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20 March 2009

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Dear Rajiv,

Lwr R Murray - Riverbank Slumping - Site Inspection of 13 Mar 09

This letter report provides a brief summary of the main outcomes of the "Technical Panel" inspection of 13 March 09 of riverbanks in the Murray Bridge region where slumping has occurred and cracking has been reported since early Feb 2009.

Inspection was by the undersigned with Alan Moon of Coffey Geotechnics, Rob Frazer of Murray Bridge, Robert Shipp of Murray Bridge Council and Damian Vears of DWLBC. Weather was fine and hot during the inspection. While sites varied widely the purpose of inspection was to obtain a big picture view of conditions and slumping along the lower River.

The "Technical Panel" who have considered the issues and made recommendations for this preliminary report consists of Alan Moon, Rob Frazer and Daryll Pain.

1. Intent of the Report

The intent of this report is to provide our preliminary findings to guide your immediate actions to safely manage the bank slumping issues along the Lower River Murray, effectively the 209km length of River from Lock 1 at Blanchetown to the point of discharge of the River into the lower lakes just south of Wellington. *The report is necessarily limited by the short time available and limited extent of the inspection.*

2. Sites inspected

The extent of inspections at sites, all within the council area of Murray Bridge, accessed variously by 4WD vehicle and 25T river cruiser, ranged from Long Island Marina through Swanport, and Murray Bridge to Wood Lane Reserve and north towards Caloote.

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3. River Condition

River flow rate past Lock 1 is very low, indicated to be about 1.5-2.0 Gl/day, down from flows of around 4 Gl/day in late 2006. The pool level at Murray Bridge is down to about -1.05m AHD since late 2006, from a nominal operational pool level of +0.75m AHD. The pool level has apparently fallen rapidly at ~0.2m/month through late summer, although it appears to be relatively static at present, aside from wind effects.

Therefore, pool level is about **1.8m lower** than normal pool level and dropping. It is thought pool level has the potential to drop another 500mm. It is noted that wind seiche can vary water level locally in the lower Murray by up to +/- ~0.4m depending on wind direction. Recent records show pool level appears to stay relatively constant during winter seasons so potentially the next significant drop in pool level may not be until next summer.

The geomorphology of riverbanks is such that where they are formed by deposition and erosion of sediments, existing riverbanks prior to water level dropping can be considered to be just stable, i.e. they have a "factor of safety" against slip failure within the soft, organic, silty clays of the riverbank of just greater than 1. The dropping water level has effectively caused an additional surcharge of nominally 20kPa or 2 tonnes per square metre to be applied to the riverbanks and adjoining flats for the length of the pool due to reduced effect of buoyancy. This is enough to generally destabilise the riverbanks and initiate slip failures, with the first failures likely to be in areas where thicker filling has been placed (e.g. in levees and paved areas) and where the river channel is deepest.

It was observed during time on the river cruiser that the river channel depth varied from ~6 to 16m and that existing slips tended to match areas where the channel depths exceeded depths immediately upstream and downstream of the slip area.

4. Riverbank Slumping and Cracking

The areas inspected were chosen because of the examples of riverbank slumping, and cracking that existed at each the sites. A photographic record of the inspection was made and is available to the Technical panel and DWLBC.

Examples of cracking and slumping ranged from:

- descriptions of sudden changes to riverbed profiles just offshore from the waterline,
- to cracks onshore parallel to and near the water line,
- to wide cracks around trees and stumps on overhanging high points,
- to tree and bank collapses along swamps,



- to major slips at Woodlane where a pump station, trees and a stobie pole were carried into the river
- and at Long Island marina where the major slips occurred
- as well as an adjacent major slip that threatened an SA Water sewer rising main.

Some of the major slips were noted as occurring as a series of slips with the landside face of the slip progressing landwards. Cracks and slips were noted where levees and roadworks had been built on the bank and where levees existed 20m and more inshore from the bank and where no levees existed at all. Crack locations were observed as much as 15-25m landside of the shoreline.

Rob Frazer provided specific slip circle analyses examples of the slumped riverbank adjacent to the marina at Long Island. Low undrained shear strength in soft clays at the low end of the range ~10-20 kPa resulted in factors of safety just less than unity with classic slip circle geometry and failure mode fitting observed bathymetry at the slips.

Cracks represent the back face of slip circles and the Long Island models show that the toe of the slip can be well out into the river channel. Channel depth is a prime driver of crack position on the bank, in that deeper channel implies greater offset of the crack landside of shoreline.

The "Technical Panel" conclude that slumping can occur at any time but anecdotal evidence is that slips occur often at night. Riverbank assets such as personal jetties and "beaches" are prevalent in residential areas along the riverbank, many of which are at risk of destruction with riverbank slumping.

