progress of the Tanami mine closure works programme to date is largely the result of effective interaction between an experienced closure and reclamation team, as well as a committed and engaged workforce. The management team provides leadership in planning, design, execution, environment, safety, community relations and cost control to assist and engage the workforce.

1 Introduction

The Tanami mine site is located in one of the most remote and inhospitable locations of Australia. The mine and its satellite pits are scattered over an area of 100 km in length and 1800 km^2 within the Tanami Desert of the Northern Territory, approximately 670 km north-west of Alice Springs and is one of the most remote mines in Australia. The majority of the project area occurs within the Central Desert Aboriginal Land Trust, administered by the Central Land Council (CLC). The site is a historic mining area which was mined for gold from the early 1900s and, most recently, from the mid 1980s up until 2004. Since 1987, under numerous operators including Zapopan NL, Otter Gold Mines Ltd and AngloGold Australia Ltd (forming the Tanami Mine Joint Venture) and more recently Newmont Asia Pacific, the project has produced 1,285,224 ounces of gold from 12,809,464 tons of ore milled. No further mineable reserves were reported at the Tanami Mine in June 2001 and mining ceased in July 2001. Following the Normandy–Newmont takeover, a satellite mining operation at the Groundrush Project was undertaken from 2001 to September 2004 with ore being processed at the Tanami processing plant. Processing at this plant ceased in August 2005 (Haymont et al., 2006b). The site is in the final phase of closure works after five years of investigation work, planning and earthworks.

