APPENDIX B3:G

Geotechnical settlement analyses

DATE October 2013 **DOCUMENT No.** 137632097-013-R-Rev0

APPENDIX G

SETTLEMENT CALCULATIONS, SUNSHINE COAST AIRPORT

G1.0 Introduction

Settlement at this site may occur due to consolidation of the underlying soft/very soft clay following loading induced by filling for the new runway embankment. Such settlement could occur as a combination of:

- primary (or relatively short term) settlement; plus
- secondary (or long term) settlement over the design life of the project/development.

Additional immediate settlement, although of a lesser magnitude, may also occur within very loose to medium dense sands.

G2.0 Primary settlement

Primary settlement in clays may be calculated from the coefficient of volume compressibility (m_v), which can be estimated from:

- empirical relationships with the undrained cohesion (c_u) of the clay, and
- laboratory testing (oedometer consolidation test).

Two undisturbed U50 tube samples of the soft clay from boreholes BH5/12 and BH7/12 were forwarded to Golder's NATA accredited geotechnical testing laboratory for consolidation (oedometer) testing. The results of that testing are attached, and indicate that the clay from the samples tested are 'normally consolidated' (i.e. any load placed on this material will result in primary settlement). The consolidation tests also indicate an m_v of 2 x 10^{-3} to 3.5 x 10^{-3} kPa^{-1}, across the expected range of loads.

Consolidation and CPT testing from our 2010 investigation correlates with the findings of the current investigation.

Assuming all fill (including pavement) loads exert influence on the underlying soft/very soft clay layer, potential primary consolidation settlements are shown in Figure G1 for varying soft/very soft clay layer thickness and varying fill heights.

55 Kingsford Smith Parade, Maroochydore, Queensland 4558, Australia (PO Box 5569, Maroochydore BC QLD 4558)
Tel: +61 7 5475 5900 Fax: +61 7 5475 5901 www.golder.com

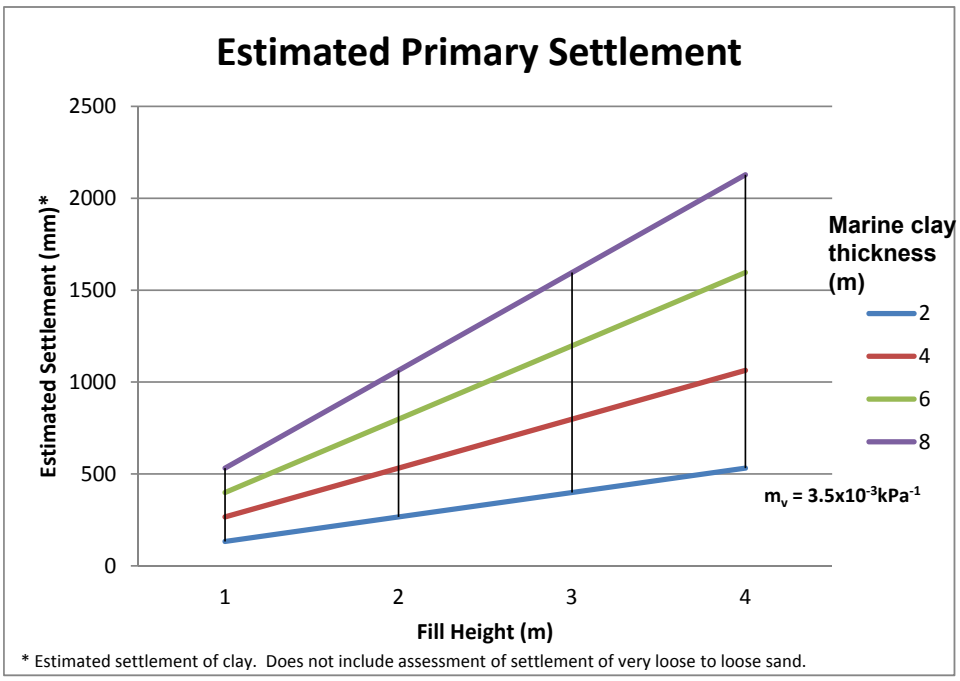

Figure G1: Estimated primary settlement under fill loads.

G2.1 Time for completion of primary settlement

The time for completion of primary settlement is calculated using the coefficient of vertical consolidation (c_v), which can be obtained from dissipation tests (as part of CPT testing) and laboratory consolidation testing.

Consolidation testing on the U50 tube samples from boreholes BH7/12 and BH5/12 indicate c_v values of 0.13 m^2/year to 1.45 m^2/year.

