07 November 2017

Manildra Group Pty Ltd c/o Cowman Stoddart
PO Box 738
Nowra NSW 2541
Attention: Stephen Richardson

Our ref: 2316208-495
Your ref: N186765

Dear Stephen,

Shoalhaven Starches Paper Mill
Shoalhaven River Bank Stability Assessment

1 Introduction

Manildra Group Pty Ltd (Manildra) was previously granted Project Approval (MP06_0228, dated 28 January 2009) by the Minister of Planning for the proposed Shoalhaven Starches Expansion project which encapsulated previous approvals for the general site.

In conjunction with their operations located at 160 Bolong Road, Bomaderry NSW, Manildra intends to utilise the former Australian Paper Mill site located at 340 Bolong Road, including:

- Use of the existing buildings on the site for the storage of finished product, as well as engineering plant;
- Use of existing storage tanks for the storage of syrups;
- Use of external areas on the site to lay down plant and materials that are to be used in the construction of approved projects at the existing factory site as well as temporary and overflow shipping container storage;
- Use of existing administrative buildings for office staff; and
- Use of workshop areas for maintenance purposes.

To proceed with the above proposed changes, Manildra intends to undertake modification of their application to the NSW Department of Planning and Environment (DPE) Project Approval for the Shoalhaven Starches Expansion Project.

This letter provides a summary of findings of our geotechnical assessment in relation to the proximity of the various structures proposed to the northern bank of Shoalhaven River and potential effects of the proposed modifications on the stability of the riverbank.

2 Project appreciation

The former Australian Paper Mill was acquired by Manildra. To further develop or use the site, a project approval was granted as part of the Shoalhaven Starches Expansion Project. Manildra is proposing changes to the original plan and the proposed changes are indicated by various coloured highlighted areas in Figure 1. To support the modification application, a riverbank stability assessment is required for the various existing structures and proposed storage areas positioned near the northern bank of the Shoalhaven River.

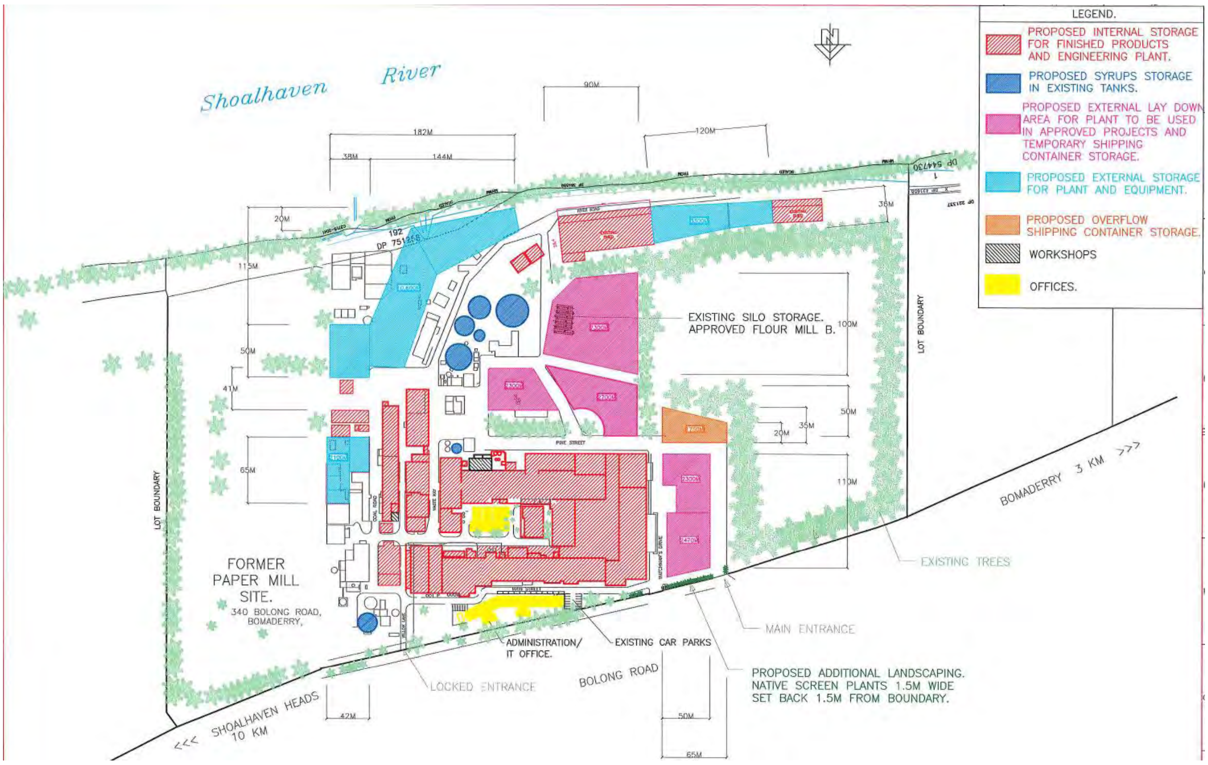

Figure 1. Proposed modifications to the Australian Paper Mill site (source: Manildra).

3 Scope of work

The following scope of work has been completed:

- Desktop study including a review of existing subsurface information from previous test holes in the vicinity of the proposed structures;
- Site visit by a principal geotechnical engineer to observe the existing surface conditions over the sites of the proposed storage within existing structures and external storage areas. The general surrounds including the condition of the riverbank were also observed;

- Numerical modelling and assessment of the effects of the proposed modifications on the riverbank stability taking into account both existing loads and additional loads applied by the proposed modification/s;
- Report our observations and advice in accordance with the objectives as outlined above.

