Submission for the:

Inquiry into the rehabilitation of mining and resources projects as it relates to Commonwealth responsibilities

April 10, 2017

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Dear Committee,

I am submitting the following comments, remarks and associated evidence, as Director of Naturally Spatial, on behalf of community members that have shared their concerns with me, parties that I might represent, and of the professional community working for the betterment of the environment in relation to improving the outcomes of efforts to effectively rehabilitate disturbed lands from mining and its associated activities.

The discussion that follows is based on the recognition of preferred methods and approaches to rehabilitation of lands disturbed by mining and resource projects. I describe best practice methods of landform rehabilitation, specifically based on fluvial geomorphic principles, and provide supporting case studies and associated information in evidence of them. Based on such practices the following submission will ideally clarify, through targeted solutions, project experience and sound methodologies of improved potential outcomes and science, how advances in current rehabilitation methods can be made.

In response to the *Terms of Reference (ToR)*, a number of issues are important to this submission. I have focussed my commentary and references to be relevant in relation to several of the specific *ToR*.

I encourage the References Committee to carefully consider the following information in the context of current limited implementations, and even inadequate practices, of Australian mine site rehabilitation. In contrast, there are proactive and realistically-positive and more progressive rehabilitation applications being implemented around the world. For Australia to be considered a leading nation we must learn from experiences gained on the international stage and adopt methods shown to be successful.

Best regards,
Mr Grant Dickins

INTRODUCTION

Recently, mainstream news media outlets and government agencies have more frequently highlighted continued concerns regarding non-rehabilitation of thousands of abandoned mine sites across Australia. The potential for long term environmental harm, risks to community, the issue of liability and associated safety concerns at each site, have been a point of debate at many levels in the mining industry and for the wider community.

To solve the many identified problems there are methods that can be employed to effectively mitigate most of them. Industry experts plus leaders in science and technology, along with the regulators, all have a valuable role to play in distilling the issues and setting strategic pathways to resolution.

This submission is focused on the fundamental area of landform design and how landform design is the very basis upon which all successful future rehabilitations must be measured. Therefore, I advocate a specific method of landform design known as *fluvial geomorphic rehabilitation*, implemented using a patented method called GeoFluv^{TM}, and how this approach, above others, has rapidly acquired a broad reputation for success in comparison to traditional methods. We discuss this method below, providing Australian and international examples.

APPLICATION AND DESIGN

Fluvial geomorphic rehabilitation is in essence a method of rehabilitation that constructs landforms that are modelled based upon specific characteristics derived from *reference areas*. To effectively design or model a landform it is crucial that the underlying parameters, the essential elements incorporated into the design (Bugosh, 2008), are collected from actual, undisturbed stable landforms (the *reference areas*) in the local environment, usually located immediately adjacent to the area being rehabilitated.

The philosophy behind this approach is simple: if a deposit (i.e. a waste rock dump) is bound to physically evolve (along decades or centuries) as erosion carves it, why then not accelerate the process using bulldozers and backhoe excavators to create a stable new surface? In other words, a mature landscape can be obtained almost instantly. This has many advantages, including minimising the erosion to very small levels. Thus, this dynamic geomorphic procedure tackles most of the erosion-related problems because it essentially reproduces the natural landform evolution to the mature stage, resulting in stable slopes and channels in balance with the local environmental conditions (Martin-Duque et al., 2010).

In short, the benefits are not only in terms of stability, but also about reducing pollution to the environment. All fluvial geomorphic designs include a constructed drainage network, which results in more efficient discharge (surface and internal) and also less residence times for surface water flows, thereby minimising surface water percolation into potentially sensitive deposits (waste dumps, tailings). Geomorphic stability gained using the GeoFluv^{TM} method has been empirically proven for more than a decade in some mines from New Mexico, USA (Bugosh, 2008; Bugosh and Epp, 2014) and elsewhere even longer.

Landforms must guarantee flexible performance and fluvial geomorphic rehabilitated-landforms must be able to meet or exceed the likely maximum impacts of storm events the natural environment will impose. As examples, these include critical elements to be designed-in such as hydrological drainage networks that tie to existing stream networks and variable-aspect slopes that provide potential habitat.