The results of the dissipation test carried out at CPT11 during our 2010 investigation, indicate a c_v value greater than 30 m^2/year (which indicates rapid consolidation). Laboratory consolidation testing from our 2010 investigation indicated a similar order of magnitude for the 1 m deep sample from BH11A, and a value of about 0.5 m^2/year for the 3 m deep sample (indicates slower consolidation).

Typical c_v values for similar clays elsewhere on the Sunshine Coast are in the order of 2.5 m^2/year to 5 m^2/year.

Using a value of 1.35 m^2/year, the estimated time for 90% completion of primary settlement (t_{90}) for the profile at BH7/12 is approximately 10 years, and less at other locations, as shown in Table G1.

Table G1: Estimated time for completion of primary settlement

Very soft/soft clay thickness (m)	2	4	6	8
t_{90} (years)	0.7	2.5	5.5	10

G3.0 Secondary settlement

The secondary settlement (or long term creep) is estimated based on the following:

- The thickness of the compressible soil layer.
- Project design life (taken as 100 years for this project).

- Coefficient of secondary consolidation (c_α); estimated to be 0.015 (or 1.5%) from the laboratory testing.
- Time for completion of primary settlement (t_{90}).

The estimated secondary settlement for the subsurface profile from BH7/12 is about 125 mm to 150 mm. Secondary settlements for other thicknesses of very soft/soft clay are presented in Table G2.

Table G2: Estimated secondary settlement

Very soft/soft clay thickness (m)	2	4	6	8
Secondary settlement (mm)	50 - 75	90 - 110	100 - 125	125 - 150

The above values assume two way drainage of pore water from the soft/very soft clay layer.

G4.0 Statistical assessment

A statistical assessment of the settlement estimates has been undertaken to allow for ranges of parameters to be used in the settlement estimates.

The parameter ranges used reflect the uncertainty associated with some of the parameters on which the settlement estimates are based.

The results of the statistical assessment are provided in Table G3. Plots of the statistical assessment output are shown on Figure G2 to Plate G5.

Table G3: Results of statistical assessment of settlement.

	Minimum	**Maximum**	**Mean**	**Standard Deviation**	**No. of Values**
Input Parameters:					
Clay thickness (m)	8	10	9	577.38	10000
Fill depth (m)	2	3.5	4.5	0.433	10000
Fill density (t/m^3)	1.8	2.06	1.93	0.0751	10000
mv (m^2/kN)	0.0025	0.0045	0.0035	0.000577	10000
c_v (m^2/yr)	0.216	2.5	1.35	0.664	10000
c_α	0.01	0.02	0.015	0.00289	10000
Output Results:					
Primary settlement (mm)	781	3071	1640	396.73	10000
t_{90} (year)	5.5	103.9	19.0	15.67	10000
Secondary settlement (mm)	0	213	111	43.28	10000
Total settlement (mm)	844	3191	1751	400.17	10000

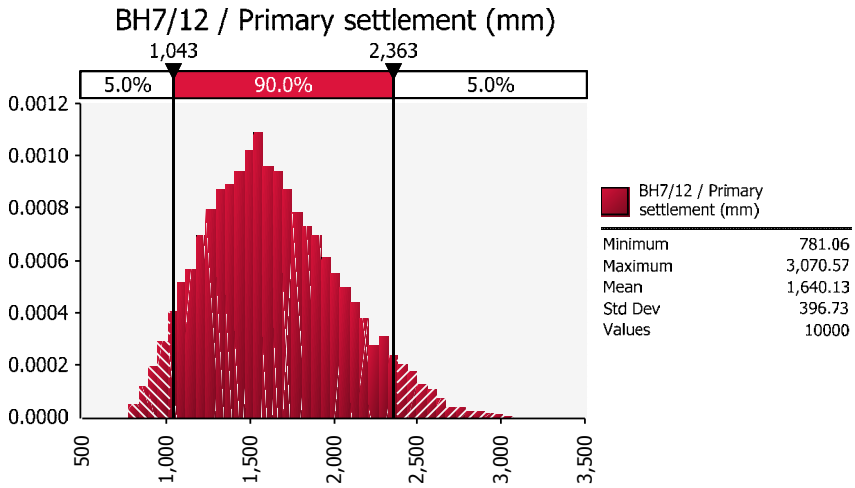

Figure G2: Results of statistical assessment of primary settlement.

