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Mr Jai O'Toole
Department for Water
Level 1, 22 King William Street
ADELAIDE SA 5000

RIVERBANK STABILITY RISK MANAGEMENT
CALOOTE BOAT RAMP, SOUTH AUSTRALIA

Dear Jai

Introduction

Golder Associates Pty Ltd (Golder Associates) was requested by the Department for Water to assess the stability of the river bank near the boat ramp at Caloote, River Murray and to provide discussion on potential management and remedial options that might allow the ramp to be reopened.

Sinclair Knight Merz (SKM) previously undertook studies of potential for river bank collapse in the area on behalf of the Department of Water Land and Biodiversity Conservation (now Department of Water). These studies are described in SKM's report *Study into River Bank Collapsing for Lower Murray River* dated January 2010, which was reviewed by Golder Associates. Our report of that review was provided in document 107662007-002-Rev1 dated 16 February 2007.

The studies included intrusive investigations at Caloote and an assessment of the stability of two cross sections of the river bank. SKM's report indicates that the assessed stability of the riverbank, assuming a river water level of either -0.8m AHD and -1.5 m AHD, presented an unacceptable risk to human safety. The report recommended establishing an exclusion zone along the waterfront at Caloote which included the boat ramp area. This effectively precluded continued use of the boat ramp.

Lyndon Sanders, Principal Geotechnical Engineer, visited the Caloote boat ramp on 9 March 2010 and 17 June 2010 with Jai O'Toole of the Department for Water to gain an appreciation of the site conditions.

Scope of services

Golder Associates reviewed the data collected by SKM at Caloote to assess the stratigraphy present near the boat ramp. On the basis of that review we performed check calculations of the river bank stability near the ramp. We considered options which might allow the boat ramp (although not necessarily the surrounding areas) to be reopened, which are discussed in the present report.

Scope of SKM Investigations

The intrusive investigations carried out by SKM at Caloote included conducting a number of Cone Penetration Tests (CPT's). There are reports of ten CPT soundings conducted by EngTest and three

attempts at CPT soundings (at two locations previously tested by EngTest – CPT 3 and CPT 9) by Black Insitu Testing at Caloote.

SKM's investigations also included drilling four boreholes (Boreholes CA-BH1 to CA-BH4), with Boreholes CA-BH3 and CA-BH4 being located in the vicinity of the boat ramp.

The investigations also included laboratory testing on samples from the bores.

Boat Ramp stratigraphy

Similar conditions were encountered in Boreholes CA-BH3 and CA-BH4. These boreholes indicated generally low strength clayey material to 17.5m and 11.5 m depth respectively, overlying higher strength (dense or very dense) granular material. In Borehole CA-BH3, a medium dense to dense granular layer was also present between 11.5 m and 12.5 m depth in the middle of lower strength clayey materials.

The CPTs conducted near the boat ramp (CPT's 6, and 9, with CPT's 7 and 10 slightly further away) suggest generally low strength material to at least 10 m depth. The Black Insitu Testing at CPT 9 (3 attempts) met refusal at between 5.5 m and 7 m depth, coinciding with a harder layer in the EngTest CPT 9 that is not readily correlated with the borehole observations.

Boreholes CA-BH3 and CA-BH4 are located some distance from the water's edge – as close, we suspect, as was reasonably practicable for drill rig access without significant temporary earthworks to provide a drilling platform or the use of a barge and overwater drilling.

SKM assumed – not unreasonably - that the stratigraphy would be consistent beyond Borehole CA-BH4 towards the River centreline.

Our review suggests that the stratigraphy adopted by SKM for its stability analyses was reasonable. There are some anomalies which it would be desirable to resolve – the difference in the depth to granular strata and the apparently stronger layer shown in the CPT tests. However, we recognise that this may not be practical – the stability assessments suggest that the risk (and cost?) of ground-based investigations near the River end of the boat ramp is likely to be unacceptable. The cost of overwater investigations is likely to be prohibitive.

