PRACTICAL COST EFFECTIVE REHABILITATION OF THE CURRENT LAKE PEDDER IMPOUNDMENT

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Restoration of the original plant communities through natural colonisation over such a large area as the current Pedder impoundment will be far too slow to combat weed invasion, erosion and significant stream sedimentation as a result of some 73,000 ha of catchment discharge. Colonisation by natural processes or by synthetic rehabilitation methods will result in a different plant community composition from that which existed pre-flooding. The colonising species will be those able to cope with the altered and alien surface conditions. Natural restoration will be achieved, but it will occur over centuries, possibly thousands of years, and not within 5-10 years.

Through the implementation of practical synthetic rehabilitation, rapid surface stabilisation that preserves landform integrity can be achieved. This will also involve the establishment of a self - sustaining system that in the long-term (several centuries) encourages a succession towards plant communities of the same provenance, structure and diversity that existed prior to inundation. There are many unknowns and uncertainties involved in predicting the rehabilitation requirements and major studies will be required along with contingency planning, should de-watering of the current impoundment proceed.

Rehabilitation is achievable, but at significant cost in both money and time where the cost is measured in terms of tens of millions and the time frame is measured in tens of years for the establishment of an effective cover of the same provenance but of different appearance, composition and diversity to that which existed prior to inundation.

Key Words: Australia, Tasmania, Lake Pedder, rehabilitation, revegetation

PROJECT SCALE

The scale of the rehabilitation requirement following the draining of the current Lake Pedder is unprecedented anywhere in the world. In determining the rehabilitation requirement we must come to terms with the physical size and associated problems involved with the rehabilitation of the impoundment basin. We must consider natural colonisation versus synthetic rehabilitation and a multitude of logistical problems and uncertainties associated with natural processes such as drought, rainfall and the potential for erosion.

The current impoundment has a surface area of approximately 24,000 ha. On de-watering the basin surface area with all the gullies and undulations, particularly at the perimeter, would approximate to an additional 10% and increases the area requiring rehabilitation to between 25,000 and 26,000 ha including the original Lake Pedder area of approximately 1,000 ha.

Past rehabilitation works in Tasmania pale into insignificance when compared to the rehabilitation requirements of the area covered by the current Lake Pedder impoundment. Rehabilitation works within Tasmania include the HEC completing 800-1,000 ha over the last 15 years, the Department of Transport and Works stabilising and rehabilitating several hundred hectares, Aberfoyle completing around 100 ha, CRA 12-15 ha, Golconda 20 ha, KIS 64 ha, and Parks & Wildlife Service around 50 ha. In terms of rehabilitation on the mainland Alcoa completes approximately 500 ha annually. All these works were thought to be "large scale".

The size of the rehabilitation project is large indeed and it compounds the practical problems in obtaining a vegetation cover of the same provenance, diversity and structure that existed pre - flooding.

COLONISATION

Through Professor Tyler's work, we know that the medium for plant growth, the peat profiles, are basically intact under the current lake (Tyler *et al.* 1993, Tyler 2001). The peat will probably be nutrient deficient and generally more acid than normal. However, peats are formed naturally under

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cool damp conditions and are made up of partially decomposed organic matter. They have a pH of between 3.8 - 4.8 and it is anticipated that the pH of the currently flooded peats will rise once exposed to the elements at pre-flooding level. Due to the volume of rain it is anticipated that the pH will return to normal within 12 months.

If we allow the area to recolonise naturally, colonisation will commence at the perimeter of the lake and gradually work toward the centre of the disturbance providing the site remains free of fire and seed sources are available.

One site inspected on the banks of the Gordon impoundment, approximately 100 m from the previously undisturbed vegetation, has recovered well through natural colonisation, since it was last flooded 14 years ago in the winter of 1981. However, the species composition is quite different to the surrounding natural vegetation types.

Another site in a similar general location 150 m from the undisturbed vegetation on the banks of the Gordon impoundment (also last flooded 14 years ago) was sparsely covered with colonising vegetation. These observations are hardly scientific and more comprehensive scientific research would be required to determine the rate of natural colonisation and the species involved. However, it appears that the density and diversity of vegetation decreases the further you move from the natural undisturbed vegetation.