COMPARISON OF EXISTING AND BEST PRACTICE METHODS

Planning for the end from the beginning. As dark as that phrase may seem, in actuality it is the very essence of what every workable and successfully implemented mine closure plan requires. It is critical that planning for the final closure of a mine site is done in the earliest stages, whether for a new mine plan or extension of an existing operation. Indeed, the lack of well thought out, realistically costed, fully comprehensive functional mine closure plans–and implemented from the beginning as an integral part of whole-of-mine-life planning–is just one reason why today there are an overabundance of poorly closed sites with a plethora of problematic mine rehabilitation issues.

To counter the growing number of challenging sites, both current and legacy, it is important to clarify the methods currently being employed as part of traditional closure works in comparison to alternatives. The following table provides a comparative view of the two main systems and approaches to mine site rehabilitation.

Existing method	**Geomorphic Rehabilitation**
Based on conveying a single extreme discharge event – not repeated events	Based on conveying all and repeated storm discharges
Conveys only water discharge effectively at lower Q (where Q = peak discharge during storm event)	Natural channel morphology conveys water and sediment discharge; hydrologic balance
Requires expensive off-site material, e.g. rip-rap and rock armouring	Built with on-site materials only
Expensive on steep slopes	Cost is significantly lower than gradient terraces and down drains on steep slopes
Requires long-term maintenance	Self-maintaining – no maintenance
Requires maximum backfill to lower slopes	Can reclaim steep slopes in stable and suitable configurations, save money on material moving
Provides minimal slope aspect diversity	Increased slope aspect diversity promotes vegetation success and animal habitat
Visual affront	Natural beauty
Rigid design sideboards limit landscape alternatives	Landscape designs can vary and provide alternatives
Regulatory agencies not satisfied	Regulatory agencies embrace

INTERNATIONAL EXAMPLES

For more than two decades Spain has been at the forefront of restoring natural and disturbed landscapes through the implementation of geomorphic rehabilitation methods to solve complex environmental problems (Martin-Duque et al., 1998; Duque and Bugosh, 2014). In fact, Spain has spearheaded so many successful geomorphic reclamation projects over the years that it is now an entrenched methodology across the country. Indeed, design of landforms using geomorphic principles is taught at the university undergraduate level (Carlson, 2009).

Numerous examples of the pioneering work in geomorphic landform design can be cited as evidence of a strong Spanish track record including its suitability and use in designing for and rehabilitating mine sites but also ex-quarry sites (Martin-Duque et al., 1998) as well as tailings deposits (Mudd and Boger, 2013; Martin-Duque et al., 2015).

Equally long-lived are the numerous GeoFluv™-constructed projects in the southwestern United States. Multiple projects have been completed and are currently under long-term monitoring. A large number of project sites in New Mexico have notable rehabilitated areas that are part of the expansive La Plata Mine complex (Bugosh and Epp, 2015) (formerly a BHP operation and now operated by the San Juan Coal Company). Also prominent in New Mexico, is Chevron Mining Inc.'s McKinley Mine, (Clark, 2008; Robson, 2009). Further afield, the Bridger Coal Company's southwest-Wyoming operation (Measles and Bugosh, 2007) is also important, among others. In the case of the McKinley Mine, geomorphic reclamation has been specifically used to drastically reduce the number and frequency of incidents of differential settling and piping occurring over a 10-year long monitoring period (Clark, 2008). The important point to emphasise is that each is a long term, even visionary, project that deliberately considered and engaged geomorphic methods as a way to achieve stable and alternative land uses. Thus, each site has been scrutinised for its suitability on the grounds of landform design and performance (slope stability and erosion), cost and community acceptance.

More broadly and international, GeoFluv™ has been used actively across 6 continents with many fully-developed design submissions, demonstration sites and completely constructed sites. Moreover, a network of GeoFluv™-certified designers are trained and have performed work in Australia, Canada, Chile, Mexico, South Africa, Spain and the United States (Duque and Bugosh, 2014), among other locations, and right now (March 2017) is seeing its introduction to Israel.

It is clear that not only is the use of fluvial geomorphic rehabilitation design principles widely understood around the globe as being more beneficial compared to traditional approaches but, more importantly, it also is considered the preferred approach. We believe it to be in the best interests of Australia's mining players to actively engage in this paradigm-shifting best practice method.

AUSTRALIAN EXAMPLES

The GeoFluv™ method has been used as the basis for successful landform rehabilitation of mine sites in Australia. Probably the most widely known industry example is Glencore's own project at their Mangoola open cut coal mine located in the Upper Hunter Valley of New South Wales (Glencore, 2015). Mangoola, believed to be the first GeoFluv™ designed landform in Australia, is a leading example of how effective mine site rehabilitation can be achieved using non-traditional and best practice methodologies.