4 Site observations

A site walkover for this assessment was undertaken by a GHD Principal Geotechnical Engineer on 19 October 2017. The walkover assessment was conducted with Manildra employees familiar with the site, Mr John Studdert and Mr John Bishop. Our site observations were primarily undertaken along the riverbank, the riparian area between the top of riverbank and the wire mesh fence, the open areas between the fence and the two existing warehouse buildings and other proposed external storage areas within close proximity to the riverbank.

Typically the riverbank is about 4m to 5m above the low tide level and the bank has been graded to about 1H:1V with some locally steeper areas near the toe and locally higher on the bank where erosion has occurred. The bank is also locally steeper at the eastern end of the development area where the bank geometry changes near a drainage outlet structure. The riverbank erosion is likely to be the result of long term tidal and wave effects as well as raised river levels during flood events. The toe of the bank is partially protected by large rocks positioned along the shoreline.

The ground surface at the top of the bank is gently sloping to near level to the fence with only a gentle fall towards the river. Beyond the fence, the surface remains near level with some slight undulations. Vegetation along the riverbank mainly comprise scattered medium size trees, thick grass and weed cover. Most of the trees were not showing any sign of distress. A few trees, however, have fallen into the river possibly due to previous erosion of the lower banks during raised river levels. Views of the observed site conditions including riverbank conditions and general condition of the proposed storage areas are shown in Photos 1 to 12.

Photo 1. View looking east along riverbank showing top of bank and batter slope down to river, with large rocks placed along shoreline of river in tidal zone. Note typical vegetation in riparian zone over riverbank and along top of bank.

Photo 2. View looking west along top of riverbank showing thick grass and weed growth along top of bank and established trees, fence and equipment storage.

Photo 3. View of riverbank looking east showing established trees and undergrowth along riverbank and top of bank.

Photo 4. View of steep section of riverbank near south-east corner of proposed storage area. Toe of bank is oversteepened in this area.

Photo 5. Typical shipping container within storage area with loads shown.

Photo 6. View looking west over open storage area with western storage shed in background. Shoalhaven River and riparian zone is located to left of photo.

Photo 7. View inside eastern storage shed nearest the riverbank showing stacked storage of materials.

Photo 8. View of western storage shed and outside storage looking west with riverbank to left of photo.

Photo 9. Open storage area in south-eastern part of site, with riverbank in background beyond tree line.

Photo 10. View of storage area near south-east corner of site with riverbank in background.

Photo 11. View of south-east corner of storage area looking south towards river, drainage outlet and location of steep section of riverbank.

Photo 12. View of storage area and existing paper mill structures looking north, including liquid storage tanks.

5 Local geology in the vicinity of the site

Reference to the 1:100,000 Kiama Soil Landscape Series Sheet (9028, First Edition), produced by the Department of Conservation and Land Management NSW (1993) indicates that the site is located on Shoalhaven Soils. These soils are described as moderately deep prairie soils on levees, red earths and yellow and red podzolic soils on terraces and alluvial soils and gleyed podzolic soils on the floodplains.

Reference to the 1:250,000 Wollongong Geological Series Sheet (S1 56-9, First Edition) prepared by the NSW Department of Mines (1952) indicates the site is likely to be underlain by Quaternary alluvium, gravel, swamp deposits and sand dunes.

6 Inferred subsurface condition

The general subsurface conditions and the inferred geotechnical model used in this assessment have been based on boreholes CBH505 and CBH506 (ref: Coffey report GEOTWOLL02584AW-AD, dated 29 January 2016) located approximately 300m to the west of the closest proposed internal storage. Figure 2 shows the location of boreholes CBH505 and CBH506 relative to the Paper Mill site. Test pits were also excavated as part of a previous Coffey investigation along the approximate alignment of the former railway through the Paper Mill. These test pits generally encountered local shallow fill and topsoil overlying stiff alluvial clays.

Figure 2. Location of boreholes CBH505 and CBH506 relative to the Paper Mill site (source: Google Earth Pro, captured image on 2 November 2017).

The subsurface conditions encountered in these boreholes (CBH505 and CBH506) are summarised in Table 1 below:

Table 1 Summary of subsurface conditions encountered in boreholes CBH505 and CBH506 (area to the east of Boweld).

Unit	Material / Origin	Depth range to top of unit (1) (m)	Thickness of unit (1) (m)	Description
1a	Fill	0.0	0.05	Silty SAND: medium dense, fine to coarse grained, dark brown, trace of fine to medium grained sub-angular gravel, trace of organics (roots).
2a-1	Alluvial Clay	0.05	2.25 to 2.95	Silty CLAY: firm to stiff, medium to high plasticity, brown to dark brown, brown mottled red/ orange, trace of fine sub-angular to sub-rounded gravel, trace of fine grained sand, trace of organics (roots).

