



14 September 2007
Project No. 43315854

Department of Sustainability and Environment
PO Box 500
East Melbourne
Vic 3002

Attention: Bernie O'Kane
Major Projects Division, Water Sector Group

Dear Bernie,

**Subject: Review of Modified Lake Mokoan Proposal Embankment Construction
and Cost Assumptions**

1. Introduction

URS were engaged by the Department of Sustainability and Environment (DSE) to overview an SKM assessment of a proposal to partition Lake Mokoan. The proposal was prepared by a group of Broken System irrigators in collaboration with Murrumbidgee Irrigation Limited (MIL). The proposal is referred to as the "Modified Lake Mokoan Proposal" in this review.

This review is of two SKM reports:

1. Review of Modified Lake Mokoan Proposal, Draft G dated 6 September 2007.
2. Addendum to Review of Modified Lake Mokoan Proposal, Draft B dated 5 September 2007.

The URS scope of work was to review and comment on the suitability of the construction methodology for the embankments and comment on the cost assumptions (unit rates, contingencies) for the Modified Lake Mokoan Proposal as presented in the SKM reports above. The URS scope did not include reviewing any cost estimates for associated infrastructure.



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2. Review of Construction Methodology

It is understood that the embankment design and construction techniques contained in the Modified Lake Mokoan Proposal were in large part based on recent experience with the partitioning of Barren Box swamp in NSW. There are aspects of the Barren Box project that are applicable when considering the partitioning of Lake Mokoan however there are some potentially significant differences that could impact on embankment design and construction methodology. This in turn would impact on the cost estimates.

The key aspects are summarised in the following sections.

2.1 Relative consequences of failure

One key area which influences the level of design effort for a water retaining embankment are the estimated consequences of failure. Although not quantified in the documentation reviewed the consequences of an embankment failure at Lake Mokoan will likely be greater than at Barren Box swamp due to greater downstream infrastructure being affected. This includes both economic and loss of life consequences.

Hence the level of design effort at Lake Mokoan should be greater than that at Barren Box swamp.

2.2 Foundation conditions

2.2.1 Geotechnical considerations

Both Barren Box Swamp and Lake Mokoan are predominantly founded on alluvial formations (Shepparton Formation) which typically comprises clays and silts with layers of sand and gravels. Sand layers are common throughout the Shepparton Formation which underlies Lake Mokoan and elsewhere they have required cut offs below embankments and in some cases they are potentially liquefiable (eg. Waranga Basin).

We understand at Barren Box sandy or silty layers were not intersected in the foundation of the embankment. We also understand that no cut off was adopted at Barren Box given the foundation conditions encountered. Such a scenario at Lake Mokoan is likely to be an optimistic assumption particularly without detailed geotechnical investigations.

The SKM report notes that the proposed Eastern embankment site is located on a lunette (wind formed deposit which is typically sandy and may have a relatively high permeability and be in a loose condition). Such wind blown sandy deposits are common in the area and if such a deposit is below the proposed embankment this will require particular investigation to determine appropriate stripping and cut off depths. Hence



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allowance for deeper stripping and cut offs as provided by SKM are considered appropriate for this level of knowledge for this area.

In addition if sandy or silty layers are encountered in the borrow areas then these may not be suitable for embankment construction resulting in increased cost of borrowing (including rehabilitation of the borrow pit).

2.2.2 Depth of stripping

The SKM report states that for the Modified Lake Mokoan Proposal a stripping depth of 0.2m and a cut off depth of 3.0m was adopted. SKM has assumed a depth of stripping of 1.0m below the embankments.

At Barren Box we understand actual stripping on site was up to 0.5m. We understand this was in part to remove near surface organics but also to strip a desiccated /cracked layer reflecting the relatively drier conditions at Barren Box. At Lake Mokoan we believe it is likely there will be greater depths of organic materials than at Barren Box due to the larger and more permanent nature of the swamps. Hence an allowance for stripping greater than 0.5m is recommended. We consider the 1.0m adopted by SKM is a reasonable upper limit given the current level of geotechnical knowledge of the site.

The proposed cutoff depth of 3m appears reasonable with full filter protection and the use of stabilised clay backfill.

