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19 July 2007

Attention: Karl Diskoros

Dear Sir

RESERVOIR 1, POTTS HILL – STRUCTURAL INTEGRITY AND FORM

1. INTRODUCTION

A proposal for disposal of inert fill associated with development of surplus SWC land at Potts Hill is to use Reservoir 1 which has heritage significance. Following a report by the Heritage Council of NSW dated 7 February 2007, Landcom acting on behalf of SWC, engaged Patterson Britton and Partners to review the impact of fill placement on the structural integrity and form of the reservoir. There has also been consideration in the Conservation Management Plan of storage of water or recycled water in the remainder of the reservoir as part of a measure to assist stabilise the reservoir walls. This water storage could also serve as a possible water management strategy for the development of the surplus lands or part of a regional recycled water scheme being considered at present by SWC. This issue has also been included in the structural integrity assessment.

2. RESERVOIR 1 DESCRIPTION

Reservoir 1 has plan dimensions of approximately 355m x 255m. The distance from the base to the top of the wall is approximately 6.4m with the design full water storage depth being 5.2m. There is a concrete encased water conduit which extends along the toe of the western wall and turns east across the floor of the reservoir about 50m south of the northern wall. No fill is proposed against this conduit because it is operational and SWC were concerned about the potential for infiltration from the fill into the conduit. The dimensions of the reservoir south of this conduit are approximately 305m x 255m to the top of the walls.

A detailed SWC investigation of the reservoir stability was undertaken in 1981 (refer **Appendix A**). The reservoir was formed by cut and fill with the natural soil profile consisting of clays and silty clays overlaying highly weathered shales, siltstones and sandstones.

The floor of the reservoir appears to be mass concrete according to historical plans from SWC which is founded on rock for about 90% of its area. The remainder adjacent to the eastern wall in the area of a former small valley (in location of the reservoir drainage outlet) is founded on a wedge of clay up to 4m thick.

The reservoir walls are formed with grouted sandstone blocks on a slope of approximately 1V:1.5H. The western wall is located almost entirely in cut, while the northern and southern walls are part in fill and cut. The eastern wall is also mainly in cut and fill except for a 90m long section entirely in fill near the existing drainage outlet.

The reservoir has a history of wall failures since its construction in the 1880's. These have occurred in areas of cut and fill and in the eastern wall in the location the wall is entirely in fill. The first recorded instability occurred in 1894 in the eastern wall. Various remedial actions have been undertaken since that time.

3. RESERVOIR STABILITY

The stability of the reservoir has been analysed by PSM (refer **Appendix A**) to verify the SWC 1981 Report results as well as review the implications of filling the reservoir with fill or water.

3.1 Wall Stability

The instability of the reservoir walls appear to have almost entirely been associated with draining water from the reservoir. When full, the groundwater level in the soils behind the wall invariably matched the water level in the reservoir. These groundwater levels where established over time at a relatively slow rate depending on the porosity of the wall and soils. This groundwater or pore pressure exerts a load on the wall which is resisted by the water in the reservoir. When the reservoir is emptied over a relatively short period, these pore pressures remain behind the wall because they dissipate very slowly given the clay type of soils. This pressure exerted behind the wall is no longer resisted by the water and the wall can fail by slipping.

PSM analysed the stability of the critical section of the eastern wall which is entirely in fill. PSM have recommended a factor of safety of 1.5 against slip failure.

PSM confirmed that:

- Factor of safety = 1.69 in the original design;
- Factor of safety = 0.99 immediately after emptying the reservoir;
- Factor of safety = 1.38 in present condition.

This indicates the effect of emptying the reservoir in that the stability assessment predicts the wall is likely to fail (slump) as the factor of safety would be less than 1.0.

The factor of safety at present with the groundwater level behind the wall located at the toe of the wall is reasonable although less than the ideal value of 1.5.

3.2 Floor Stability

The majority of the floor was identified in the SWC report to be located on bedrock. The testing indicated that water had leaked through the reservoir floor and had caused some weathering of the bedrock. One observation following dewatering of the reservoir noted heaving of a small section of the floor generally assumed to be caused by excessive pore pressures under the floor slab. These pressures dissipated relatively quickly and the floor slab returned to its original position. As such, it is expected that the concrete floor would have a maze of fine cracking.

No major deformations of the floor slab were observed during our site inspection however minor deformation/erosion of the floor surface was evident due to traces of water ponding areas.

4. IMPACT OF PROPOSED WORKS

Preliminary geotechnical and contamination investigations along with preliminary development concept layout and landform grading work to date have provided an estimate of the likely extent of excess sediment derived from development of the surplus land. This estimate is approximately 330,000m^3.