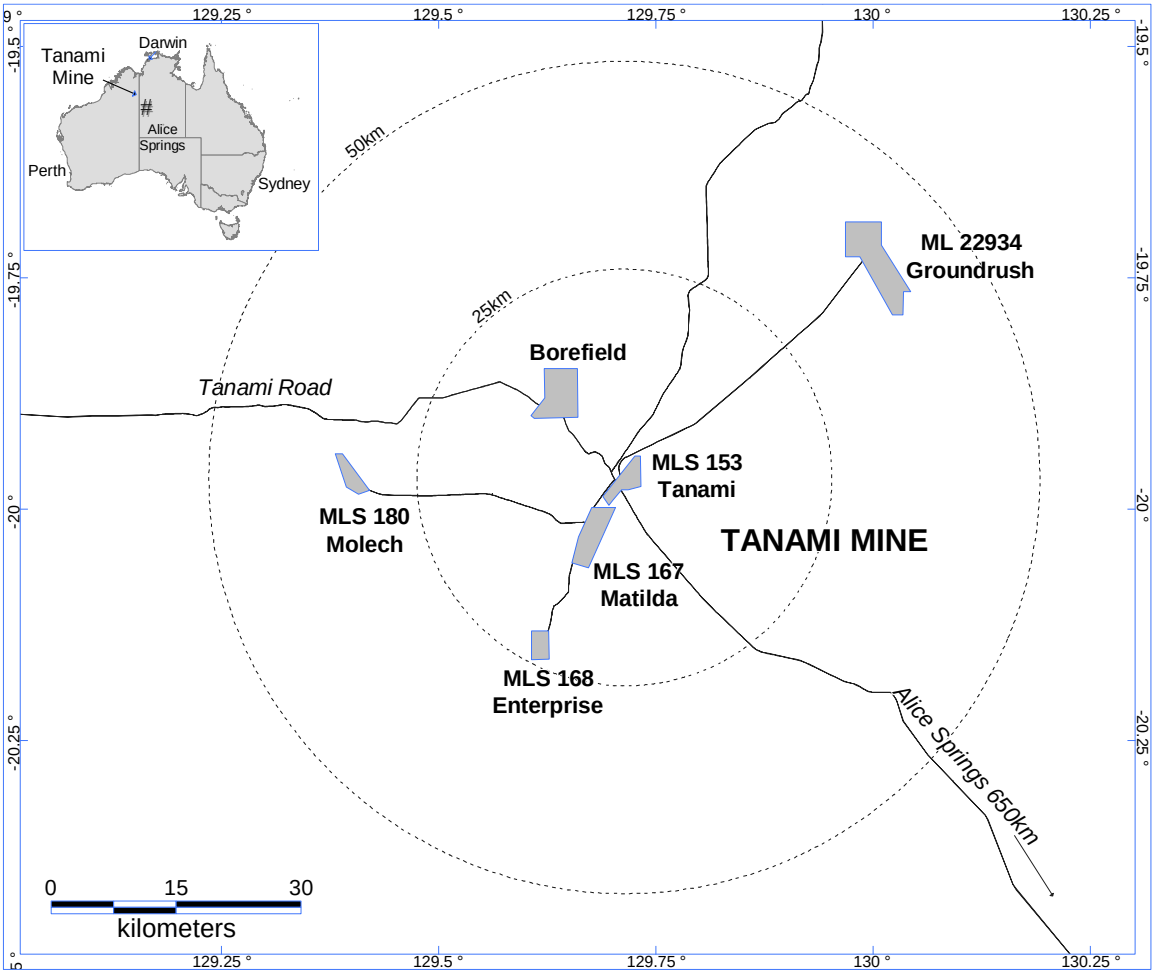

Figure 1 Mine location in the Northern Territory of Australia

Table 1 Summary of site features

Number of open-cut pits	45
Backfilled	8
Utilized for tailings storage*	11
Number of tailings storage facilities	
Above ground paddock style	2
In-pit*	11
Waste rock landforms (no.)	24
Low grade ore stockpiles (no.)	9
Roads (area/km)	149 ha/124 km
Total disturbance (area)	1500 ha

* indicates pits that became in-pit TSFs.

1.1 The environment

Situated in a semi-arid region of the Tanami Desert of the Northern Territory (Figure 1), the project area experiences a semi-arid and monsoonal climate, with approximately 90% of annual rainfall occurring between November and April. Mean annual rainfall is 429 mm. The 1-in-100 year 72 hour rainfall event is

approximately 350 mm. Summers are hot with a monthly mean maximum of 39.3°C in December. Winters are generally cold, with a monthly mean minimum of 6.6°C in July. The annual evaporation is approximately 3000 mm. In 2006 when annual rainfall equaled 970 mm, 486 mm occurred in one 72 hour period, representing a 1 in 910 year annual exceedance probability for a 72 hour rainfall (A. Vitale, pers. comm., 2006).

The project area consists of low sandy soil plains with minimal relief, containing tall open Acacia shrub land and low woodland with mainly Spinifex and hummock grass understorey. A biogeographical regionalization of Australia (Thackway and Cresswell, 1995) identified the Tanami as Region 49, covering 292,194 km^2. Less than 1% of the region is reserved in conservation areas.

The region is described as "Mainly red Quaternary sand plains overlaying Permian and Proterozoic strata, which are exposed locally as hills and ranges. The sand plains support mixed shrub steps of *Hakea subera*, desert bloodwoods, acacias and grevilleas over *Triodia pungens* hummock grasslands. Wattle scrub over *T. pungens* hummock grass communities occur on the ranges. Alluvial and lacustrine calcareous deposits occur throughout. In the north they are associated with Sturt Creek drainage, and support *Chrysopogen* and *Iseilema* short-grasslands often as savannas with River Gum; in the south the saline alluvia of Lake Mackay support samphire low shrublands and *Melaleuca lasiandra – M. glomerata* shrublands" (Gibson, 1986).

1.2 Current land-use

The project area is located on Aboriginal Freehold Land, being land granted as inalienable freehold title to traditional owners, with much of the land in the region being of high ceremonial and cultural value to the Warlpiri people. The Tanami region is sparsely inhabited. The nearest settlements are Lajamanu and Balgo, 230 km north and 200 km north-west respectively, of the Tanami Mine. Rabbit Flat Roadhouse and The Granites Gold Mine are located 40 km and 100 km respectively, south of the Tanami Mine.

1.3 Challenges

Amongst the many challenges faced by the closure and reclamation team during the rehabilitation and closure works programme were:

- The remote and isolated site with associated fly-in fly-out logistical and supply requirements, workforce retention and safety management issues.
- The harsh environmental conditions of cold winters to extreme summer temperatures, highly variable rainfall from occasional drought to intensive, short duration cyclonic rainfall.
- Frequent extensive wildfires and management, as well as protection of assets and early rehabilitation.
- Highly-weathered and dispersive smectitic clays randomly mined in the past and placed on the outer surfaces of the landforms.
- Landforms placed on the geotechnical zone of instability and inherently unsafe to earthmoving activities.
- Topsoils either not retained, or of insufficient volumes for final closure work requirements.
- In-pit tailings storage facilities with no underdrainage systems provided to assist in consolidation prior to closure works. Half of the in–pit TSFs were unconsolidated and therefore difficult to cover.
- Drainage control failures on existing waste rock dumps, including (1) large catchments on upper surfaces concentrating flow and overtopping, (2) large gullies on outer faces, and (3) some berms concentrating water at low points, resulting in erosion gully formation.
- Above-ground paddock-style tailings storage facilities decommissioned as a final conical surface, with run-off during highly intense cyclonic rainfall likely to be extreme and requiring management.
- Providing an environment that can sustain a vegetation community adapted to desert conditions on mine wastes often found to be dispersive, prone to erosion and unstable.