The reason, in part, that this particular project is a success is because it formed an integral part of the life-of-mine planning from a very early stage: the disposal location and configuration of waste material was carefully considered to ensure minimal double-handling of material, thus reducing overall costs. Again, this pro-active approach led to it receiving approval, and subsequent construction, as a preferred method and resulted in significant cost savings for the operator.

Equally, a pilot project has been constructed in the Pilbara, amongst the Wodgina hills, in Western Australia. This project's goal was modifying an existing waste rock dump based on geomorphic principles. That site is currently undergoing monitoring. There are several further examples of geomorphic design principles having been applied to existing waste rock dumps and tailings deposits in Western Australia, including at Wiluna.

In addition to these constructed examples there are far more numerous examples of project submissions that include full and iterative geomorphic designs at existing mine sites in preparation for construction. Specifically, there have been design submissions made on behalf of BHP, Newmont, Rio Tinto, Global Advanced Metals, Glencore, among others, and they have all been positively received and assessed to be cost effective and suitable methods of achieving mine closure.

POLICY AND CURRENT GUIDELINES

The Commonwealth Department of Industry Tourism and Resources, in their 2006 publication *Mine Rehabilitation: Leading Practice Sustainable Development For The Mining Industry* stated a preference for "*Fluvial geomorphic mine waste rehabilitation design principles, such as those used at La Plata and San Juan coal mines in the Badlands of New Mexico (BHP Billiton, 2001), should be employed in preference to linear engineering design principles*." (DITR, 2006). This is an important statement of intent and attempt to set the direction of voluntary use of best practice methods.

However, as a current member of a team working with those very people that directly worked on that successful project, a project which still garners international respect as being amongst the 'best of the best' examples of rehabilitation, it is not without some concern that only minimal progress toward the widespread use of geomorphic rehabilitation has occurred across Australia.

That document was published over ten years ago. Since then very little on-ground advancement toward the stated preferred goal of using geomorphic designs has been achieved. In fact, among the few examples that do exist some have been constructed using geomorphic design principles that are somewhat rudimentary at best. Although relatively stable, such sites often use single-profile concave gradients or linear features that still require surface armouring to ensure resilience against erosion. As a result they offer little if any ability to evolve over time with respect to erosion, and such simplistic slope designs are only constructed with an expectation of storm events that do not exceed a maximum level. The point being, it is often due to traditional performance criteria and limitations imposed by existing policies, regulations and guidelines that dictate what approach to final landform designs will be implemented.

Of concern today are the unequal and often contradictory sets of guidelines and design regulations that require specific construction methods to be used, while still providing no flexibility in design to ensure resilience over the long term. Further, where specific policies and regulations state that construction of rehabilitated landforms must include drainage infrastructure or barrier protection systems, as examples, these have been shown to be short-sighted methods only. I would suggest that when the long term stability and safety of reactive materials are in question then, at a minimum, only solutions that demonstrate stability of slopes and material performance over many centuries should be considered: short term thinking (in the order of 10-20 years, a typical life-of-mine plan) is not relevant against the evidence, the likelihood and known consequences from long term failure. Indeed, mined dangerous and reactive materials should be treated as hazardous waste, not unlike those generated by the nuclear waste industry, and treatment of them considered on century or millennial timescales.

Consistent regulations must be in place that support best practice technologies. Where mine site rehabilitation has the stated goal, or opportunity, of returning landforms to an acceptable alternative use, then preference for proven methods should be given.

The United States introduced the Abandoned Mine Lands Act (AML) in 1977. Administered through the Surface Mining Control and Reclamation Act (SMCRA) it employs the Abandoned Mine Land Reclamation Program in relation to surface coal and operations and the acquisition and reclamation of abandoned mines. It is overseen by the Office of Surface Mining Reclamation and Enforcement (OSMRE, 2016). In several US states the use of fluvial geomorphic rehabilitation technologies to construct closure landforms is very well established. There are numerous projects of significant extent (thousands of hectares) that are excellent examples of its success. States that have benefitted from multiple GeoFluv™-designed and constructed projects include, New Mexico, Wyoming, Colorado and Indiana, among others.

