# ASHBY CONSULTANTS LTD

(Mine, Quarry and Landfill Planning - Geotechnical Engineering - Risk Analysis)

**15 July 2010**

## RE: LPC RECLAMATION

## GOLLANS BAY QUARRY OPERATION

## S92 REQUEST FOR FURTHER INFORMATION

### PURPOSE

The Canterbury Regional Council has requested further information under Section 92 of the Resource Management Act, 1991.

The purpose of this report is to provide answers to those questions relating to quarrying and associated operations. These are questions 21, 22, 23, 28 and 50 of the further information request, dated 10 March 2010. The report answers the questions in the order contained in the Request.

## Slope Stability

*21) Please provide details of the final landform of Gollans Bay quarry and the hillside that is to be excavated to demonstrate that the cut slopes will be stable in the long term.*

A contour plan showing an approximate final landform of the Gollans Bay quarry is attached – Drawing 1: Proposed Landform (Landform17.pdf). To achieve, the final landform, the following development sequence has been recommended to LPC, noting that floor investigations may change the sequence:

**Pre-Production Development Stages (PP)**

PP1 Establish temporary ramp to Te Awaparahi Bay

PP2 Widen Main Haul Road

**Quarry Development Stages (Q)**

Q1 Develop Access SW and W and Produce West GBQ,

Q2 Investigate floor and if satisfactory drop cut to bench RL100 from W to E, then go to (Q5)

Q3 Develop N Ramp and Produce North Ridge

Q4 Develop NE Ramp and Produce East Ridge

Q5 Continue extracting GBQ Floor dropping to the RL 85 bench and then the RL70 bench



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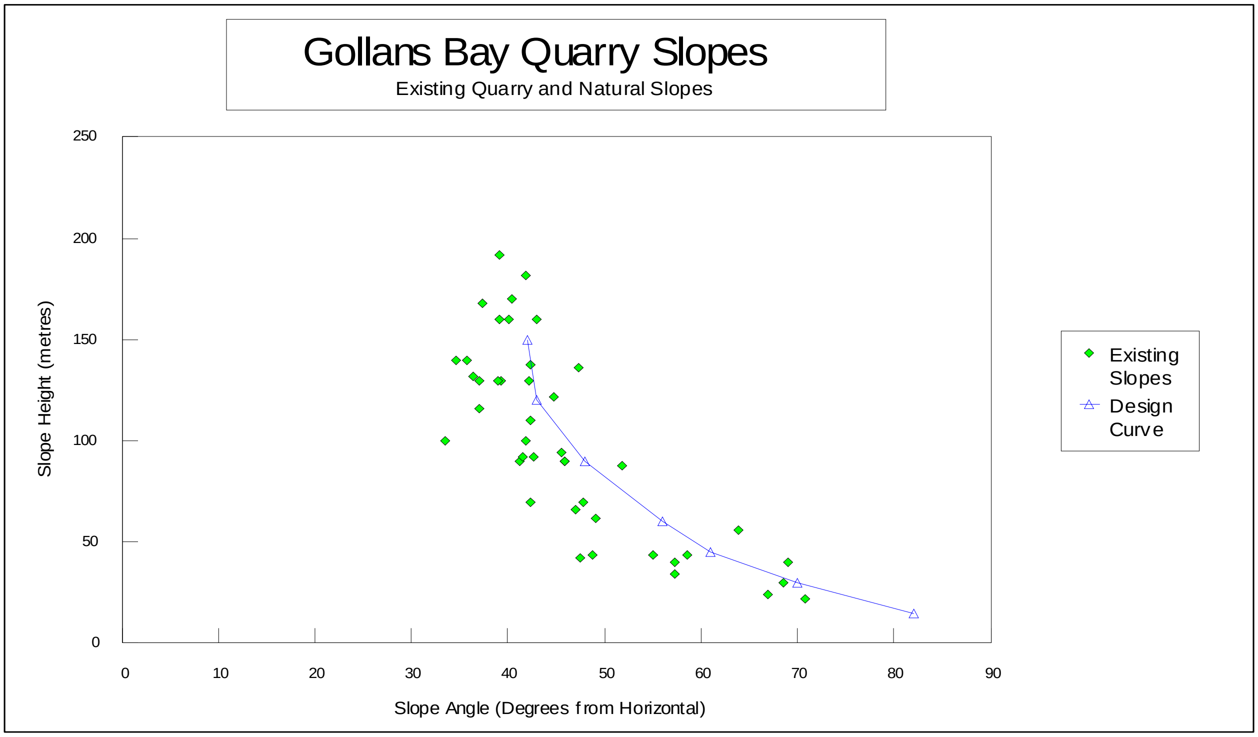
If the geology of the floor proves that sufficient armour stone can be recovered for the foreseeable future, then continued floor development Items Q4 and Q5 is likely to be completed ahead of Item Q3 North Ridge and Item Q4 East Ridge.