Further investigation including geotechnical investigations would be required to optimise the cutoff and stripping depths any further.

2.3 Compaction control

2.3.1 Compaction methodology

We understand at Barren Box compaction of the embankments was primarily achieved via trafficking from scraper placement. MIL describes placement of the earthfill at Barren Box by a "ramped" technique rather than the more typical horizontal placement in layers. We understand this same technique is proposed for the Lake Mokoan embankments as reported by SKM.

A ramped technique typically uses the earthwork plant (scrapers in the case of Barren Box) spreading the material to form angled layers i.e. a ramp rather than the more traditional horizontal placement. Although this technique was successfully utilised at Barren Box it is not commonly adopted for structural earthworks due to difficulties associated with the technique. Achieving consistent layer thickness, uniform and



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adequate compaction and uniform and adequate moisture content can be problematic with this technique. In addition there is less ability to control the exclusion of deleterious material from the borrow pit. At Lake Mokoan it is possible there will be variable layering in the borrow pit and some of these materials will require exclusion.

An additional concern with a "ramped" compaction technique is that if highly dispersive materials are to be used in construction without any stabilisation such as with lime, a high level of compaction is critical to the long term performance of the embankment. Hence we would not recommend adoption of a ramped technique for earthworks construction at Lake Mokoan.

The optimal (and unusual) conditions that allowed the successful placement of fill by this ramped technique at Barren Box are unlikely to exist at Lake Mokoan and more traditional placement and compaction methods are likely to be required. This will increase the unit rate for this activity compared to Barren Box.

2.3.2 Compaction specification

The SKM report states compaction standards of 95% of standard maximum dry density at $\pm 2\%$ of optimum moisture content for the Modified Lake Mokoan Proposal. In highly dispersive soils which is likely to be the case at Lake Mokoan, higher compaction standards are generally required to minimise the potential for piping. Hence we would recommend adoption of a more demanding compaction specification similar to that proposed by SKM. The exact specification would need review at the detailed design stage when the fill type to be used is known and other design details such as filter extent and quality are better known.

2.4 Earthfill treatment

SKM have allowed for lime stabilisation of the embankment earthfill to reduce the dispersion potential of the soil. We agree local soils are likely to be dispersive in rainwater (hence the sinkholes etc on the existing Lake Mokoan embankments) however it is not certain if this is the case with typical Lake water. An alternative to full lime stabilisation would be to cap the more dispersive materials with either lime stabilised materials or some other material as was the case at Barren Box. The need for and the specification of any capping would need to be considered in combination with filter design and the properties of the fill material when known.

At this stage we consider it appropriate to make allowance for capping of the earthfill with a stabilised material. The need for any further stabilisation of the fill could be considered after further detailed studies.



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2.5 Allowance for Dewatering

Barren Box was constructed in the dry with the swamp being able to be drained. We understand the dead water level at Lake Mokoan is at 160m and at least some portions of the proposed embankments will be founded below this level.

Hence if Lake Mokoan is to be completely dewatered this will require actions beyond gravity draining of the Lake to the existing outlet. On the information presented it is not clear if Lake Mokoan can be effectively dewatered to a point where construction in the dry is feasible. We understand some cost allowance has been made in the Modified Lake Mokoan Proposal for dewatering although it is not clear from the reviewed documents what this amount is.

There is a possibility that instead of the larger coffer embankments proposed by the SKM an alternative system could be adopted to allow construction in the dry. Such a system could utilise temporary diversion drains, smaller coffer dams sourced predominantly from local materials and some pumping to the outlet from the dead water storage.

To determine if such a system could be viable, and would also deliver adequate flood protection for the period of the works, requires further assessment. There is insufficient information in the material reviewed to determine the adequacy of the proposed dewatering scheme.

If such a system was viable this may reduce the cost allowed for however some level of dewatering/flood protection will likely be required.

As indicated by SKM if full dewatering is achieved the supply of water to Lake users during the period of the works would be an additional project cost.

2.6 Embankment Profile

The modified embankment profile as reported by SKM for the GHD modified design generally appears reasonable with the exception of stripping (see Section 2.2.2), compaction specification (see Section 2.3.2) and filter configuration.