Regulatory approval and acceptance is key. If a decision making process exists to consider all possible options, when deciding on how best to implement a method of site rehabilitation, then it makes sense to have as much information as possible for consideration. Thinking about mine closure involves a fundamental approach to the expectations of the final site condition. If we are to construct relatively stable and topographic landforms that nature would eventually form over long time periods (Clark, 2008) then geomorphic principles enable this. Any other strategy is akin to behaving *as it has always been done* or, according to the Mining and Minerals Division (MMD), the coal regulatory authority in New Mexico, is an old-fashioned attempt to “strive to conquer nature” and is arguably not justified (Clark, 2008).

As one who has seen these projects first hand I believe Australian companies are not embracing this potential for our benefit. I would pose the question, why are international companies such as BHP and Rio Tinto (randomly selecting two from many), both of immense scale and resources, not actively rolling out and implementing similar techniques across their Australian mine sites? From discussions with those directly involved it is clearly a case of regulations not being current with best practice.

As previously stated, Spain has a long history of active and successful mine and disturbed-site rehabilitation using geomorphic techniques. It is accurate to say that the practice is now an entrenched approach at the planning stages of new projects. Not only is it implemented at a large number of locations but its deserved reputation has been reinforced by the very recently notified (March 2017) set of legal requirements that as part of a Environmental Impact Assessment (EIA) process that consideration must include using fluvial geomorphic rehabilitation methods. This ‘rule of law’ decision by the Spanish authorities specifically identified the benefits of GeoFluv™ and Natural Regrade in their decisions (Martin-Duque, 2017). These statements have profound and fundamental implications for the before-mentioned paradigm-shift occurring at this moment.

Moving beyond Spain, the European Union has also indicated that the role of geomorphic techniques in rehabilitation is to be raised to the level of Best Available Technique (BTA) for the Management of Waste from the Extractive Industries. Although not law, as yet, it is support for the method to be used for the wider industry. Definitive EU approval for geomorphic rehabilitation methods as BTA will be made in 2018 (Martin-Duque, 2017).

An important point to make regarding the use of the ideas and principles of fluvial geomorphic rehabilitation design is that it may not in fact require legal enforcement or a change to existing policies. In fact, when New Mexico's MMD were asked the question "When did the rules change to require this?" the MMD reminded the operators that, in fact, no rule had been changed and that it was already incumbent upon them, as per their state-permitted contracts, to employ the Best Technology Currently Available (BTCA) (Clark, 2008). MMD's incitement of geomorphic reclamation principles was a means to encourage the operators to actively seek best practice methods for their own benefits.

Returning our attention to the Australian context, even from the above brief overview there is ample international evidence to show that rehabilitation of disturbed sites, including active and abandoned mine sites, plus disturbed areas such as waste landfills and quarries, as well as urban development areas, will benefit from the use of fluvial geomorphic techniques. A concerted effort to approach each project with an eye on the long term land use outcomes rather than perceived short term monetary gains, and what overriding rehabilitation guidelines might specify, is needed. Most Australian states have a system of mine approvals and process that assess each new application. Equally, and in varying degrees of wording, each state stipulates similar objectives including oversight of the ecological sustainability of the development, including inter-generational equity and environmental, and that social and economic factors are also considered (NSW, 2017). This statement directly speaks to the requirement to meet long term environmental outcomes.

COST FACTORS

Due to the relatively recent introduction of fluvial geomorphic rehabilitation in Australia there is little hard comparative data regarding costs. However, there is ample data from overseas that indicates, based on actual results, a wide range of all-in costs savings of between 0 to 37%, where 0 represents a cost-neutral outcome and 37 represents the best case scenario (so far). This spread is expected due to the need to specifically tailor geomorphic designs to each site: designs and approaches are customised and cannot be extrapolated to reflect wider applicability across disparate locations. However, in no case have geomorphic implementations been more expensive than traditional methods and these numbers do not include yet-to-be-realised savings from the elimination of ongoing maintenance.

Upon first introduction to using geomorphic rehabilitation methods, each operator is faced with the decision to consider closing their sites using GeoFluv™-based methods versus traditional linear methods. The first question raised in response is *how much does it cost*? To answer that, there are several perspectives to consider.

1. Does the current life-of-mine, or closure plan, adequately address all construction and related costs inclusive of ongoing monitoring and maintenance? This may seem an easy 'yes' answer, however the basis for most calculated closure costs is simply based on the expected costs of construction happening only *one time*. Little regard or even expectation is given to historic examples and actual costs incurred if (and when) the site undergoes some form of degradation through extreme natural environmental (storm events) or chemical impacts (ARD). Both can be managed through additional works and treatments (and cost) but it highlights how a traditional approach might not be correctly costed from the outset. No company that I know of is willing or prepared to fund maintenance of their site for another 100+ years.