The dominant species colonising the second site were:

Gymnoschoenus sphaerocephalus
Restio australis
Xyris sp.
Leptocarpus tenax
Hibbertia procumbens
Bauera ruboides
Gahnia grandis

Sections of the surface not covered by larger plants were colonised by moss and algae forming broken mats. These mats provide excellent erosion control by binding the peat surface. Plant species such as *Gahnia grandis* were observed colonising the stable mats. The remnant bases of plants killed by inundation were colonised by moss and lichen.

Sites where the mats of algae and moss had not formed were devoid of colonising vegetation. Based on discussion with the Department of Agricultural Science at the University of Tasmania, the exposed previously - inundated peats on drying oxidise, crumble and decompose more readily than under normal consistent buttongrass plain conditions where the surface condition is more stable. The greater the degree of decomposition the more susceptible peats are to erosion and the less resistant to running water. Fine organic material was observed building up against obstructions such as timber along the Lake Gordon shoreline. If a surface is unstable, effective plant colonisation in the short term will not occur.

The initial formation of an algal/moss mat over the peat surface will reduce surface erosion and increase the speed of colonisation by other native species.

Surface conditions created by de-watering and exposing the peats are totally alien to the conditions that exist in a fully vegetated buttongrass plain. Sections of the exposed peats will be relatively level with little micro-relief suitable for plant establishment. As the area is approximately 25,000 ha and is exposed to all environmental extremes, colonisation will be by those species most able to cope with the altered conditions and will commence in the most protected sites. The most serious factors inhibiting colonisation will be surface drying, drought stress and heating of any dark peat surface.

On-site discussions with Will Fletcher of Plants of Tasmania Nursery suggest that many of the normal buttongrass plant community species will be unable to survive these exposed conditions. As an example, buttongrass propagation from seed appears to involve the seed remaining damp in a saturated acid peat environment for a period of at least 6 months. Will is one of very few, if not the only, person(s) who has successfully established buttongrass from seed. Following de-watering the peat surface will dry out and the dark colour absorb heat, making the site unsuitable for buttongrass establishment from seed. However, buttongrass will colonise from the perimeter and will probably survive as planted stock.

Suggestions have been made during discussions held at the Pedder 2000 Symposium, that there may be a viable seed store contained within the peats under the current impoundment. Glasshouse trials have been proposed to validate this suggestion using peats removed from the floor of the impoundment. The exposed surface conditions following de-watering will be completely different to any pot trial and the proposed trials must take this difference into consideration. The trial should not only establish if a viable seed store exists but it must also determine whether the seed can germinate and survive in altered exposed conditions.

Gahnia or cutting grass will be one of the few species to actively colonise the exposed peats naturally.

EROSION POTENTIAL

During the development of a vegetative cover a number of problems are faced. The total catchment is some 73,000 ha discharging into a de-vegetated site of some 25,000 ha with an annual rainfall of around 2.2 m/year. Natural catchment discharge is released from a vegetated area slowly as the vegetation acts like a sponge. Once the catchment discharge reaches the de-vegetated area its velocity increases. With an increase in velocity, erosion will increase and the exposed peats will erode, particularly on drying, even though they are one of the most resistant soil types known.

The loss of 1 mm of peat over 1 hectare equates to the loss of 10 m^3 of material. The loss of 10 m^3/ha of peat over 25,000 ha results in the loss of 250,000 m^3 of material. Without some form of stabilisation the potential exists for the movement of sediment to affect the integrity of some of the geomorphological features, particularly in any slow meandering stream and lake system.

The protective peat coverage is broken at the perimeter of the current impoundment by wave action erosion, particularly on the southern and eastern shores. If there is no artificial intervention and stabilisation, erosion will commence and continue at this break, increasing sediment loads.

Erosion will also commence in the natural drainage paths. The peats along the drainage paths have a higher proportion of sand and are free draining. The higher proportion of sand may make them more prone to erosion than other fibrous peats. If the sub-surface unconsolidated glacial tills, quartzite and sands are exposed they will erode more rapidly, again contributing sediment to the lake and stream systems. The potential for the production of outwash alluvial fans is real and will be created where sediment is deposited over *in situ* peats resulting in a strong colour contrast and a significant visual scar.