Unit	Material / Origin	Depth range to top of unit [1] (m)	Thickness of unit [1] (m)	Description
2b-1	Alluvial Sand	3.0 (only in CBH505)	3.0	Silty SAND: medium dense, fine grained, grey mottled pale brown, with some medium to high plasticity clay, trace of organics (rootlets), thin bands of high plasticity clay, grey, approximately 50mm spacing.
2a-2	Alluvial Clay	2.3 (only in CBH506)	2.2	Sandy CLAY: firm to stiff, medium to high plasticity, pale brown, grey mottled red brown, fine grained sand, trace of silt.
2a-1 **2a-2**	Alluvial Clay	4.5 to 6.0	11.2 to 13.5	Silty CLAY: firm to hard, high plasticity, grey mottled pale brown to brown/ red, trace of fine grained sand. Sandy CLAY (only in CBH505 from 15.5m to 17.2m depth): stiff to very stiff, high plasticity, grey, fine grained sand, trace of silt, trace of organics (rootlets).
2b-2	Alluvial Sand	17.2 to 18.0	4.0 to 4.3	Silty SAND: loose to dense, fine to medium grained, grey to grey brown / grey mottled pale brown, trace of medium plasticity clay, trace of fine grained sub-angular to angular gravel.
2a-3	Alluvial Clay	21.5 to 22.0	Not proven (end of hole at 26.5m)	Silty CLAY/ Clayey SILT: very soft to soft, high plasticity, high liquid limit, grey mottled brown, dark grey, trace of carbon.

Note 1: The depths and thicknesses of the various units are based on a limited number of boreholes and may not represent the maximum or minimum values across the site or all materials beneath the site.

As per the Coffey report, groundwater inflow was encountered at 4.5m depth below existing ground surface level at the time of investigation for both boreholes CBH505 and CBH506, which is close to water level in the river.

7 Riverbank stability assessment

7.1 General

The northern riverbank is partially protected from erosion by vegetation within a fenced riparian corridor, including the presence of many established trees. Occasionally, these trees have fallen when the bank has been locally steepened by erosion and undercutting of the toe, together with high winds.

Based on both our past and recent investigations along the Shoalhaven River bank in the vicinity of the Manildra property, a number of riverbank failures have occurred, with the majority of these attributed to a progressive failure mechanism caused by a combination of river scour and internal erosion during a rapid drawdown situation following flooding (or high flows) in the river in recent years.

7.2 Assumed loading

Based on the brief, the proposed use of the existing buildings on the paper mill site will include storage of finished product as well as engineering plant. The proposed use of external areas on the site will include lay down plant and materials that are to be used in the construction of approved projects at the existing factory site, as well as temporary and overflow shipping container storage.

Based on our site observations and discussion with Manildra, we have assumed the following loading scenarios:

- Existing buildings will likely be used for storage of:
  - bags of starch, approximately 1 tonne per bag, stacked to various levels;
  - storage tanks for the storage of syrups;
  - engineering plant and equipment ; and
  - materials, plant and equipment will be placed on existing concrete slabs.
- External areas will likely be used for:
  - storage of shipping containers, maximum 30.5 tonne each when fully loaded and one level only, ie. not stacked;
  - lay down area for various plant and equipment (maximum weight assumed as 50 tonnes), with many having relatively lighter materials; and
  - the shipping storage containers, machinery, plant and materials are placed in a broader area with often some space between (generally >2m in most instances).

Based on the above scenarios, the maximum loading to be distributed over the existing foundation/floor areas within the existing buildings and external areas is estimated to be 25 kPa.

7.3 Design water levels

The groundwater level (GWL) in the boreholes as reported in the Coffey report ranged from RL1.7m to RL1.8m. Information provided by Manildra indicates that the tide levels in the Shoalhaven River generally range from about RL-0.4m to RL+0.6m. During the rain event and flooding of August 2015, the river level rose to within about 1m of the top of bank or to about RL +3.5m. Minor, moderate, and major flood levels recorded at Nowra, as provided by the Australian Bureau of Meteorology, are RL+2m, RL+3m and RL+4m, respectively.

The critical case for instability of the riverbank is expected to be the rapid drawdown case, when the river level recedes to the low tide level following a moderate or major flood event. During a flood event, the groundwater level on land may also rise, and then fall as the water level in the river recedes. Based on the above information, we have adopted the following design water levels for the rapid drawdown case following a flood event:

- Temporary groundwater level at the landside (within riverbank) = RL+3m to RL +4m; and
- Low tide level in the river = RL-1m.

7.4 Geotechnical parameters

Based on the field investigation results, the subsurface profile and estimated geotechnical parameters shown in Table 2 were adopted for the assessment.

Table 2. Estimated geotechnical parameters adopted for geotechnical assessments.

Unit	Description	γ (kN/m^3)	S_u (kPa)	c' (kPa)	ϕ' (deg.)
1a	Medium dense silty sand/ sandy gravel (above GWL)	20	-	0	30
2a-1	Firm to hard silty clay	19	30 to 150	2 to 10	25 to 28
2a-2	Firm to very stiff sandy clay	20	45	5	25
2a-3	Very soft to soft silty clay	16	15	0	25
2b-1	Medium dense silty sand	19	-	0	28
2b-2	Loose to dense silty sand	20	-	0	30
5	Slip debris	17	10	0	20

Legend:

γ = bulk unit weight

S_u = undrained shear strength

c' = drained cohesion

ϕ' = drained friction angle

7.5 Assessed factors of safety

The slope stability analysis has been conducted using Slope/W 2012 and adopting the Morgenstern – Price method. The minimum acceptable FoS against slope instability is set as follows:

- Short term FoS ≥ 1.3;
- Long term FoS ≥ 1.5;
- Rapid drawdown (assessed drawdown piezometric level with drained condition) FoS ≥ 1.2; and
- Temporary earthquake (seismic) with drained condition FoS ≥ 1.2.