The design of the slopes of the Gollans Bay Quarry is based on the configuration of the existing natural and previously quarried slopes using the process of back-analysis shown in Figure 1. The procedure involves the measurement and plotting of slope height versus slope angle for existing natural and cut slopes as shown by the points in the graph. A design curve is fitted through the points for the theoretical design slopes of varying slope height, subject to circular arc failure. The unique combination of Mohr-Coulomb design parameters for the design curve is Effective Cohesion 50kpa and a Friction Angle of 48 degrees assuming a unit weight 2.6t/bcm. For the purposes of the analysis, a highly recharged groundwater condition was assumed. The design approach produces slopes that are of a similar stability to the existing ones including the quarry slopes which have remained generally stable since excavation.

**Figure 1: Slope design based on Back-Analysis of Existing Natural and Quarry Slopes**




During quarrying care will be exercised during production blasting to minimise damage although minor ravelling and local bench scale instability may be encountered during excavation of the quarry faces. Long-term stability of the final cuts will be consistent with that of the existing slopes. In other words, the design slopes will have a Factor of Safety or Probability of Failure similar to those of the existing slopes that have had a long history of relative stability.

Similarly, the stability of the hard rock hillside excavation at Te Awaparahi Bay is expected to be consistent with that of the existing benched slopes. In the area of relatively thick loess, for example near the hairpin, stability will be managed through careful construction followed by stabilisation work as recommended by CPG.

## Haul Road Considerations

*22) Please provide design details for the road and an assessment of stability and erosion effects.*

*23) Please clarify whether the quarry access road is to be a single or double lane road.*

It is proposed that the quarrying operations operated be carried out on a single shift basis (with provision for extended shifts during daylight hours) and up to 24 hour, 7 day per week for load out and transport of quarried material along the haul road to the reclamation.

For safety reasons, wherever practicable, the quarry haul roads will be constructed for two way traffic. As a general guideline, for two-way traffic, a haul road rolling surface should be 3.5 times the overall truck width. This provides adequate separation for approaching trucks and for passing of a parked or disabled vehicle on the roadside. A 10% gradient has also been assumed.

The main haul road from Gollans Bay Quarry to the proposed Reclamation initially follows the alignment of the Old Sumner Road until it reaches Battery Point where it descends to a hairpin and on down to Te Awaparahi Bay. This is shown in Drawing Landform17.pdf and Table 1, entitled Haul Road Widening (overleaf). The Chainage has been measured along the cut-line starting on the eastern side of the Quarry Floor and follows the direction of the loaded trucks from the quarry to Te Awaparahi Bay.

The approximate haul road alignment shown in red in Landform17.pdf is the initial alignment which follows the cut-line with the existing topography. In the quarry areas the haul road will be progressively moved back to the final location adjacent to the quarry walls. A temporary road alignment shown in Landform17.pdf may be constructed SW of the hairpin direct to the Coal Yard.

## Haul Road Width

The width of the existing road varies from 7 metres up to 20 metres in places as shown in Table 1. With minor work the road width in this section can be increased to 12 metres, sufficient for 2-way use by 30 tonne articulated dumpers. It is proposed that for most of its length in this section, with relatively minor excavation, the haul road can be widened to a 15 metre nominal carriageway, and a total width of 17.6 metres if a berm is included. This width is favoured for 2-way use by mobile equipment including articulated dump trucks up to approximately 45 tonnes or slightly smaller rigid dumpers.

There is a small section between chainage 1200-1300 where the road width will be left at about 9 metres (single lane) in order to retain the existing bluffs in this locality. The width of the section of haul road from Battery Point down to the hairpin would be approximately 12-15 metres and from the hairpin down to the stockyard will be approximately 8 metres (single lane).