More detailed investigations and design are to be undertaken to refine the extent of excess sediment. In recognition that the volume of excess sediment could be higher than this preliminary figure of 330,000m^3, this structural integrity analysis was undertaken on a worst case scenario in which the reservoir may be filled completely south of concrete encased water conduit while leaving the reservoir walls exposed with a 5m setback from the toe of the walls. This forms Option 1 as described in **Section 4.1.1**.

Placement of fill against the reservoir walls would improve their stability especially for the eastern and southern walls which have failed in the past and presently have deformations indicating evidence of instability. The second option in the structural integrity analysis reviewed the impact and extent of filling involved with 330,000m^3 of excess sediment *(preliminary estimate)* when placed against the southern and eastern walls but with the 5m offset from the other walls or structures.

4.1 Fill Area

4.1.1 Option 1

The first option for fill placement in the reservoir would be to maintain the fill clear of the walls and the raised conduit on the western and northern sides. It was proposed that the toe of the fill be setback 5m from the toe of the walls/conduit and that the fill be placed with a stable batter slope of 1V:3H.

The approximate fill volume up to 6m high which could be placed in this manner would be 375 000m^3. This would cater for the present approximate volume of inert fill to be disposed from the surplus land development (330 000m^3).

4.1.2 Option 2

Fill could be placed onto the eastern and southern reservoir walls to improve their stability to acceptable standards. The fill would be offset a minimum of 5m from the raised conduit on the western and northern sides of the reservoir.

Placement of fill over this area would provide an approximate volume of 405 000m³ which exceeds the present estimate of 330 000m³ for fill to be placed in the reservoir. In order to cater for the 330 000m³ of fill, it would extend approximately 245m north from the top of the southern wall leaving a clear distance of approximately 60m to the raised conduit across the northern section of the reservoir.

4.2 Impact on Wall Stability

The estimated factor of safety for the critical eastern reservoir wall with the proposed fill options are:

- Option 1 – FOS 1.38 – no change from FOS for existing conditions;
- Option 2 – FOS 4.50 – significant improvement in factor of safety.

The filling against the reservoir walls (Option 2), especially the eastern and southern walls which have experienced instabilities in the past, would significantly improve the factor of safety for stability. This would potentially reduce the future maintenance required for the possible repair or prevention of slip failures in these walls.

Filling internally without impinging on the reservoir walls would not change the factor of safety for stability of the walls. While the factor of safety of 1.38 is below the preferred design value of 1.5, PSM has concluded that the walls are stable and would remain so provided pore pressures were to remain at similar levels to existing conditions. There are areas of the eastern and southern walls which have deformed in the past and may require maintenance in the future.

The placement of a temporary access earth ramp over part of the reservoir southern wall for Option 1 would enhance the stability of that section of wall.

4.3 Impact on Floor Stability

PSM has estimated that the placement of 6m of fill (twice the past water loading on the floor) would induce a settlement of about 15mm over the majority of the reservoir which is in cut and 30mm over the fill area adjacent to the eastern wall. It was concluded by PSM that these pressures would not result in unacceptable stress or displacement of the reservoir floor (refer **Appendix A**).

4.4 Water Storage in Reservoir

Storage of water in the reservoir is being considered as part of either the local or regional recycled water strategy or as a means of improving the stability of the reservoir walls. As part of a water supply, it is likely that the water level in the reservoir would vary in response to supply and usage rates. For any option, the storage would have to be emptied from time to time for maintenance. It is likely that this type of operation would lead to instability in the reservoir walls for the same reason as has caused the instabilities in the past. Also, the leakage rate from the reservoir without a liner is likely to be high given the existing condition of the reservoir.

It is recommended that, for any bulk water storage in the reservoir, an impermeable lining be installed to the full height of the reservoir wall. This liner would reduce leakage and minimise the buildup of pore water pressures (groundwater) under the floor and behind the walls of the reservoir. It would also be required on the raised conduit in order to prevent infiltration of stored water into this conduit. When the water storage was to be emptied, it should be undertaken slowly to permit dissipation of pore water pressures behind the reservoir walls.

5. SEPARATION WALL

The separation wall would be a concrete or block reinforced wall supported by grouted dowles into the base of the reservoir. The purpose of the wall is to trap rainfall runoff from the stored sediment to allow appropriate treatment with alum to ensure suitable suspended sediment concentrations prior to discharge from the reservoir.

6. IMPACT ON OPERATIONAL WATER INFRASTRUCTURE BELOW RESERVOIR 1

Operational trunk infrastructure *(water tunnels)* below the base of the reservoir are located at the northern end. The reservoir base in this area is founded on rock. The location of the infrastructure and the presence of bedrock would mean that any fill placed to the top of the reservoir walls would not have a significant adverse impact on the operational trunk infrastructure below the base of the reservoir.