Under seismic condition, riverbank stability has been checked for a seismic hazard corresponding to an annual probability of exceedance of 1 in 500 according to AS1170.4, which corresponds to an acceleration coefficient of 0.1 for this site. As such, the pseudo-static horizontal acceleration coefficient for the design of flexible structures will be very low or close to zero. For the purpose of seismic risk assessment for this site, we have performed seismic stability analysis with a horizontal acceleration coefficient of 0.05 (half of the full coefficient of 0.1) to check that the computed FoS is greater than 1.2.

8 Effects on the stability of Shoalhaven River bank due to modifications of the Paper Mill Site

For this assessment we have considered the proximity of the proposed storage areas to the northern bank of Shoalhaven River, the current profile of the bank and the surface conditions between the bank and the proposed modifications to the relevant areas of the Paper Mill site. We have carried out our assessment on the following sections:

- Section 1: closest existing building proposed for storage assumed to be 16m away from the riverbank crest and with a bank slope of 45 degrees measured from the horizontal; and
- Section 2: proposed laydown external area assumed to be 11.5m away at the closest point to the riverbank crest and with a bank slope of 70 degrees measured from the horizontal.

The results of the completed analyses for the representative sections are presented as Figures 2 to 9 and the results are summarised in Table 3. Based on short term analysis, the FoS are shown to be above the acceptable level (Figures 2 and 6).

In the long term, however, wherein the soil parameters become drained due to the potential washing out of clay particles within the soil matrix, rapid drawdown and seismic conditions will likely lead to slope failure extending between 2m and 8m from the crest of the bank for Section 1 (Figures 3 to 5). For Section 2, the slope failure will likely extend between 4m to 8m (Figures 7 to 9). In both sections, however, the surcharge of 25kPa has no impact on the likely failure mainly due to its position away from the riverbank crest.

Table 3. Summary of assessed cases and resulting Factors of Safety.

Section	Figure Reference	Case Description	FoS	Remarks
1	Figure 2	Short term scenario (undrained condition)	> 1.3	
	Figure 3	Long term scenario (drained condition)	< 1.0	Failure likely to occur at the riverbank extending 2m to 8m back from the crest. Load has no impact on the likely failure.
	Figure 4	Rapid drawdown after major flooding (drained condition	< 1.0	
	Figure 5	Seismic (drained condition)	< 1.0	
2	Figure 6	Short term scenario (undrained condition)	> 1.3	
	Figure 7	Long term scenario (drained condition)	< 1.0	Failure likely to occur at the riverbank extending 4m to 8m back from the crest. Load has no impact on the likely failure.
	Figure 8	Rapid drawdown after major flooding (drained condition	< 1.0	
	Figure 9	Seismic (drained condition)	< 1.0	

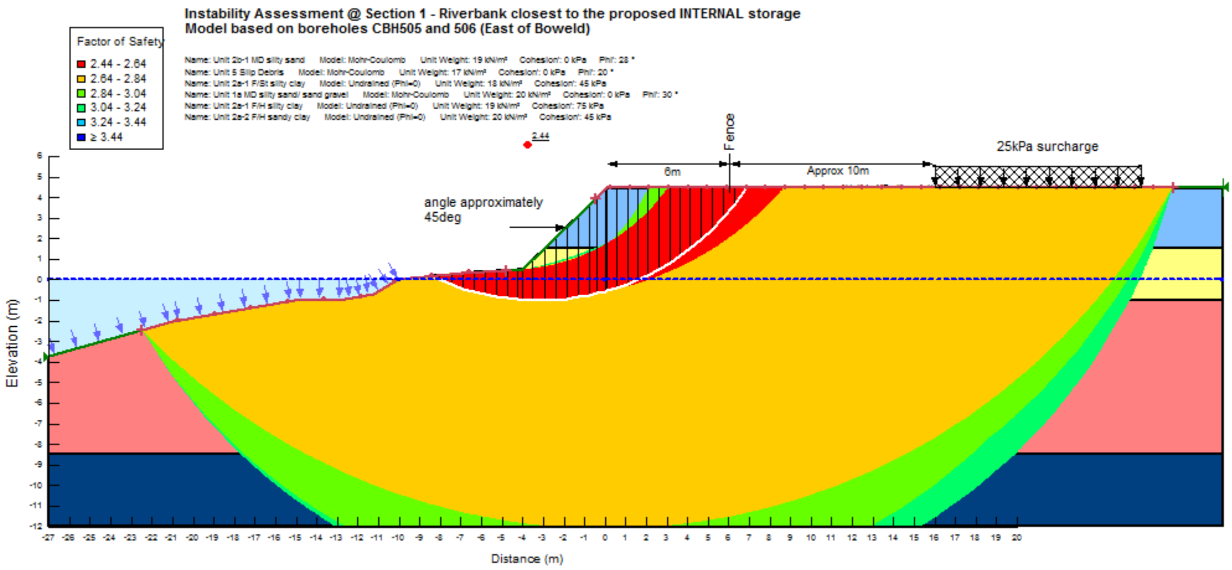

Figure 3. **Short term – undrained condition with surcharge located approx. 16m away from the crest**