- Development of appropriate completion points and the measurement of those across the large diversity of rehabilitated landscapes and features.

2 Closure planning process

2.1 Governance

Newmont takes a holistic approach to closure programmes and has developed a specialized closure and reclamation team. This is a very different approach to the completion of closure and rehabilitation works as an afterthought and naturally there is a need for a critical mass of activity to support such an approach. Newmont has been taking this approach for several years with its Australian team. The team works on the Tanami Programme with reference to the Tanami Mine Closure and Rehabilitation Plan (Haymont et al., 2006b). The plan has been developed to meet the following minimum requirements:

- Newmont Asia Pacific policy and standards.
- Mineral Council of Australia Code of Practice.
- Northern Territory legislation and guidelines.
- Relevant agreements with the traditional owners.

In addition to the above, all activities associated with this plan are guided by the Newmont values. These values are to:

- Act with integrity, trust and respect.
- Reward creativity, a determination to excel and commitment to action.
- Demonstrate leadership in safety, stewardship of the environment and social responsibility.
- Develop our people in pursuit of excellence.
- Insist on, and demonstrate, teamwork as well as honest and transparent communication.
- Promote positive change by encouraging innovation and applying agreed upon practices.

Stakeholders recognized and consulted as part of the closure process include: the Traditional Owners, Central Land Council, Northern Territory government, Newmont Tanami Operations, and Newmont Asia Pacific shareholders, workforce and contractors.

2.2 Closure, completion and end land-use objectives

The final land-use objective for the Tanami Mine is for rehabilitation of the mined environment to occur over the long term to promote the establishment of sustainable ecosystems. Following the demonstration of rehabilitation and the achievement of lease relinquishment, the area will be returned to the site's traditional owners for traditional use (Haymont et al., 2006a).

Primarily, the closure objectives are to:

- Ensure the site is physically safe and does not pose a human health risk.
- Ensure that land is left in a stable condition that minimizes long-term environmental impacts.
- Rehabilitate disturbed land such that it is ecologically sustainable and generally reflects the surrounding ecology or, where appropriate, the ecosystem relevant to the land-use.
- Ensure that water quality does not pose an ecological or health risk to humans or livestock and, where risk restrictions may apply, ensure that appropriate notification and controls are in place.
- Establish final land-use objectives to meet land capacity as well as the surrounding social context and relevant agreements, and where land-use restrictions are required, provide clear notification and management of land that has usage restrictions.

- Engage in community/stakeholder consultation to a degree that there is general acknowledgement that the process has been satisfactory and was delivered in a way that enabled understanding and provided opportunity for stakeholders to exert reasonable influence on relevant processes.

An example of the style of completion matrix applied to work toward the objectives for closure of the site is provided in Table 2.

Table 2 Example of the approach towards the management of completion criteria

Objective	Criteria	Method	Measure
Establishment of sustainable ecosystems.	Disturbed lands are rehabilitated to final land-use considerations through appropriate consultation and approvals, unless specified otherwise.	Disturbed lands are rehabilitated by application of suitable growth medium, management of surface water and application of vegetation seed.	Disturbed areas are rehabilitated, unless specified in section B of the closure plan.
Rehabilitate disturbed land such that it is ecologically sustainable and generally reflects the surrounding ecology or, where appropriate, the ecosystem relevant to an appropriate land-use.	Demonstrate measured values for landform function analysis, and habitat complexity trends towards the relevant analogue sites, or are appropriate in terms of an appropriate regional completion criteria. If, for any reason, analogue sites are not an appropriate measure (where analogue sites are not the measure), this will be specified.	Monitoring is conducted as outlined in the performance monitoring plan.	As measured in the annual ecosystem function analysis (EFA) monitoring, with results provided in the annual monitoring report.
	Demonstrate which vegetation establishment trends relevant towards analogue sites, or are appropriate in terms of plant species composition, diversity, abundance and function (provision of goods and services). If, for any reason, analogue sites are not an appropriate measure (where analogue sites are not the measure), this will be specified.	Monitoring is conducted as outlined in the performance monitoring plan.	As measured in the annual EFA, monitoring with results provided in the annual monitoring report.