We understand the filters proposed do not extend above full supply level nor do they extend into the foundation (SKM June 2007). Also they are not fully drained with drains spaced approximately every 50 metres of embankment length. This is not considered adequate for Lake Mokoan given the likelihood of variable foundation conditions and the likelihood of dispersive soils being used as fill. We concur with SKM and recommend that given the level of current knowledge a full height filter which is fully drained be adopted. The final configuration of this filter can only be determined after further detailed geotechnical investigations.



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From the available documentation it is not certain if the embankment as part of the proposed alternative may periodically impound water on its downstream side. If any part of the downstream embankment might be inundated sufficient erosion protection will be required.

3. Review of cost assumptions

3.1 Contractual costs

The key observations from our review are:

1. The adoption of a 40% contingency for the level of investigations and analysis currently completed is considered appropriate. It is important that any known cost items should be included in the cost estimate and the contingency be separated. Any inclusion of known costs into the contingency is not warranted given the level of information available and the consequences of failure. As further information becomes available the contingency may be able to be reduced however this would need to be evaluated after this information is fully considered.
2. In the costings provided there is an allowance of 15% for survey, design, project management and administration. We consider the unit rates adopted rates are unlikely to cover additional contractor costs such as establishment, staffing and OH&S requirements. Typically for concept level estimation we would include an additional 15 to 20% on to the estimated net construction cost to allow for this. Also there appears to be no allowance for contractor overhead and profit. This would likely add an additional 15 to 20% onto the estimated net construction cost.

3.2 Rates

1. The unit rates listed in the SKM report for riprap, filters and stripping appear reasonable.
2. The unit rate for borrow for embankment earthfill may be high if an alternative to cap the dispersive material is adopted rather than full treatment. A rate of approximately \$10 per cubic metre may be more appropriate however this is subject to identifying a suitable source of borrow and determining its properties, likely borrow pit wastage, haul distance and any treatment.
3. The unit rate for coffer dam borrow at \$15/ cubic meter appears reasonable (Table 13 of SKM report). A rate of \$35 / cubic metre is shown in Appendix A of the same report. At this stage if it is assumed the coffer embankments are temporary a unit rate in the order of \$15 /cubic metre may be appropriate.



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The allowance in the costing for coffer dam settlement appears relatively high. This may be a conservative estimate that with further information may be able to be reduced. Any reduction in the dewatering/flood protection cost estimates should be done on the basis of a better understanding of the flood construction risk.

4. Conclusions and Recommendations

The components of the SKM report reviewed by URS are considered to be of an appropriate level given the limited geotechnical information available and the likely consequences of failure. We have the following comments that may be considered if this project progresses further.

There are some areas for possible further consideration which may reduce the cost estimates (dewatering configuration, full earthfill stabilisation) however these will require further investigation if any cost savings were to be realised.

We have not reviewed any information on safety upgrades of existing infrastructure (such as to ANCOLD guidelines if required). In addition we have not reviewed information on any control structures or water delivery systems nor any information on costs associated with environmental management during construction. This review is limited to the embankment only.

Although there may be some cost savings that could be realised with further studies these appear unlikely to significantly reduce the SKM cost estimate. In addition when the appropriate contingency is adopted and an allowance made for contractor overhead, profit, establishment, staffing, OH&S, testing the cost may increase.

Given the level of uncertainty in any cost estimate at this stage it may be appropriate to adopt a range of cost estimates based on what is likely to be encountered on site. For example the range could include an optimistic case, planning case and pessimistic or worst case. Rates could be adopted for each case assuming the lowest cost option occurred (optimistic), best estimate conditions occurred (planning) and worst case conditions eventuated. Note that all these cases would still have a 40% contingency applied given the level of information available. As new information becomes available the cost estimates could be updated to reduce uncertainty which typically has the effect of reducing the range of costs.

In our experience the actual realised cost typically falls around the planning estimate with optimistic cases rarely transferring to reality.

We trust this review meets your immediate needs. If you have any queries please contact Stephen Newman in our Melbourne office.



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Yours sincerely,
URS AUSTRALIA PTY LTD

A handwritten signature in black ink that reads 'Steph Newman'. The signature is written in a cursive style.

Stephen Newman
Senior Principal