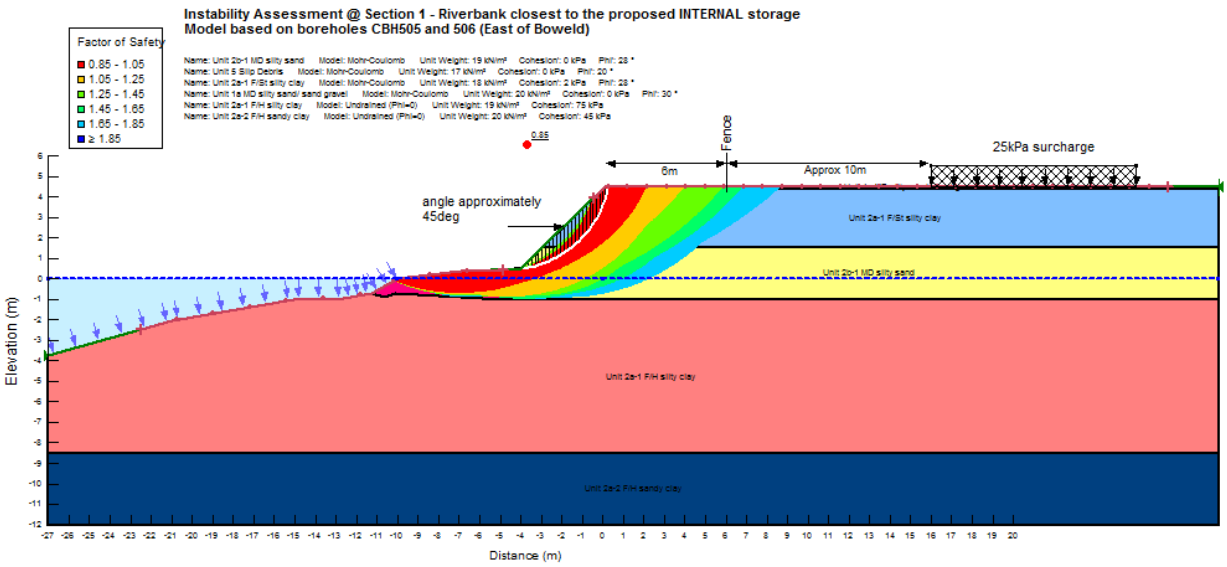

Figure 4. **Long term – drained condition with surcharge located approx. 16m away from the crest**

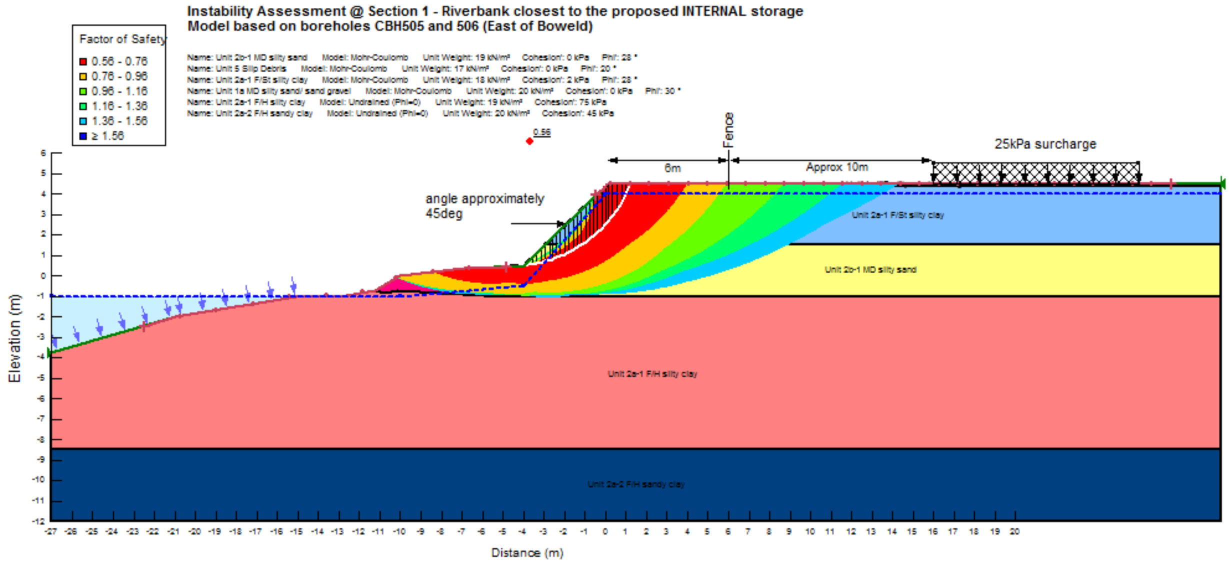

Figure 5. **Rapid drawdown post flooding – drained condition with surcharge located approx. 16m away from the crest**