Boat Ramp stability

Our calculations gave similar results to SKM's and we conclude that the river bank at the boat ramp would not have acceptable stability (that is the calculated Factor of Safety would not be above 1.5) at water levels up to pool level (+0.75m AHD).

We therefore conclude that if the boat ramp is to be reopened, its stability will require improvement. This would imply improving the load carrying capacity of the soil by strengthening , reinforcing it or removing some of the load on the slope imposed by the boat ramp.

We also calculated the difference in stability between situations where the crest of the slope is loaded and unloaded (SKM assumed a 2.5 kPa surcharge load at the crest of the slope). The calculations suggest about 10% improvement in stability for the unloaded situation – calculated Factors of Safety around 1.35 and 1.5 for the loaded and unloaded situations assuming river water at pool level.

Stability improvement

Based on the investigations performed to date, low strength clayey materials are likely to be present to around 18 m depth along the boat ramp alignment – to 17 m or more below river water level. This suggests that the scale of works needed to achieve an acceptable improvement in stability by earthworks (construction of buttresses or shear keys) is likely to be significant and probably impractical.

We expect that driving enough piles to strengthen the ground in the ramp area to prevent landsliding is likely to be difficult if not impossible. However, it would be possible to use piles to carry the traffic loads. This would reduce the risk of landsliding being triggered by trafficking, even if the stability of the ground itself was not greatly increased by the pile installation. In effect this new boat ramp would be a piled bridge which used the ground only as construction support. This option is likely to be feasible, if expensive.

Based on the stability analyses (both SKM's and Golder Associates'), we expect that piles would need to be placed starting approximately 50 m inland of the water's edge and extending some distance into the River. We expect that the piles would have to be at least 20 m long and would be capped with a structural slab. Pile spacing and slab thickness depend on each other, but 'back of envelope' estimates suggest a pile spacing of around 3 m and slab thickness of around 0.3 m. The final scheme would have to involve structural engineering design.

Even with a piled bridge in place there is still risk associated with trafficking of the river bank crest because if the land started to slide because the water level in the river dropped to a sufficiently low level, the piles would not be strong enough to hold the ground back and support the traffic loads. Therefore we expect that the boat ramp could only be used when the assessed stability of the unloaded river bank was acceptable.

Based on analyses presented by Richard Brown of the Department for Water at an emergency response planning meeting on 28 July 2010 the trigger level may be around 0.0 m AHD, at which level the Factor of Safety for the loaded riverbank is assessed by SKM to about 1.25. However, that would require confirmation by the various stakeholders, as the Factor of Safety for the unloaded river bank is likely to still be below 1.5.

This approach would require the river level to be monitored and a restriction placed on the use of the ramp during times when the river falls below the trigger level. We expect that enforcement of that restriction may be difficult or impractical.

There is some uncertainty as to the stratigraphy at the boat ramp. It would not be feasible to conduct on-land intrusive investigations closer to the river bank due to the safety risk management issues. Conducting intrusive investigations over-water near the bank edge would be possible although expensive (we expect that the cost to establish a drill rig to the location would be in excess of $20,000 and daily drilling costs are likely to exceed $5,000).

The most practical option may be to design the piles on the current stratigraphic information. In this case, the required depth to drive the piles would be finalised during installation. There would be a risk to the pile installation cost with this approach from the uncertainty in the depth to the higher strength material.

It must be noted that this approach would allow access only to the boat ramp and would not stabilise the nearby public areas, which would presumably have to remain closed until the stability of this area is acceptable.

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Closure

Should you have any queries regarding this letter, or if we can be of further assistance, please do not hesitate to contact this office.

GOLDER ASSOCIATES PTY LTD

Lyndon Sanders
Principal Geotechnical Engineer

AJB/LJS/ed

Attachments: Limitations (LEG04, RL1)

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