## Table 1: Haul Road Widening - Gollans Bay Quarry to Te Awaparahi Bay Reclamation

| Chainage (m) | Description | RL Cutline | Existing Width (m) | Existing Height (m) | Proposed Width (m) | Additional Cut Height (m) | Total Cut Height (m) | Volume from Road Widening ($m^3$) | Comments |
|---|---|---|---|---|---|---|---|---|---|
| **0** | Start East GBQ | 100.0 | >20 | 100.0 | 15m | - | 0.0 | | East GBQ |
| **100** | GBQ | 100.1 | >20 | 79.9 | 15m | - | 0.0 | | |
| **200** | GBQ | 101.0 | >20 | 79.0 | 15m | - | 0.0 | | |
| **300** | W GBQ | 104.5 | >20 | 75.5 | 15m | - | 2.4 | | West GBQ |
| **400** | W GBQ | 111.5 | 7.2 | 68.5 | 15m | - | 5.2 | | " |
| **500** | Junction GBQ Ramp | 119.2 | 21.2 | 70.8 | 15m | - | 14.0 | | " |
| **600** | West GBQ | 119.1 | 9.7 | 60.9 | 15m | - | 7.9 | | " |
| **650** | Junction GBQ High access | 117.2 | 15.6 | 16.0 | 15m | 12.2 | 28.2 | | " |
| **700** | SW GBQ | 115.3 | 7.0 | 9.7 | 15m | 2.5 | 12.2 | | SouthWest GBQ |
| **800** | SW GBQ | 108.2 | 7.3 | 11.8 | 15m | - | 10.8 | | " |
| **900** | Junction Landfill Access | 100.5 | 10.8 | 6.0 | 15m | 4.3 | 10.3 | | |
| **1000** | | 93.5 | 6.5 | 12.0 | 12m | - | 11.8 | 4200 | |
| **1100** | | 88.4 | 13.4 | 12.0 | 12m | - | 11.0 | 3250 | |
| **1200** | <Bluffs> | 88.3 | 8.7 | 12.0 | 8m | - | 10.0 | 1950 | Restrictions + Railing |
| **1300** | <Bluffs> | 88.1 | 11.2 | 18.0 | 8m | - | 0.0 | 1350 | Restrictions + Railing |
| **1400** | | 88.1 | 14.3 | 23.9 | 15m | - | 4.5 | 400 | |
| **1500** | | 88.5 | 12.6 | 14.0 | 15m | - | 5.4 | 1100 | |
| **1570** | Start ramp down | 88.0 | 16.9 | 12.0 | 15m | - | 4.5 | 500 | Ramp to Te Awaparahi Bay |
| **1600** | | 84.0 | 12.5 | 16.0 | 15m | 4.5 | 20.5 | 6180 | Ramp Entrance widened |
| **1700** | Battery Pt Corner | 72.5 | +12.9 | 27.5 | 15m | - | 16.0 | 18300 | |
| **1800** | | 63.5 | +11.9 | 36.5 | 15m | - | 10.6 | 15000 | |
| **1900** | | 53.5 | +10.4 | 6.5 | 15m | - | 5.2 | 8150 | |
| **1960** | Hairpin | 52.0 | +6.8 | 8.0 | 12-8 | 1.6 | 9.6 | 4680 | Lower Ramp |
| **2000** | Single Width | 42.0 | 0.0 | 18.0 | 8m | - | 11.4 | 3820 | Restrictions |
| **2100** | " “ | 32.0 | 0.0 | 58.0 | 8m | - | 23.6 | 9000 | " |
| **2200** | " “ | 22.0 | 0.0 | 68.0 | 8m | - | 14.3 | 8900 | " |
| **2300** | " “ | 12.0 | 0.0 | 8.0 | 8m | - | 2.2 | 3450 | " |
| **2340** | Reclamation Yard | 6.0 | >20 | 0.0 | 8m | - | 0.0 | 40 | Fill 2m |

Notes: Chainage measured along cut line

Area and volume of Cut ignoring access

Design width consists of filled safety berm plus road width, entirely in cut

Shaded Portion = Extent of Quarry

## Safety-Berms

The roads will be constructed with a safety-berm on the outside and a drain on the inside. The berm has been included in the design width. The safety-berms will be constructed of run of quarry fill and provide not only for vehicle safety but also would assist to control stormwater by minimising the potential for washouts and erosion of the slope below.

In situations where the road is cut in steep terrain such as around the “Bluffs” (Chainage 1200-1300) and below the “Hairpin” down to the coal stockyard excavation (Chainage 1960) width may be preserved by erecting steel barriers in place of the berms.