2. We must keep in mind that project permits have, usually, been issued based on the best knowledge and understanding of the time. We should not be attempting to undermine those decisions based on what we have learned since.

3. Did existing projects receive approval based on best practice techniques (of the day) or were they expedited for reasons of convenience and economics? We cannot deny the possibility that past project approvals may have been based on political pressure or short term economic factors. Irrespective of the reasons, the cost savings from short term political or economic decisions is far outweighed by the long term costs of ongoing repairs and expensive treatment plans.

4. What are the costs? *On average* it is reasonable to state that like-for-like comparisons where sites are similar topographically and in extent, that when a fluvial geomorphic rehabilitation approach is implemented early on in the mine life cycle that costs will be reduced by about 10-15% (Hause, 2011). If an operator is currently setting aside say 20 or even 100 million dollars then potential savings of $3 to $15Million, respectively, is surely not insignificant?

   Two fundamental factors contributing to that range are firstly, the significant reduction to material double handling and, secondly, elimination of maintenance once construction is complete. Regarding the former, traditionally as material is moved and then re-moved the operator immediately takes a cost 'hit'. Essentially, the result is lost money due to poor planning. In contrast, if a geomorphic approach is considered at the outset then the bulk of, if not all, waste materials can be deposited in a configuration conducive to final landform design and can be done in complete harmony with active mining operations and within budget.

   This fundamental aspect cannot be over-emphasised: waste material should only be hauled (once) and deposited (once) where it will be needed at the time of closure.

5. How do you measure the costs when a project does not receive approval to proceed beyond the design stage? At least two projects (the Imperial Eagle project in Toledo, Spain and a limestone quarry in Majorca, Spain) provide good examples in that the decisions to proceed were ultimately made, requiring the use of GeoFluv™, because the traditional designs did not provide satisfactory solutions to all relevant concerns. Thus, fluvial geomorphic designs provided real solutions whereas traditional designs did not allow the mines to get permitted (Duque and Bugosh, 2014).

POTENTIAL FOR RELINQUISHMENT AND THE ISSUE OF LIABILITY

Great hype and even hysteria has been made of the very state of the number of abandoned mine lands in Australia. To be sure, there are literally thousands of them (ABC, 2017) and arguments concerning the long term liability and costs of performing rehabilitation of both active mine sites and abandoned mined lands have been put forth with many approaches and solutions being entirely suitable and achievable.

But we must remain level-headed in our efforts to improve practices and keep focus on the specific issues at hand. By remaining openly critical of techniques and methodologies that have fallen short of their intended goals we must also praise the efforts of those that have genuinely contributed to the effective solutions already implemented.

By first taking a deliberate step back to view the overall issue of effective rehabilitation we can perhaps gain a new perspective on the current problems. The questions then become, what are we trying to achieve in terms of rehabilitation and who is responsible for it? If the goal of rehabilitation is to leave behind safe, geomorphically stable, and non-polluting landscapes then existing methods simply do not achieve that goal.

In fact, I would argue, the short timeframes within which mining and resource projects are planned, costed, and projected to last are actually among the select few causal factors that directly demonstrate why the entire extraction industry and the established processes they follow are deficient. A disproportionate number of projects are based on short term economic viability and stakeholder demands (job creation, community support, stock prices, mineral prices, etc.). However, the fact that Australia currently has now accumulated a vast catalogue of abandoned mines, which are now genuine public liability safety and fiscal nightmares, points clearly to a failure of satisfactory government oversight, legal inadequacy and corporate risk-aversion. It also speaks to community awareness and a community's ability to influence change. Ultimately, society must render a judgment concerning the perceived severity and acceptability of a given disturbance and its impact (Toy and Hadley, 1987).

For example, one cannot stress enough how current methods employed to rehabilitate mine sites through construction of linear features such as constant gradient slope batters plus limited-by-capacity drainage features are simply not adequate to the task. Evidence for this situation is readily available all across Australia (and globally) by the literal thousands of waste rock dumps that have failed already and those that are showing signs of impending failure.