POTENTIAL FOR WEED INVASION

Weed invasion must also be considered as a threat to rehabilitation and WHA values, and following de-watering the current Lake Pedder impoundment will potentially be susceptible to weed invasion as:

- it is an open exposed shallow basin surrounded by sedgeland / heathland communities and is not protected by surrounding forests and steep topography as is the case in the nearby Gordon impoundment;
- the area exposed will be approximately 25,000 ha without any competitive established native species; and
- the majority of weeds are introduced through human activity, the major access roads into the area run along sections of the shoreline, and the local camping grounds are adjacent to Lake Pedder (*Cumbungii* has already been introduced to the Edgar Camping Ground).

Environmental weed species that come to mind and that are present in the area are Gorse (*Ulex europaeus)*, Broom (*Genista monspessulana* & *Sarothamnus scoparius*) and Ragwort (*Senecio jacobaea*), and they are known to rapidly colonise exposed acid peat sites. Ragwort was found one kilometre from the shore of the current Lake Pedder, along the Gordon Road between McPartlan Pass and Strathgordon and has been discovered in the Anthony area (western Tasmania) invading disturbed peats. New Zealand pampas grass (*Cortaderia richardii*) is also known to colonise acid soils but is currently not present in the area.

Common garden and agricultural weeds are not considered as a major threat to the area due to the acid, low nutrient status of the peats.

SYNTHETIC REHABILITATION

In view of the enormous area, the potential for erosion and weed invasion, and the difficulty for native plants to colonise the exposed area, synthetic or assisted rehabilitation will be required.

Active synthetic rehabilitation should be aimed at rapid site stabilisation and the establishment of a self-sustaining local provenance plant community that encourages a succession towards the original pre-flooding vegetation type.

There are several advantages in synthetic rehabilitation:

- it will reduce the effects of erosion as vegetation is the ultimate surface stabiliser;
- through a reduction in sediment loads, the integrity of the landforms will be preserved;
- by establishing native plants on the surface the areas available for weed invasion are reduced;
- it will reduce the unacceptable visual contrasts such as quartzite scarring; and

- with the establishment of colonising plants there is a gradual alteration of the surface conditions making the site more suited to colonisation by less hardy, less tolerant buttongrass sedgeland / heathland community plants.

Synthetic rehabilitation measures aimed at stabilisation and succession will initially involve the preparation of sites more suited to plant establishment. Plants will establish more successfully if the surface is undulating and friable with suitable micro-relief. Cultivation may be required on accessible sites and contour cultivation will also assist in reducing sedimentation. Seedlings developing from sown or natural seed will benefit from the creation of an undulating surface and they will usually colonise the moist depressions.

The species known to be reliable colonisers of disturbed sites which are also economic to establish, will bear little resemblance to (and will represent only a small fraction of) the species within the original plant community. Only those species able to cope with the altered exposed conditions will readily invade the peat surfaces. These species will gradually alter the site conditions encouraging a succession. A.D. Bradshaw states that "In natural ecosystem development, species invade slowly and can take advantage of the developing environments produced by physical and chemical changes that occur during primary succession" (Bradshaw & Chadwick 1980, Jordon 1992).

The recovery towards the natural vegetation types is extremely difficult to determine. Species such as the *Acacia, Leptospermum, Melaleuca* and *Eucalyptus* readily colonise disturbed sites and are economical to establish for the rehabilitation of large areas. Once established they must be considered as a tool in achieving a succession.

The recommended cost effective treatment would involve the application of the colonising species as seed followed by the sequential introduction of other plant species over time in order to increase system complexity and species diversity. Once the plants are introduced, are reproducing and the system is self sustaining there will be a return to a cover similar to the original vegetation types.

There are also a number of plant species that cannot be sown as seed, but can be propagated successfully in nurseries and, if planted as seedling stock, will cope with the harsh surface conditions. As planting is expensive these species should be planted in isolated areas, in pockets (the size and number of the pockets would be determined by the budget). Over time, these species would colonise from the pockets outwards.

In order to re-establish the original plant species more quickly, the less hardy, less tolerant species should be introduced as planted stock progressively over several years throughout the site, but only after the establishment of the colonisers.