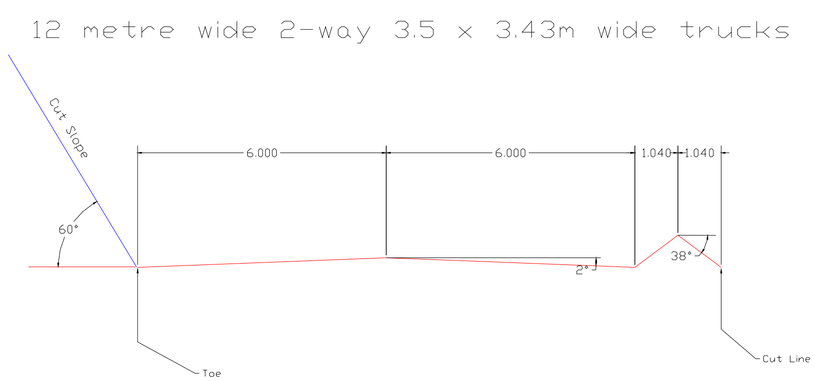
The roads will generally be constructed on cut to minimise sidecasting and the potential problems of erosion and sediment yield. Typical profiles of the road are shown in Figure 2 below.

## Haul Road Profile

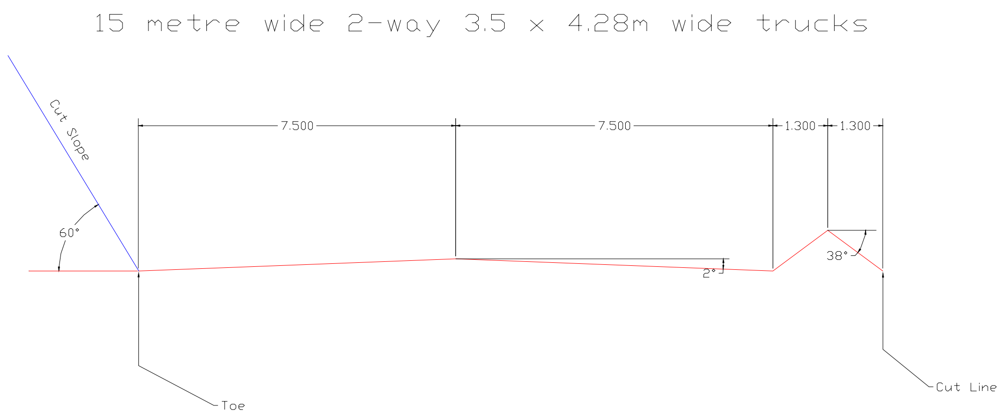
The haul road can be constructed on cut to minimise sidecasting and any potential problems of erosion and sediment yield. Typical profiles are shown in Figure 2 below. Detailed design of road cut would be completed prior to commencement of construction. The preliminary design shown on Table 1 assumes a 60 degree cut slope.

**Figure 2: Haul Road Profiles**

**12 metre wide carriageway**



**15 metre wide carriageway**




Detailed design of the road cuts will be carried out prior to construction. In the interim, preliminary design of the road cuts has been carried out assuming a 60 degree cut slope as shown in Table 1.

Once stabilised and re-vegetated, erosion and sediment yield from the roadside cuts should be equivalent to the existing situation.

Where the steepness of slope above precludes road widening of the road carriageway to the full 15 metres, then the road width will be reduced and traffic restrictions applied as necessary.

Finally, it is noted that the contractor may elect to construct a haul road that is narrower over longer stretches and/or is of a steeper slope/gradient up from Te Awaparahi Bay or when accessing the quarry faces. Therefore, the cut heights and volumes of material required to be removed are considered to be conservative.

## Haul Road Cut Stability

The stability of the haul road cuts including the NE Te Awaparahi Bay cut will be subject to a thorough geotechnical assessment. In the interim, a slope angle of 60 degrees for cut heights less than 20 metres has been used in this assessment as shown in Table 1.

The management of stormwater is addressed by CPG.

## Sources of Armour Stone

28) *Please provide details of the volume of rock required for seawall and armour stone, clarification of where the rock will be sourced from and the density requirements of the rock. Please assess the stability of the seawall for the traffic of vehicles along the crest and clarify whether there a limit to truck weight on the seawall.*

Opus International Consultants estimate that about 80,00$m^3$ of armour stone is required for the reclamation associated with this project. Refer to their response to this question.