So, what to do? In the first instance, a shakeup of existing contractual and permitting obligations must be made. For a proposed mining or other resource project to receive approval, permitting, development consent, or whatever term the regulator wishes it to be coined, recognition of *real* long term liability and responsibility must be appreciated. As stated above, approved closure and rehabilitation plans limited by 10, 20 or even 50 year timeframes are simply too short with respect to the *actual* evolution the final landforms will undergo. It does not take millennia but mere decades to induce strong erosion. Thus, most of the solutions proposed in environmental impact assessment reports (including mine closure plans) are not bound to last more than a few decades with some not surviving after a few years (Martin-Duque et al., 2015). Nature's evolutionary hammer has no restraint and will forever beat down upon all inadequate efforts in an effort to have them conform. It should be an absolute minimum requirement for every project to show how its end-plan can meet this challenge for centuries and for successive generations.

To receive eventual site relinquishment, the final state of a closed resource project, whether a mine site, a quarry, or landfill, must be designed to withstand all that the environment can inflict and be flexible enough to evolve in step. Based on this premise then only approaches that fully understand how fluvial geomorphic approaches can mitigate environmental impacts and re-establish dynamic equilibrium within the geomorphic system (Toy and Hadley, 1989), will be acceptable. The natural geomorphic balance will become dominant over time regardless of what method is employed so it makes logical sense to target the underlying fundamental elements as part of any rehabilitation plan.

The seminal reference in the science of geomorphology was published 30 years ago this year. Terrence Toy and Richard Hadley, in their ground-breaking book *Geomorphology and Reclamation of Disturbed Lands* succinctly identified the fundamental mechanisms of landform evolution and behaviour. In it they identified control of soil erosion as the major goal of reclamation (Toy and Hadley, 1987). They also identified, realistically, that complete restoration of disturbed lands is not always entirely possible, suggesting instead that alternative land uses may be more suitable for the affected area so that society does not lose important land use opportunities that were available prior to any disturbance.

An examination of alternative land uses such as grazing, recreation, and even urban development, as opposed to reestablishment of natural ecosystems, affords the potential for communities to harness unforeseen employment opportunities after a mine has closed. I am cautious to not advocate any one particular land use, however, the burden of long term liability often falls on the local community that once hosted the mining operation so it makes sense to plan for this succession and maintain economic options that are viable in a healthy community, once a mine has closed.

Toy and Hadley (1989) also remind us that sometimes post-reclamation land use is responsible for site deterioration. For example, excessive grazing intensity by livestock may produce deterioration in the vegetation cover. Hence, it is not wise to decide that one land use should be promoted above another. In fact, a combination of final land uses from vegetated, to grazing to natural bushland, to recreation and eco-tourism, can help establish a more resilient landscape and local economy.

The science of geomorphology and our understanding of the nature of landforms are not new. They are well recognised processes and should not be surprising ideas to those actively working in the mining and resource sectors. For an operator, or even the regulator, to be averse to sound geomorphic methods and mechanisms and their development and application indicates that these decision makers are in fact not aware of the already-established and game-changing capabilities at their disposal. It might also indicate a lack of sincere community engagement and stewardship, a lost opportunity if you will, by highlighting how companies could play an even greater and more proactive role in promoting effective rehabilitation options that are in keeping with a community's desire for naturalistic and sympathetic rehabilitations: visually appealing and balanced rehabilitations that blend with the surrounding landscape and not be simply a blight on the skyline.

I would encourage the Committee to look more closely at what 'long term liability' *actually* entails because, as we see across our landscape today, the vast majority of projects have resulted in poor outcomes of both landscape stability as well as community flexibility precisely because of short term thinking and non-geomorphic project planning.

COMMUNITY ENGAGEMENT

When a mine is closed and the operation has ultimately concluded it is the townsfolk, the community, which must move on. To be feasible, when the mine itself was the life blood of the community's economic system, the employment base must shift from being skilled on the mine site to being skilled in other, equally meaningful, roles in the community.

At the recent Best Practice Mine Rehab Conference 2017, in the Hunter Valley NSW, community ownership was a prominent topic of discussion. Encouragingly, not only was there direct discourse on the ways and ideas on how to achieve long term viability from a community perspective but the very essence of what the landscape means to the people was addressed. Both of these topics were raised as reminders that the mine is not just a means of income but, for long-lived operations, can and do become an integral part of the community. Indeed, it is common for multiple generations of families to work at a mine or one of its related support industries and for them to become entirely dependent upon it for security and even meaning.