Slips can occur in channel sides underwater, and can be associated with release of gases as bubbles of (most likely) methane and or hydrogen sulphide. The bubbles are therefore potential indicators of slips and imminent bank slumping.

It was observed that large trees have collapsed into the river channel creating navigation and recreational hazards. Also trees are splitting and collapsing where branches and foliage, normally supported in and on the water surface, become unsupported as pool level drops.

There are potential issues with oncoming winter rainfall, for example:

- trees breaking branches as mass of foliage becomes heavier with wetting; and
- water finding its way into cracks, lubricating slip surfaces and potentially promoting further movement.

5. Hazards of slumping

The main hazards identified are the following:



- Onshore: campers, vehicles and similar can be swept into the river on slips if parking and camping close to the riverbank. Consequences include loss of life and property so are extreme. Other fixed or temporary assets could also be displaced or undermined by slip failure with moderate to high consequences.
- Offshore: Houseboats and recreational vessels tied up to mooring posts or trees on soft or cracked section of riverbank could sustain damage and /or capsize in the event of bank slumping. Consequence again include loss of life and property so are extreme.

Action is considered absolutely necessary to mitigate these hazards.

6. Preliminary Recommendations

The following immediate actions are recommended by the "Technical Panel" members along the lower Murray, in the context of safety of the public camping along the River during Easter in early April:

- All camping and parking of vehicles and trailers to be beyond a 40m slip zone from the waters edge (depending on river channel depth which should be mapped to identify potential high risk areas as observed slip zones were broadly 3 times the channel depth, and a 40m zone assumes a maximum depth of around 13m);
- At sites where cracking is noted, refrain from any activity in the area between the cracks and shoreline;
- At sites where tall trees grow along the riverbank, do not moor houseboats or recreational vessels;
- Do not moor houseboats in areas where bubbles are, or have been, observed in the waterway;
- If bubbles are noted after mooring, do not sleep on board overnight until the vessel has been moved to another mooring;
- The public and recreational water users would be expected to be aware of underwater snags and obstructions in the river, however the recent and future slumping will add new hazards of this sort in areas where they have not been seen before so increased caution is warranted.
- That DWLBC continue monitoring and reporting cracks and slumps via Murraywatch and gathering data reported by the community. A proforma for such monitoring should be followed to maximise the reliability and usefulness of the data which should include at least location (GPS coordinates or distance and direction from a recognisable marker, building or the like), approx distance from the shoreline, any asset or feature that is riverside of the crack (e.g. tree, pole, pump station, pipeline, culvert or the like) date and



time of the observation, name and contact of observer, measurement of crack width at a specific location and measurement of level difference across the crack where possible.

7. Remediation

The most effective remedial action is to raise water levels to nearer pool level as soon as possible by whatever practical means are available. Cracks already formed would not be prevented from proceeding to slumping in all cases.

The construction of Wellington Weir may be the only practical short term remediation available to slowly restore higher pool levels but this could not be expected to have such an impact in less than 12 months from now.

8. Qualifications

At this early stage for Technical Panel members "we don't know what we don't know" along the whole of the lower pool so the "Technical Panel" recommend an urgent and detailed study to compile a more comprehensive understanding of conditions and issues along the lower pool.

9. Proposal for Further Work

Further to the meeting earlier this week with yourself, Damine Vears, Alan Moon and Brenton Harris of Coffey, and myself, I confirm SKM, with Coffey and Rob Frazer as sub-consultants, is preparing a proposal to undertake the investigations and studies we consider necessary to provide the ongoing advice and support you are seeking in relation to the management of the Lower Murray riverbank slumping incidents of the last year and especially since Feb 09.

We expect the proposal to be available by Wednesday next week and will detail a proposed scope of work covering the ~210km of River from Wellington to Lock 1 including methodology, team structure, programme, confirmation of appropriate Terms of Agreement with a fee estimate.

As discussed, our ability to provide adequate support as a "Technical Panel" is contingent on this approach being adopted by DWLBC.

We understand your desire that the individual panel members that provide ongoing support to you and the Department, in the form of monthly meetings or workshops with you on slumping incidents, to comprise Lyn Sanders of Golder, Alan Moon and Roger Grounds of Coffey, Rob



Frazer from Murray Bridge and myself. Interaction and potential stakeholder engagement with the three councils covering the River from Murray Bridge to Blanchetown is understood to be likely and we will need to develop an effective methodology for this. This "Technical Panel" work is seen by SKM as separate to the proposal referred to above.

Please don't hesitate to call if you have any questions on the above.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'D. Pain', written over a light blue horizontal line.

Daryll Pain

Sr Associate and Civil Engineer.

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