7. CONCLUSIONS

The conclusions with respect to the structural integrity of Reservoir 1 are:

- Filling of the reservoir with inert fill to 6m high against the reservoir walls should provide the greatest improvement in structural integrity of the walls;
- Filling of the reservoir generally in accord with Option 1 is not estimated to have a significant adverse impact on the structural integrity of the reservoir walls and base based on the investigations in this report;
- Any filling of the reservoir with water should incorporate an impermeable liner or other measures to control dissipation of pore pressures and prevent infiltration into the raised conduit along the western wall and across the northern section of the reservoir;
- Any filling of the reservoir should be accompanied by a monitoring program for the reservoir condition and stability;
- Any filling of the reservoir should be accompanied by a water management strategy for ensuring stormwater discharges from the reservoir meet existing guidelines;
- Filling of the reservoir to the top of the walls with a 5m setback from the concrete encased water conduit on the western wall and at the northern end of the reservoir would not have a significant adverse impact on the operational trunk infrastructure below the floor of the reservoir;
- The separation wall would be constructed on reinforced concrete or block wall with grouted dowels into the base of the reservoir;

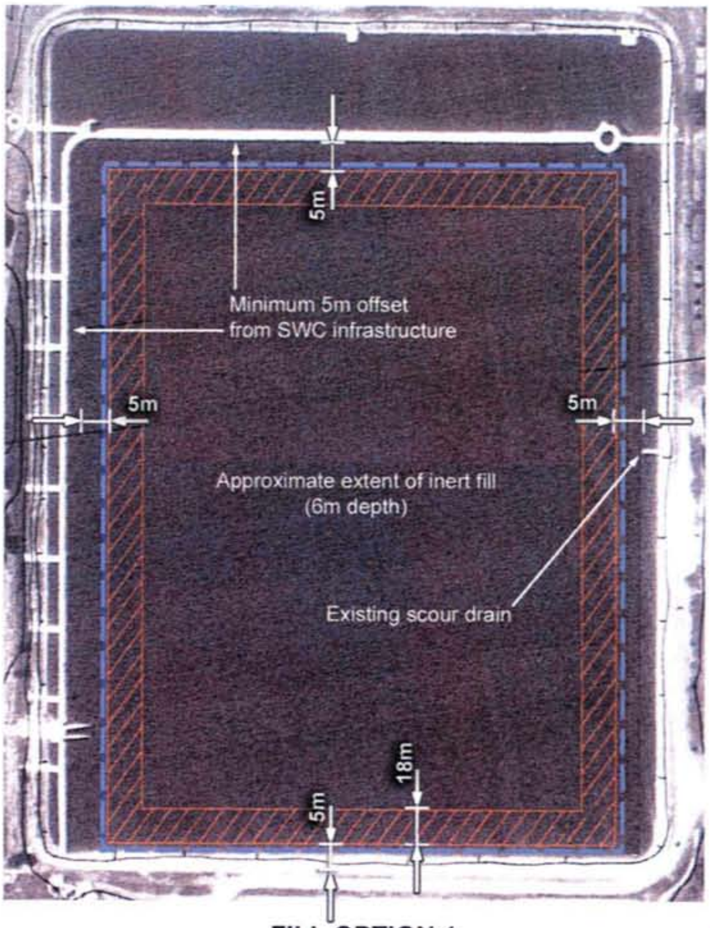
- the proposed location of the separation wall would be as shown in Figures 1 & 2 – the extent of the wall would vary to suit the filling extent; and
- the structural rational is explained in detail in this report.