The quantities and characteristics of the armour stone to be supplied from the quarry are shown in Table 2:

**Table 2: Gollans Bay Armour Stone Production**

| Material | Description: Size /Weight Range | * Quarry Percentage of stone |
|---|---|---|
| "A" Armour Stone | Hard Rock > 1 m diameter, or > 1 tonne | 2.10% |
| "B" Armour Stone | Hard Rock 0.5 - 1 m diameter, or 0.25 – 1 tonne | 11.40% |

Notes: * Percentages were estimated by Coates (1994) by face mapping of the Quarry

It is anticipated that the two categories of armour stone will be supplied by the Gollans Bay Quarry from three rock types as follows:

- *Trachyte*, a light coloured igneous rock will be sourced from an intrusive sill and dyke feeder outcropping on the North Wall. Although the width of the structure reduces at depth, it is anticipated that the block size and hence the proportion of Category A armour stone will increase in the floor.
- *Porphyritic Basalt* occurs in a number of flows but particularly the lower flow that outcrops on the East Wall.
- *Volcanic Agglomerate* occurs in a number of flows particularly the middle and upper flows. It is anticipated that the material will be sourced mainly from the Western part of the quarry.

## Blasting

*50) Blasting is proposed during daylight hours to excavate the hill. Please provide further information on the proposed hillside blasting methods including a blasting noise monitoring plan and details of proposed best practice blasting methods. Please include details of the time(s) of day and days of the week that blasting will occur, the predicted number of blasts per day or week, and the expected duration of the blasting.*

Generally rock will be blasted by bench blasting using vertical or sub-vertical holes. Special care will be taken in drilling to ensure that the charges are properly burdened to minimise fly rock and blast overpressure (noise). The holes will be charged using bulk explosives brought to the site by contractor and will be backfilled with appropriate stemming to direct the explosive energy into fragmenting the rock and minimising overpressure. The charges will be initiated in a delay sequence to minimise vibration and noise and to minimise any damage to the surrounding rock mass. Blasting at the site would be carried out generally in accordance with the Australian Standard AS2187 Part 2 - Use of Explosives. It is not anticipated that delayed blasting will result in any adverse effects beyond the site boundaries. The report by Hegley Acoustic Consultants predicts the proposed blasting would fall well within the specified District Plan limits.

Explosives will not be stored at the quarry but brought to site on an “as required basis” and the excess, if any, will be taken back to an approved magazine off the site after blasting is finished.

**Blasting Times**

It is not anticipated that more than one blasting period of 20 minutes per day will be required. Blasting would be carried out at a fixed time between 9am and 3pm to suit local circumstances. During peak production periods, a number of primary and secondary blasts may be fired within the same 20 minute interval but separated by short delays. Secondary blasts would be considerably smaller and would be used for breaking up very large rocks that are too big to handle and/or that are hanging up from previous primary blasts.

Prepared by

**Ashby Consultants Ltd**

John P Ashby

Mining / Geotechnical Engineer

## APPENDIX: STATEMENT OF QUALIFICATIONS

This report has been prepared by John P Ashby. John is an independent consulting engineer with 40 years of experience in the mining and quarrying industry.

John Ashby holds a first degree in Geology and a Masters in Engineering Rock Mechanics, both from London University. He is an Honorary Fellow of the Institute of Quarrying, a Member of the New Zealand Geomechanics Society and a Fellow of The Australasian Institute of Mining and Metallurgy.

John has particular expertise in quarry development planning including geological investigation, geotechnical / slope design, water management and blasting and its effects on the surrounds. He has written a number of technical papers on the topics and has presented expert evidence at a number of hearings in New Zealand.

Lyttelton Port Company: Reclamation
Drawing 1: Proposed Landform
Legend:
Stage PP1 Sequence of Pre-Production Development
Stage Q3 Sequence of Quarry Development
Existing Roads
Existing Topographic Contours 10m
Proposed Design: Ultimate Quarry Slopes
Crest-Line
Toe
Proposed Design: Initial Haulroad
Cut-Line
Chainage measured along Cut-Line
SCALE
1:3000 @ A1
0
200 m
Mt Pleasant Local Circuit 2000 LPC Port Datum
Prepared by Ashby Consultants Limited
Tel/Fax +64 +9 520 1984
Email: consult@ashby.co.nz
Topographic Base Precision Aerial Surveys August 2008
Original Quarry Design Mine Design Services Dwg 11b
Drawing: Landform17.dwg
Stage PP1: Temporary Ramp
Stage PP2: Widen Main Haul Road
Stage Q1: Widen Main Haulroad SW Quarry
Stage Q1contd.: Produce West Quarry
Stage 4: Drop to RL115 >
Stage Q2 >RL100
Stage Q5 Drop Cut > RL85
Drop Cut > RL70
Stage Q3: North
RL130
Stage Q4: East
799,500mN
799,000mN
798,500mN
400,500mE
401,000mE
401,500mE
402,000mE
402,500mE