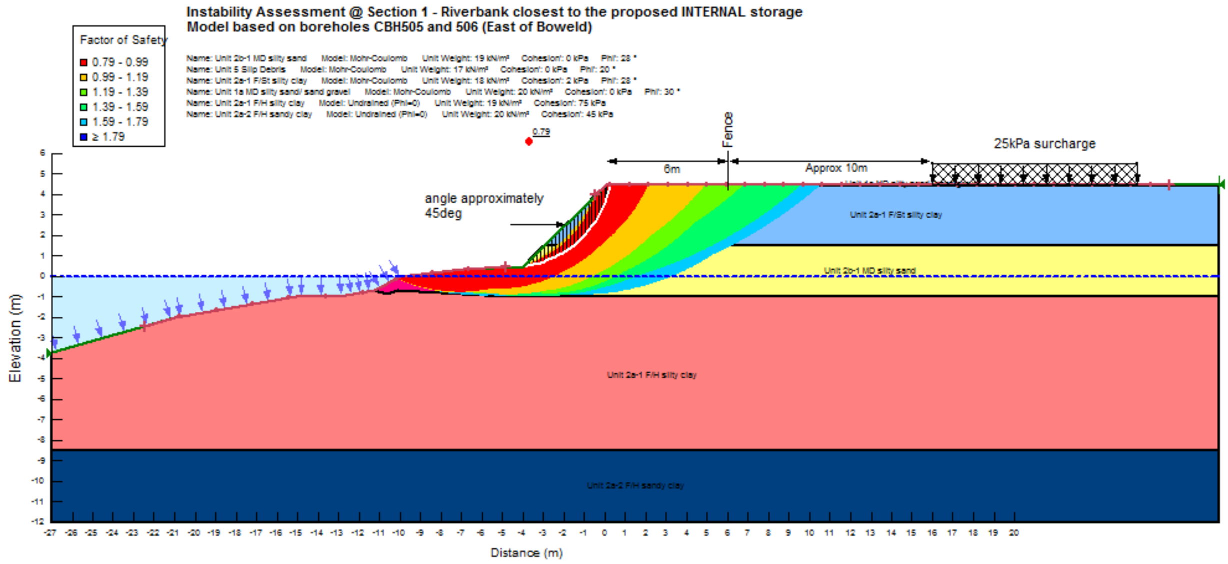

Figure 6. **Seismic case – drained condition with surcharge located approx. 16m away from the crest**

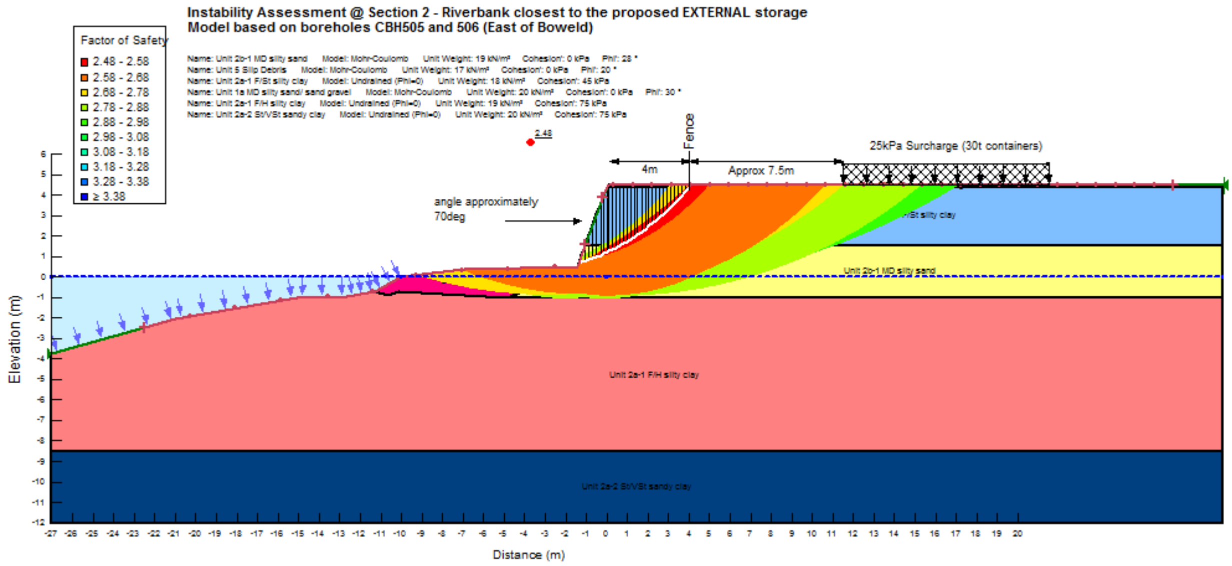

Figure 7. **Short term – undrained condition with proposed surcharge located approx. 11.5 away from the crest**