Yours faithfully
PATTERSON BRITTON

Mark Tooker
Principal

APPENDIX A – PSM GEOTECHNICAL ASSESSMENT

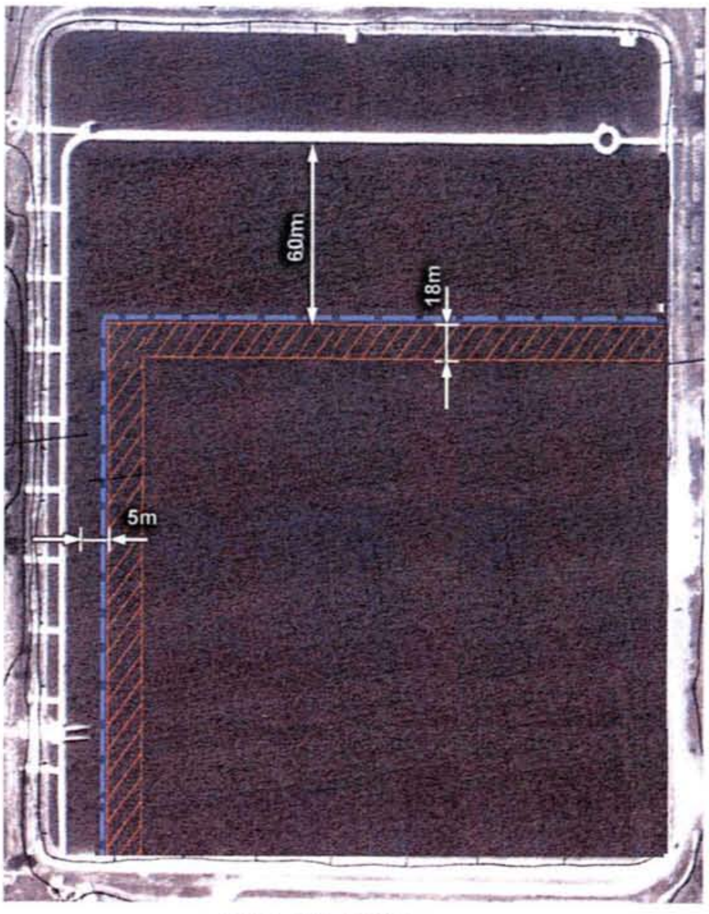
FIGURE 1



FILL OPTION 1

Batters around fill at 1 in 3

Wall /bunding to control surface run-off



FILL OPTION 2

NOTE:

Diagramatic
For discussion purposes only

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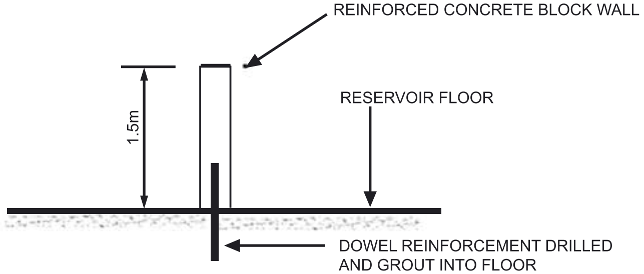
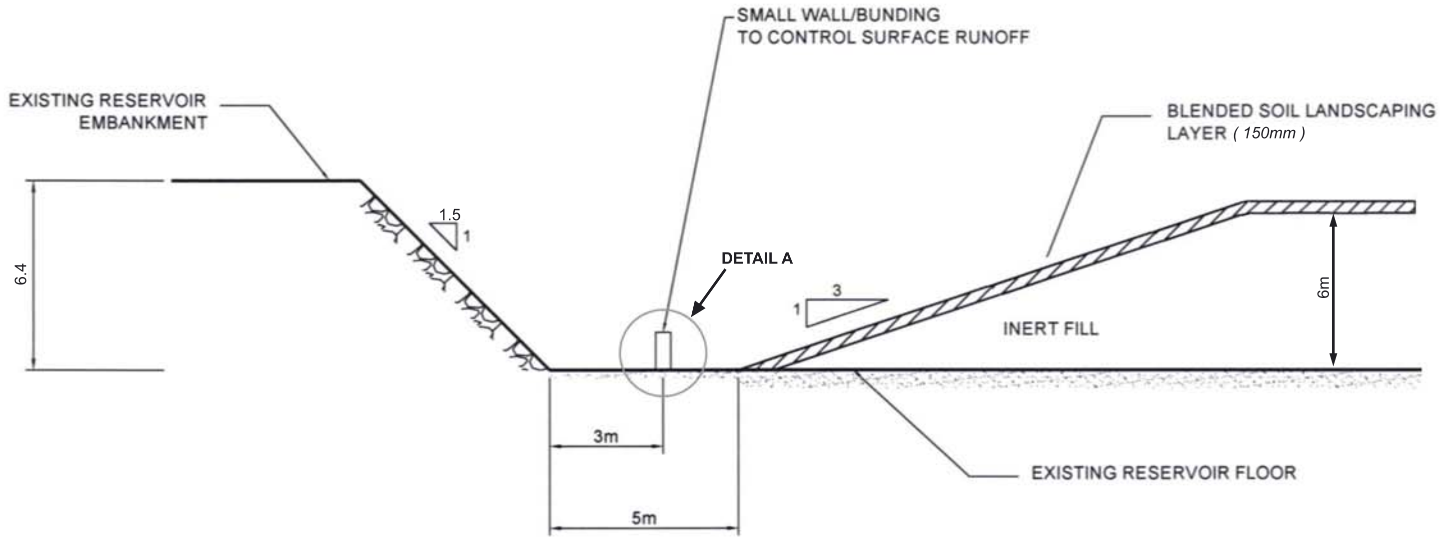
POTTS HILL
RESERVOIR 1 INERT FILL REPLACEMENT
OPTION 1 & 2

J6242/FIG1_IndicativeExtents.jpg

FIGURE 2



DETAIL A



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J6242/FIG2_IndicativeTypicalSection.jpg

POTTS HILL
RESERVOIR 1 INERT FILL PLACEMENT
INDICATIVE TYPICAL SECTION