2.3 Closure and rehabilitation planning framework

Despite the best corporate intentions, policy and years of commitment to high closure performance standards, the process of closure often occurs in an environment of negative cash flow. An alternative to the situation of closure processes that are often an afterthought and are fraught with difficulty, is to provide good quality planning, preparation and budgeting prior to closure. With robust and tested implementation processes, appropriate review, regular adjustments to design and utilizing a mining fleet of specialist rehabilitation earthmovers, it is likely that a project will stay within original budgets (Haymont et al., 2008b).

The closure and reclamation team works on processes that focus on engaging, maintaining, developing and supporting specialist teams within Newmont and with specialist contractors to carry out closure and rehabilitation works in order to:

- Develop appropriate site-specific and scientifically supported criteria, standards and designs appropriate for the location and conditions.

- Estimate, record and report costs as well as develop budgets based on robust processes.
- Provide high quality and accountable leadership for projects.
- Implement projects to the agreed standards with a strong focus on safety and cost control.
- Encourage innovative thinking from all participants in projects to create improvements in standards and reductions in costs.
- Negotiate and interpret closure process to regulators, indigenous people, landholders and other stakeholders.
- Record and report activities through manageable processes.
- Benchmark and understand leading practice and disseminate improvements based on experience.
- Promote the development of a rewarding work environment (Haymont et al., 2008b).

The closure plan and its framework provides planning, budgeting, cost control and works direction for all aspects of the mine site including roads and airstrips; drill sites, drill pads and exploration trenches and drill hole abandonment; open pits and borrow areas; non-process ponds, reservoirs and water management; landforms, stockpiles and landfills; tailings storage facility reclamation; drainage and diversion channels; facilities demolition as well as equipment disposition and salvaging; post-closure monitoring; stakeholder engagement and owner management.

3 Project team

There are approximately 25 to 30 employees and contractors directly involved in the closure, care, maintenance and reclamation of the Tanami Mine. The majority are contractors engaged specifically for their rehabilitation earthworks expertise. A specialist closure projects team, the Newmont Asia Pacific Closure and Reclamation group, has been formed to manage closure and reclamation activities. For the Tanami, this includes a senior regional manager in Perth, a roving regional coordinator travelling to all closure sites, a site-based closure superintendent and an environmental advisor. Newmont Tanami Operations assist in providing logistical support for supplies, travel and emergency response as required from the Granites Gold Mine.

A closure project team bears some resemblance to a construction team. They are involved for a relatively short term, they need to be focused on safety, quality and costs, and they are operating when some of the usual support staff and infrastructure of a mine site have reduced or disappeared (Lacy and Haymont, 2006). They have the opportunity to influence the closure and rehabilitation process in many ways, and a range of skills and knowledge is required. Haymont et al. (2008b) proposed that questions, such as those below, should be asked of team members and the team management:

- Are the people selected to be involved in the project experienced in the specific field of rehabilitation and closure?
- Have the leaders led well before and will the team accept that leadership and, where necessary, challenge leadership?
- Is the team to be supported and well resourced?
- Are the types of people in the team able to provide feedback, accept and deliver constructive criticism as well as make observations at all levels?
- Are they familiar with the physical and climatic environment they are in, as well as its various cycles and events?
- Are they the types of people who will collaborate and contribute across disciplines or focus only on their own?
- Will they care about what they do?

- Have they the capacity to respond to new information or emerging patterns (capacity to demonstrate adaptive management)?

The primary functional units of the closure and reclamation team for the project comprised the following:

- Newmont Corporate (sponsors) have the responsibility of instilling leadership and accountability in the workforce by delivering a closure vision, engaging in support as well as making informed and considered decisions. They provide adequate budgets and resources, and work to ensure that budgets were planned and executed appropriately. The sponsors are interested in achieving outcomes of high standard, whilst also focusing on cost management.
- Newmont regional support personnel facilitate the resource flows into the project and are the important bridge between the corporate sponsors and those that actually apply the resources. The regional personnel are also responsible for building the relationships with regulators and landholders, corporate, technical and operational personnel, and consultants. They are critical to the key processes of effective contractor and consultant selection, management of team needs as well as dynamics and analysis of the performance monitoring associated with the projects.
- Newmont administrators support the complex closure activities, with good administration, contracting, accounts payable and accounting systems being managed effectively. Without all of the right corporate systems being appropriately managed, the efficiency of the project can be compromised.
- Newmont site coordinator provides details and strategy to the site personnel. The role of resolving and avoiding conflict, rewarding good performance, encouraging feedback and soliciting innovation is a critical task. The project has benefited from having a site coordinator (the co-author) with a long-standing commitment to the site and a genuine desire to see the works completed appropriately.
- The contractors are an essential component of the team. They maintain the routines of internal and external communications through daily and weekly meetings, inspections, and hazard and issue management. The ability to remain innovative and confident in suggesting and discussing ideas and concerns, contribute to the project's team-based dynamics. The capacity to maintain experienced personnel is critical. The capacity to remove personnel who do not have the appropriate competencies or are unsuited to remote area work whilst retaining effective and skilled operators, assist to ensure that the closure team remains effective.
- Consultants to the project provide effective communication through the promotion of practical ideas and designs, based on science and experience, and are able to give project support when called upon.
- The planners, through coordination and cooperation of the Newmont leadership, contractors and consultants, have a good understanding and experience in mine closure and rehabilitation processes, in addition to an intimate knowledge of the site and site conditions. They provide appropriate rehabilitation designs specific to the site and site conditions.