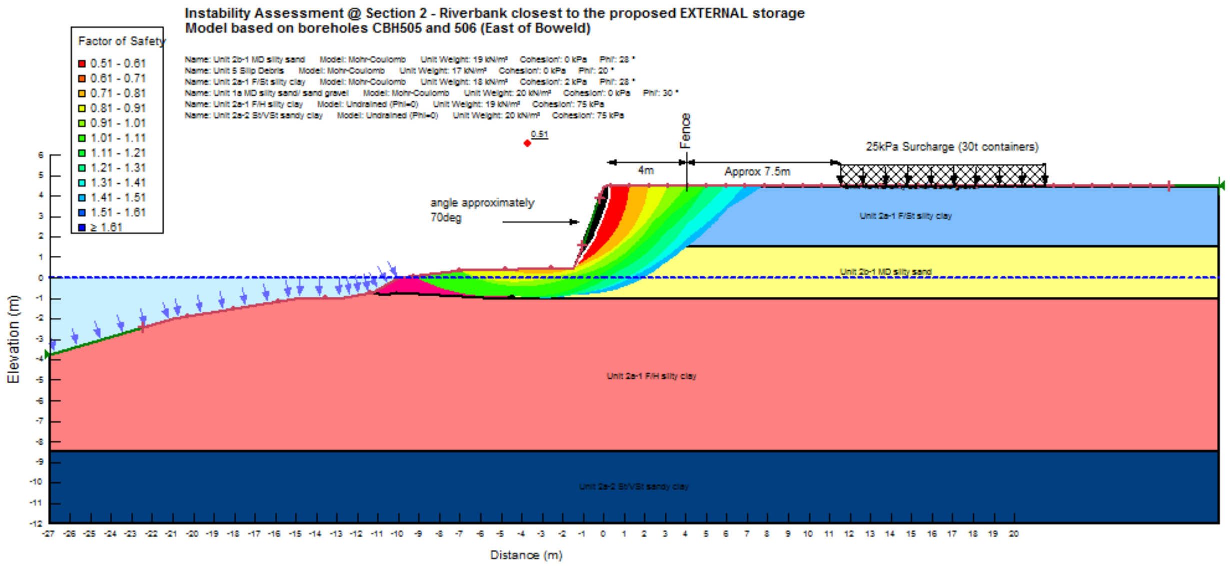

Figure 8. **Long term – drained condition with proposed surcharge located approx. 11.5 away from the crest**

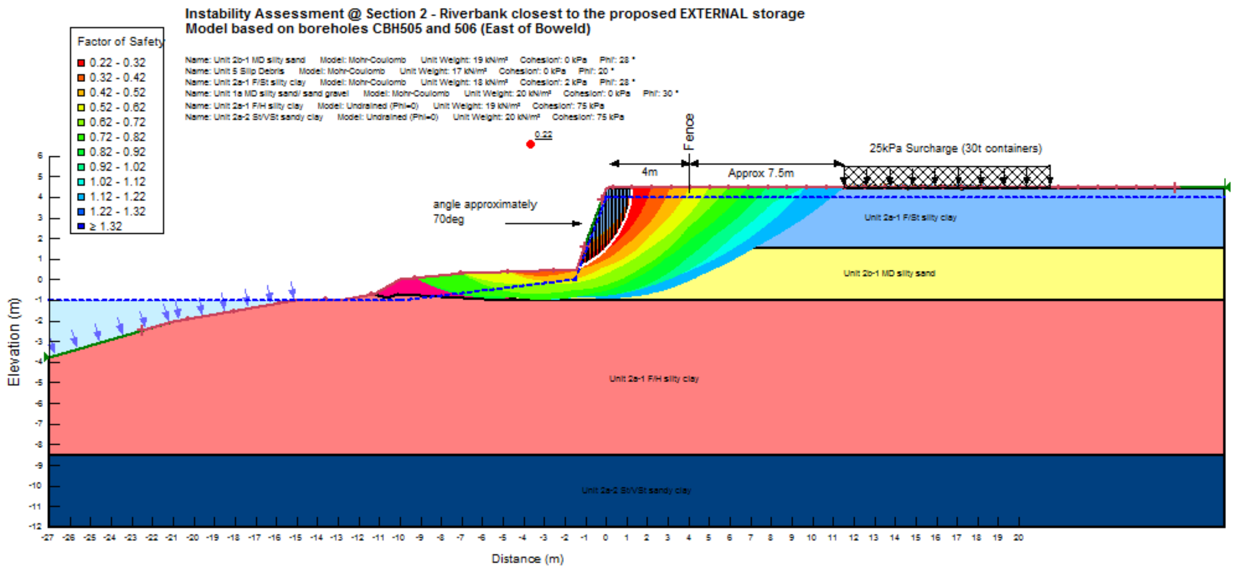

Figure 9. Rapid drawdown post flooding – drained condition with proposed surcharge located approx. 11.5 away from the crest

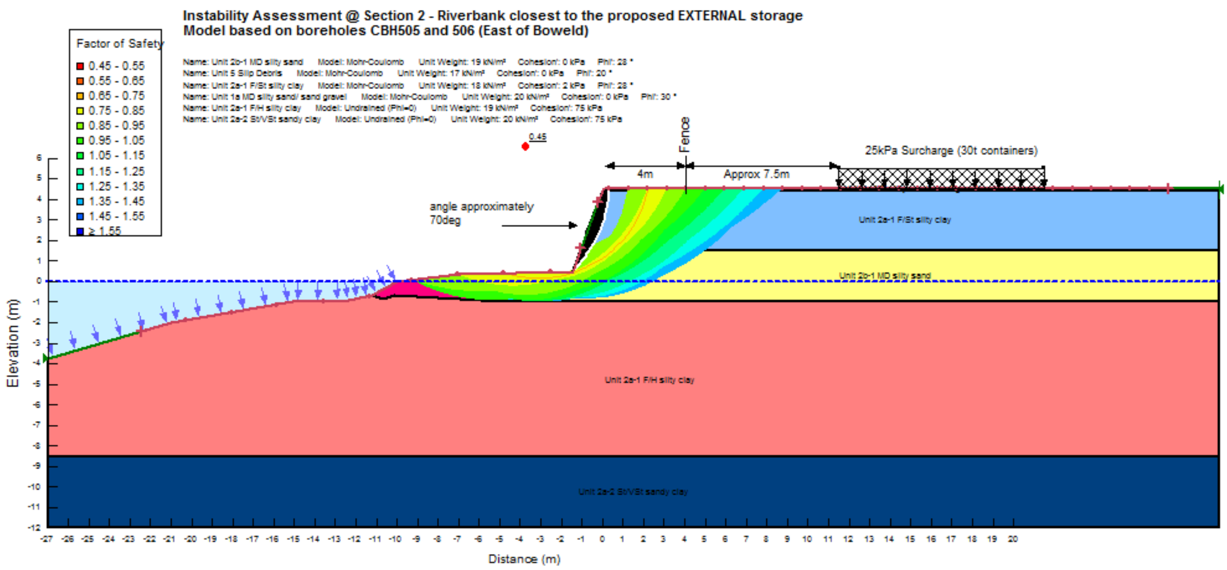

Figure 10. Long term – drained condition with proposed surcharge located approx. 11.5 away from the crest