The species that are known to be good colonisers of disturbed sites, are members of the local plant community, and are economic to establish in that they produce large volumes of collectable seed, are:

Acacia mucronata
Acacia verticillata
Allocasuarina monolifera
Leptospermum glaucescens
Leptospermum lanigerum
Leptospermum scoparium
Leptospermum nitidum
Eucalyptus nitida
Melaleuca squamea
Melaleuca squarrosa

Based on the Hydro-Electric Commission rehabilitation works standard on peats where the soil profile is intact, seed is usually sown at 2 kg/ha. More than 50,000 kg of seed will be required. To obtain this volume of seed from the local area, based on a professional seed collector's assessment (T. Walduck *pers. comm.*), would take approximately 5-10 years. If the current Pedder impoundment was to be de-watered, seed collection would need to commence 5-10 years prior to de-watering. Based on the availability of species in the area the proportion would be approximately 10 - 15 % *Acacia, Eucalyptus, Allocasuarina* and 85-90% *Leptospermum* and *Melaleuca.*

The provenance of the collected seed is extremely important for gene pool preservation and following discussions with Jayne Balmer, WHA Botanist, the range for seed collection would approximate to a 20-30 km radius from the current impoundment.

Weed invasion is a threat to the rehabilitation process and will be a major problem in areas adjacent to access roads and sites available to the general public. Areas of concern are the access to the Serpentine Dam, Strathgordon Village, works areas and abandoned tip site, Hermit Basin, Edgar Bay, Edgar Dam Picnic area, and Scotts Peak Dam. A weed management plan would be a component of any rehabilitation program, should be concentrated in these areas, and would involve control and monitoring. Any public access into the area being re-established with native vegetation will require stringent hygiene requirements to the point where access should be limited.

The next step in rehabilitation will be nutrient application. No doubt the proposed use of nutrients as fertiliser in the WHA will result in discussion and argument. Nutrient application will be essential for surface stabilisation and vegetation establishment. However, water quality and nutrient loading would need to be monitored very carefully and this will affect the method of application and the form of nutrient supplied. From a practical point of view the benefits will far out-weigh the disadvantage, particularly through moss and algal establishment and as a consequence by providing greater surface stability.

The HEC have used N:P:K low phosphate fertiliser 8:4:10 to encourage moss establishment to alter the appearance of rock faces and to provide a level of surface stabilisation. As the exposed non-vegetated peats will be susceptible to low level erosion, moss establishment will assist in holding the organic soils.

In the early 1980's, the Hydro-Electric Commission trialed fertiliser application rates in the Pedder area. At the time they found an N:P:K mix of 6:5:5 applied at 250 kg/ha encouraged rapid colonisation in peats and increased growth in plants establishing in exposed quartzite (Hydro-Electric Commission, 1980-85). Subsequent works found that the application of nutrients to returned peats encouraged rapid colonisation of local native species not present in the original seed mix.

Seed and fertiliser will need to be applied as soon as possible after cultivation and the most practical method of application will be aerially. Isolated gullies will need to be seeded by hand.

The quartzite disturbances associated with wave action will be extremely difficult to repair, particularly where peat overhangs an eroding unconsolidated quartzite horizon. Road cuts in similar situations do not stabilise naturally and often continue to extend in length. Rehabilitation will involve the application of fertiliser to alter the stark colour contrasts of the quartzite and provide nutrients for the applied plant species establishing in accumulated fines. Unstable sections will continue to erode unless stabilised by rock packing and other engineering works. Unfortunately, as engineering works may be required, machinery access is necessary and that would involve additional disturbance through access construction. In many cases this would probably not be practical, or would result in such additional disturbance that it could not be justified. The scars that could not be effectively treated would remain and would be revegetated to the highest standard practical and possible.

The majority of the dam construction disturbances would have exposed quartzite and bedrock and a similar treatment will be required as for the perimeter scars. Compacted surfaces will require contour ripping where practical and for effective revegetation, peat replacement may be necessary.

Peat can often be recovered from deep deposits and used for the treatment of the wave action scars, providing sufficient peat remains for the rehabilitation of recovery area. Peats 1-2 m in depth are often found in natural depressions and on flats.

Sand will be exposed in the dunes regardless of whether they have been damaged during water level rise, damaged during draw down or they remain intact. The original peats will provide a degree of stability. However, due to exposure, wind erosion will occur and the establishing plants will be blasted by sand particles. Wind protection fencing and artificial surface stabilisers such as jute hessian may be required to encourage more rapid stabilisation and revegetation of the dune system.