4 Major activities undertaken

Many works have been undertaken during the programme to address the challenges faced. The major activities for the project were:

- Material characterization studies: There was a lack of sufficient data on the characteristics of mine waste and rehabilitation materials in order to develop a robust plan for rehabilitation adequately. A programme of research and investigation was commenced between 2003 and 2006 to establish a detailed understanding of materials characteristics in order to form the plan adequately. This involved extensive sampling programmes and detailed analysis, as well as advice by a range of specialists, and this continued up to, and during, the work programme.
- Reworking problematic waste rock dumps, in some cases removing and utilizing materials from these poorly-constructed and rehabilitated landforms, to accomplish reclamation works on other areas e.g. removing waste rock material to armor dispersive clay areas of other waste landforms, or

using the waste and dispersive clays recovered during reshaping either to backfill and/or cover in-pit and above-ground paddock style TSFs.

- Capping of above-ground paddock-styled tailings storage facilities to manage rainfall catchment on the rehabilitated surface, so that rainfall catchment will only shed from the facility during a potential maximum precipitation event. This involved deep ripping the consolidated tailings surface prior to placing a 500 mm cover of benign waste rock, constructing contoured catchment bunds and drainage catchment channels and then spreading and ripping topsoil into the cover.
- Capping the unconsolidated in-pit TSFs to natural surface with waste rock material. Various methods using existing earthmoving equipment, whilst initially effective, became cost-prohibitive and ineffectual. An alternative option of utilizing a long-reach excavator to reach out and place a layer of cover material over tailings surfaces, became a better approach to utilizing existing stocks of cover material.
- Making areas safe through abandonment bund placement, and rock bunding in water flow areas.
- Designing and working to design to manage water flow.
- The many different eras of reclamation techniques on landforms provided the opportunity to analyze approaches that had been ineffective. The team used the knowledge and experience gained from site personnel over previous years, and experience of recent extreme weather events, so that current applied designs were of the required standards.
- Striving to accomplish the works with minimal resources and infrastructure while still being required to ensure the normal day-to-day operational requirements and demands were met.
- Clearing up all regional infrastructure and work areas.
- Gaining approval and access for topsoil harvesting, where possible, using the most viable material in the most critical areas.
- Consulting with regulators, internal stakeholders and the Central Land Council (with occasional open days) has maintained awareness and provided a forum for opinion and communication with the indigenous stakeholders.

5 Conclusion – experience gained and lessons learnt

As the Tanami Mine closure programme is entering its final phase, observations from experiences gained and lessons learnt to date, are presented below:

- Focus on team involvement and utilize expertise from the functional groups within the project team. A team-based effort, including operators' contributions, drive accountability and ownership of works. Empowering specialized and experienced rehabilitation personnel with ownership and involvement in the process, results in positive outcomes in many aspects of the project.
- Questioning advice and designs given until a clear understanding is gained of those materials/ideas.
- Aim for an effective quality outcome rather than focusing just on the cost constrained option. This improves the outcomes and eliminates the need to return and address issues again.
- Ensure benchmarking of other sites/areas/methods to understand issues that have/have not worked. Closure experience and closed mines are an invaluable source of knowledge.
- Revisit designs, methodology, cost estimates and budgets allocated to the closure process, because of a number of factors including poor estimation, inadequate planning and investigation, poor cost and resource control result in exceeding budgets (Haymont et al., 2008b).
- Frequently, the use of equipment specific to mining and mine engineering applied to mine rehabilitation activities results in suboptimal outcomes.
- Be cognizant, flexible and adaptable to varying conditions, environmental variables, and business needs and communicate with stakeholders to ensure an informed understanding of the processes.

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