29. Noted. Given the analyses were for the preliminary stage and the exact details of the liner had not been established, the liner was not included in the slope stability analyses. We have revised the analyses by including the liner as a region with lower strength parameters. Based on discussions with the landfill engineer, we have adopted the following lower bound parameters for double textured HDPE liner to be incorporated into the liner:

- Friction angle range of 16 degrees to 18 degrees for a double textured HDPE liner. This parameter is mainly based on GRI Report #30 2005.
- Unit weight of 17 kN/m^3

The revised analyses for both Sections 1 and 2 based on the lower bound friction angle of 16 degrees for the liner indicate the factors of safety are still satisfactory under the static case and seismically induced displacements are small (estimated as 15mm maximum based on methodologies by Ambraseys &Srbulov (1994), Ambraseys & Menu (1988) and Jibson (2007), with possibly up to 30mm (i.e. 2 times) based on the yield acceleration ~0.17g). Please find the analyses outputs attached (refer PDF titled 'Updated Analyses Outputs – Response to #29').

The GIR will be updated based on the revised analyses outputs and results. Based on discussions with the landfill engineer, we understand that double textured HDPE will be specified for the liner.

30. The indicative alignments of the cross sections are shown on the concept design drawings in Appendix B – refer Drawing C206. These have been further annotated in the PDF titled 'Response to Item #30').

The critical cross sections were selected in the 'east-west' and 'north-south' directions of the proposed landfill. We acknowledge the sections were not cut perpendicular to the contour lines. However, we manually modified the landfill batters to model the steepest angle of 1(V): 4(H). The level of the crest of the landfill was also manually adjusted to RL36m as the final level of the landfill. The analyses are therefore considered to be representative of the steepest sections of the batters.

All temporary slopes are considered to be 1(V): 4(H) max and therefore expected to be stable.

31. The site investigations did not identify evidence of any faults across the site.

32. For the purpose of preliminary analyses, we have adopted moderately conservative values for the *in-situ* soils and rocks. The slope stability analyses indicated the critical slips are contained within the refuse and the liner (refer item #29) as the parameters for the refuse are lower than the in-situ soils and rock.

We have carried out a sensitivity analysis for **Section 1** using the lower bound parameters for the *in-situ* soils and rock as specified in the GIR. Please refer to the analysis outputs attached (refer PDF titled 'Updated Analyses Outputs – Response to #32). The analyses indicate the critical slips are still constrained to the landfill refuse/liner and therefore not sensitive to lower in-situ soil and rock parameters.

The analyses for Section 2 (refer response to Item #29) also consider lower bound parameters for the refuse. We have adopted the lower bound friction angle of 16 degrees for the double-textured HDPE in all the analyses.

33. Noted. As you are aware, there are no specific standard currently in NZ to assess design earthquakes for landfill. We had initially considered the landfill to be an IL2 facility but acknowledge

that it can fall under the IL3 criteria. We have therefore revised the analyses based on IL3 seismic loads to assess the impacts on the analyses, mainly the slope stability and liquefaction assessments. The revised PGA under the DCLS/ULS case is calculated as 0.29g (in comparison with 0.23g for IL2).

The findings based on the revised analyses indicate the following:

- The seismically induced displacements at the landfill expansion location are still small (typically < 30mm) - refer to the Slope/W outputs in response to Item #29.
- Liquefaction of an approximately 0.5m thick layer of alluvial deposits is anticipated at depths ranging between 4.0m and 4.5m bgl. The seismically induced displacements affecting the existing landfill are expected to range between 60mm and 330mm (and 150mm on average) based on the three adopted methodologies (refer to response to Item #36).

Based on discussions with the CDC, the facility is not considered to be a post disaster critical site as there are two other landfills in general vicinity of Balclutha. We will revise the GIR based on IL3.

34. Bedrock was encountered at shallow depths across the majority of landfill, with the exception of the western section, where thicker alluvial deposits were encountered. Therefore, we have separated the site into Site Subsoil Class C for the western section and B for the remainder of the site.

We have now assessed the seismically induced displacements based on the PGA of 0.29g associated with site subsoil class C (and IL3) and the results indicate the displacements are still small (<30mm). The liquefaction triggering assessments have also been based on the PGA of 0.29g for site subsoil class C.

35. We had not assessed the impact of the National Seismic Hazard Model (NSHM), given this guideline is in draft form and the preliminary stage of the project. There is an opportunity to incorporate this as part of the detailed design stage, if agreed with the client. Given the relatively small seismic loads, we do not consider the higher PGA (estimated as 0.35g based on the NSHM) would make a material difference in the findings from the geotechnical assessments.

A Probabilistic Seismic Hazard Analysis (PSHA) has been outside the scope of the project at this preliminary stage. Given the relatively low seismicity of the region, we do not consider that PSHA is warranted.

36. We appreciate the preliminary liquefaction analyses are based on limited investigation data (mainly BH1) and laboratory testing at this stage. We have assessed the liquefaction susceptibility of soils based on the borehole log descriptions and laboratory testing results – refer to the attached PDF titled ‘Annotated BH1 Log’.

We have revised the liquefaction analysis based on an increased PGA of 0.29 g (refer to revised analyses outputs). Please note the outputs presented in the current GIR had the incorrect SPT depth intervals and these will be revised in the final issue of the GIR.

The findings from the revised liquefaction analyses are as follows:

- Liquefaction of an approximately 0.5m thick layer of alluvial deposits is anticipated at depths ranging between 4.0m and 4.5m bgl.
- Seismically-induced displacements are estimated to range between 60mm and 330mm (and 150mm on average) based on the three adopted methodologies and the yield acceleration of 0.05g. We consider these displacements to be moderately conservative as they do not consider any pinning effect from the existing sheet pile wall and therefore the actual

displacements on site are expected to be smaller. These displacements are not expected to result in releasing landfill contaminants, but may cause some cracking of the capping soils that may need to be re-profiled/topped up.

We consider the estimated settlements to be moderately conservative due to the following reasons:

- The alluvial deposits are likely to be highly variable and interbedded and therefore liquefiable layers are unlikely to be laterally or vertically continuous across the site. We have currently allowed for a continuous layer in the models, which is likely to be conservative.
- Any pinning effect from the sheet pile cut off wall has been ignored in the stability analyses.

The relevant sections of the GIR (namely liquefaction and slope stability) will be updated to reflect the above changes.