RESTORATION TIME PERIOD

In order to determine the time period required for the recovery of the site examples of time scale can be found from research into American Prairie community restoration. Prairie restoration was among the first plant community restoration attempts. Prairie species mature considerably faster than other vegetation types considered for restoration. Kline states that " A complex and dynamic community develops rather quickly in prairie restoration, and measurable changes take place on a scale of decades even though it may take centuries to achieve a prairie comparable to the pre-settlement prairies" (Jordon, 1992).

Prairies were considered for study based on the rapid maturation of species. A comparison of prairies to buttongrass plains is difficult with their natures being completely different, but prairie studies do give us insight into the rate of community change during restoration. Buttongrass and the other dominant species mature more slowly than prairie species and therefore the changes that occur with time are relatively slow.

Over the last 15 years the Hydro-Electric Commission has successfully established local provenance vegetation on peats disturbed during construction (Hydro-Electric Commission, 1980-85). The aim was to establish a self-sustaining plant community that encouraged a succession towards the original vegetation types. A complete cover was usually attained in 5 to 7 years.

Given enough time, money and assistance, rehabilitation and stabilisation of the exposed peats following de-watering of Lake Pedder, could be achieved in a relatively short term (at a guess 10-20 years), but to a vegetation type and composition that will be significantly different to the original.

Restoration of the original communities with the same provenance, structure and diversity as the pre-flooding vegetation is still centuries away.

Even in this reduced time frame the potential for erosion and weed invasion is high and contingencies must be made to cater for any related difficulties and degrees of uncertainty. Synthetic rehabilitation will not be a panacea, and in some instances it may fail, but it will reduce the severity of the adverse environmental effects associated with erosion, weed invasion and visual scarring, and it will increase the rate of recovery of the original plant communities.

COST

The cost estimate, based on a minimalist approach for the establishment of a suitable provenance plant species, has been addressed in detail in the Land Management and Rehabilitation Services' 1995 submission to the House Of Representatives Standing Committee on Environment, Recreation and the Arts (Land Management and Rehabilitation Services Pty Ltd, 1995).

In summary, the cost estimate can be broken-down into 3 major components.

Firstly the administration, professional organisation and rehabilitation plan preparation, research and ongoing monitoring, which is approximately $15 million over 20 years, where one professional costs approximately $100, 000 to employ per annum (wages, support etc). Speaking to senior Parks and Wildlife personnel this figure is not at all unrealistic.

Secondly, the cost of rehabilitation plan implementation (physical implementation of rehabilitation and stabilisation) is approximately $31 million where the cost of seed is approximately $10 million.

Thirdly, there is a 30 % contingency in case of sedimentation and erosional problems, access difficulties, slumping, failure due to unnatural seasonal extremes such as the 1994 summer drought on the West Coast, and also to cover uncertainties and unknowns.

Following discussion with mainland companies involved with large scale rehabilitation the contingency of 30% is seen as being low. However, as the rainfall is generally predictable 30% is considered reasonable.

The bottom line is approximately $62 million (at 1995 costs) for basic assisted rehabilitation, stabilisation and monitoring based on the techniques discussed here, and does not include dam decommissioning or rehabilitation outside the perimeter of the existing lake. More comprehensive programs such as intensive planting, can be initiated to aim at more rapid complete community restoration but the costs will be several orders of magnitude higher.

Malcolm Pirnie, in their submission to the House of Representatives Standing Committee on Environment, Recreation and the Arts (Malcolm Pirnie, 1995), conducted a review of ecosystem restoration following dam removal in other counties around the world. Based on this study, it is anticipated that ecological restoration to community levels similar in structure to the original, would cost hundreds of millions of dollars.

DISCUSSION

The aim of this paper has been to address many of the perceived problems faced in the staged rehabilitation of the current Pedder impoundment and their practical solutions. The position taken is minimalist, aimed at stabilisation and the establishment of a succession towards the original plant communities. This suggested rehabilitation procedure would need to be technically assessed to meet WHA management requirements, particularly when addressing nutrient application, an essential component of a rehabilitation program. There are so many unknowns and uncertainties involved in predicting the rehabilitation requirements that major studies will be required should de-watering of the current impoundment proceed.

Finally, as the community rationally debates this issue, carefully consideration must be given to the potential for erosion and weed invasion and the reduction in WHA values should they occur. Consideration must also be given to the difficulty and cost of rehabilitation of 25,000 ha. These factors along with many others need to weighed against the symbolic significance of restoring the original lake.

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