I won't delve into the psychological aspects of community recovery after a mine has departed, because I am not expert in this area, but many positive ideas have been suggested by those with past experience with important transitional, interim and permanent roles for the community to participate in. For example,

- Getting active engagement via local community teams to take direct ownership of rehabilitation projects. This could involve programs comprised of employees and volunteers to establish and oversee long term planting, monitoring and vegetation maintenance tasks, on behalf of the mining company.

- Establishment of volunteer organisations with the goal of building pride in younger people to become leaders in how their community envisions the surrounding landscape and to develop new niche or micro-industries such as local eco-tourism, vegetation management and education (vocational and short courses) through to building healthy communities that are engaged with the outdoors. I note here that, as of March 2017, for the first time, at least two organisations are actively engaging in the Muswellbrook area.

RECOMMENDATIONS

1. We recommend the establishment of a program or other mechanism to actively record the status of abandoned mine lands and to specifically focus on the areas that can be effectively rehabilitated using current best practice technology,

2. As part of regular reporting obligations every active disturbed site should require submission of accurate spatial data representing the area and type of rehabilitation undertaken. Data captured by operators of currently active mine sites implementing rehabilitation of disturbed ground should be entered into a site database to facilitate long term monitoring. This is not too dissimilar to ground disturbance reporting currently required under Western Australia's Mining Rehabilitation Fund (MRF), but where annual or even quarterly submissions would specify total area, type and the method of rehabilitation employed. Over time, this national record would lead to a fundamental shift in the understanding of methods employed and the extent of rehabilitation efforts nationwide,

3. To foster broad improvements in rehabilitation methods and project successes it is important to share best practice knowledge (MCMPR, 2010). Only through the sharing of successful techniques and methodologies can the industry elevate itself to better overall management systems.

CLOSING REMARKS

In summarising, I wish to make it clear that the above text is based on my experience and best understanding of the current status of the information given and my awareness of the industry's efforts in each case. Naturally, I acknowledge that in the absence of further and new information that may yet come forward, that some of these arguments may indeed be either additionally supported or require revisions. Regardless, I would be pleased to provide supplementary supporting commentary as appropriate.

A few key closing points:

- Savvy operators are learning that there are tremendous savings by having the rehabilitation design prior to mining and integrating the mine plan with it to eliminate very costly material re-handling. Thinking of rehabilitation as something that only begins after mining is a very inefficient approach,

- The focus of geomorphic landform design is to achieve an array of outcomes including surface stability, resilience and resistance to erosion, the provision of habitat diversity through variations in slope and aspect, and establishment of connectivity between the restored mined lands and the downstream watersheds, but guaranteeing not having higher erosion than that of the surroundings,

- Based on mounting evidence from studies to quantify erosion and sedimentation rates, if the goal of rehabilitation is to minimise the potential for erosion and leave only stable landforms then no other method can compare to fluvial geomorphic rehabilitation, while also eliminating built infrastructure including fixed-capacity drainage systems,

- When one approach (i.e. GeoFluv™) is identified as being able to achieve all of these elements, simultaneously, then we should focus on that solution first. When it can also demonstrate, through actual implementation, that costs are reduced in comparison to current methods, then we have a second support. If we then also exhibit that an increase in habitat diversity is likely, a pattern emerges that surely gives just cause for questioning established methods?

- We must *break the linearity*. This term encapsulates everything that fluvial geomorphic rehabilitation endeavours to do. Linear systems (constant gradient batters, on-contour drainage, and waste dumps comprising towering lifts and berms), as potential landform rehabilitation design solutions, are not reliable or aesthetically pleasing or even functionally equivalent to geomorphic approaches. They should *not* be considered comparable or suitable for the purposes of mine rehabilitation or as equivalent and *realistic* long term solutions,

- History already shows that projects have received approval purely on the merits of geomorphic designs versus traditional approaches. By demonstrating that designs mimicking the natural landscape can exceed the performance criteria of engineered (built) solutions we have good reason to advocate the role of geomorphic principles over existing methods.

- To be blunt, there is little advantage to be gained through superficial or cosmetic rehabilitation efforts when the underlying landform–the geomorphic foundation upon which all future land use depends–is not fully addressed.

I would strongly contend that only fluvial geomorphic rehabilitation methods can do a better job of satisfying all of the many rehabilitation goals and monitoring criteria, including water quality discharge requirements, vegetation species and diversity requirements, designated post-mining land uses, and relieving maintenance and obtaining bond release. Anything else is not up to the task.

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