9 Conclusion and limitations

The results of the stability analyses on the representative assessed Sections 1 and 2 indicate that the general FoS is above acceptable level considering short term cases with undrained condition. For a long term scenario where drained conditions may likely prevail, and in combination of rapid drawdown post flooding and seismic events, it has been assessed that failure of the riverbank could occur. Considering that recent erosion and slumping of part of the northern riverbank in some areas along the river, we recommend maintaining a clear distance of 11.5m away from the riverbank crest at all locations for long term storage. Short term lightly loaded storage (eg, empty crates, pipes, small plant and equipment) within the clear distance of 11.5m and to the north of the fenceline is acceptable.

Based on our site observations, our knowledge of the general subsurface conditions and the above stability analysis, we conclude that the proposed storage and redevelopment areas are unlikely to influence the stability of the riverbank, based on the assumed storage loads and setbacks from the riverbank not exceeding those used in the above analysis. In some cases the southern limit of the storage area may need to be offset to the north of the existing fenceline to maintain the required setback of 11.5m from crest of bank. This will mainly affect the south-east corner of the external storage area (refer Photo 11). We recommend the shipping containers within this area be relocated to positions away from the assessed clear distance from the crest of the riverbank.

In addition to the above conclusions and recommendations, we also recommend that existing vegetation over the riverbank be maintained and managed, and that the rock protection of the toe of the bank be repaired if damaged by flooding.

The above report summarising our assessment and advice is based on our visual assessment of the area and review of available information. GHD should be advised of any future observed significant changes to the ground surface conditions along the northern banks of Shoalhaven River.

We draw your attention to the document following the report entitled 'General Notes" which should be read in conjunction with this report.

Yours sincerely
GHD Pty Ltd

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GENERAL NOTES

GHD GEOTECHNICS
Specialist Services in Geotechnical Engineering, Geology, Field/Laboratory Testing and Hydrogeology
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The report contains the results of a geotechnical investigation or study conducted for a specific purpose and client. The results may not be used or relied on by other parties, or used for other purposes, as they may contain neither adequate nor appropriate information. In particular, the investigation does not cover contamination issues unless specifically required to do so by the client.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the report are excluded unless they are expressly stated to apply in the report.

TEST HOLE LOGGING

The information on the test hole logs (boreholes, test pits, exposures etc.) is based on a visual and tactile assessment, except at the discrete locations where test information is available (field and/or laboratory results). The test hole logs include both factual data and inferred information. Moreover, the location of test holes should be considered approximate, unless noted otherwise (refer report). Reference should also be made to the relevant standard sheets for the explanation of logging procedures (Soil and Rock Descriptions, Core Log Sheet Notes etc.).

GROUNDWATER

Unless otherwise indicated, the water levels presented on the test hole logs are the levels of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater level may differ from this recorded level depending on material permeabilities (i.e. depending on response time of the measuring instrument). Further, variations of this level could occur with time due to such effects as seasonal, environmental and tidal fluctuations or construction activities. Confirmation of groundwater levels, phreatic surfaces or piezometric pressures can only be made by appropriate instrumentation techniques and monitoring programmes.

INTERPRETATION OF RESULTS

The discussion or recommendations contained within this report normally are based on a site evaluation from discrete test hole data, often with only approximate locations (e.g. GPS). Generalised, idealised or inferred subsurface conditions (including any geotechnical cross-sections) have been assumed or prepared by interpolation and/or extrapolation of these data. As such these conditions are an interpretation and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in ground conditions do occur in the natural environment, particularly between discrete test hole locations or available observation sites. Additionally, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site. Furthermore, conditions may change at the site from those encountered at the time of the geotechnical investigation through construction activities and constantly changing natural processes.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed or reported should be referred to this firm for appropriate assessment and comment.

GEOTECHNICAL VERIFICATION

Verification of the geotechnical assumptions and/or model is an integral part of the design process - investigation, construction verification, and performance monitoring. Variability is a feature of the natural environment and, in many instances, verification of soil or rock quality, or foundation levels, is required. There may be a requirement to extend foundation depths, to modify a foundation system and/or to conduct monitoring as a result of this natural variability. Allowance for verification by appropriate geotechnical personnel must be recognised and programmed for construction.

FOUNDATIONS

Where referred to in the report, the soil or rock quality, or the recommended depth of any foundation (piles, caissons, footings etc.) is an engineering estimate. The estimate is influenced, and perhaps limited, by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The material quality and/or foundation depth remains, however, an <u>estimate</u> and therefore liable to variation. Foundation drawings, designs and specifications should provide for variations in the final depth, depending upon the ground conditions at each point of support, and allow for geotechnical verification.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in our geotechnical report, or other technical information, for the inclusion in contract documents or engineering specification of the subject development, such reproductions must include at least all of the relevant test hole and test data, together with the appropriate Standard Description sheets and remarks made in the written report of a factual or descriptive nature.

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Ref: DS5.5.1 Issue 1.8 Date: 5/10/2012