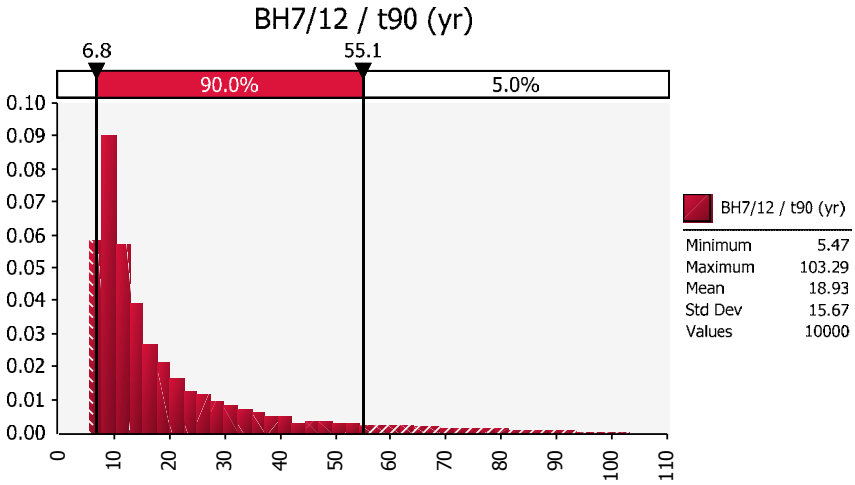

Figure G3: Results of statistical assessment of t_{90}.

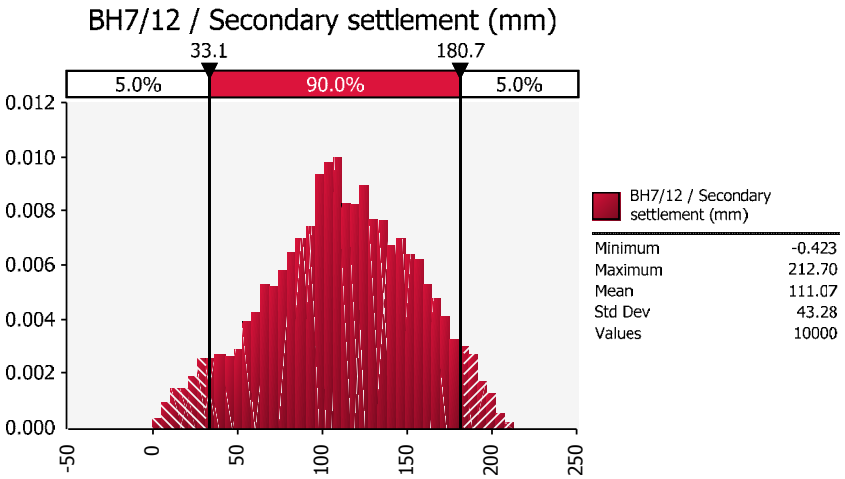

Figure G4: Results of statistical assessment of secondary settlement.

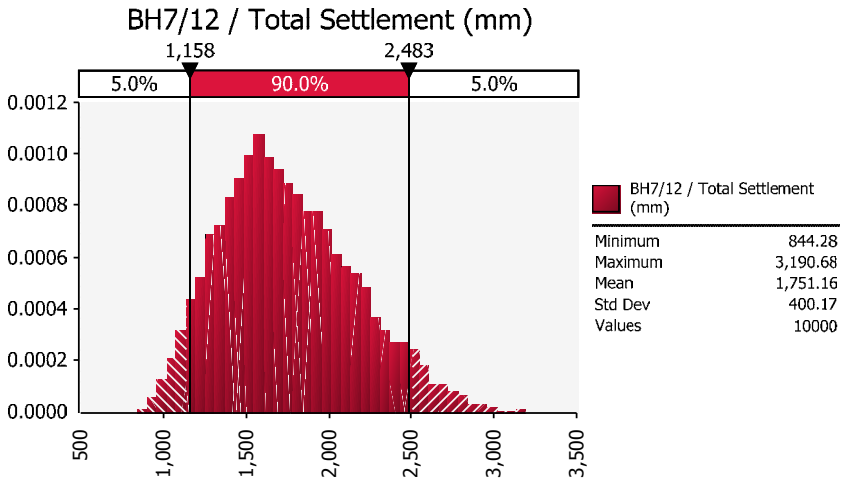

Figure G5: Results of statistical assessment of total settlement.

j:\2012\enviro\127683017 sc airport\correspondence out\combined eis chapter report\final\appendices\geotech\appendix g -settlement.docx