Date: 1/11/2017

John Scandrett,
Dairy Green Limited,
10 Kinloch Street,
Waikiwi, **Invercargill 9840**

Dear John,

RE: Firdale Farms Ltd – Existing Pond Structural Review - (Revision 1)

1. Introduction

RJHall and Associates Ltd, have been engaged by Dairy Green Ltd, to review the Firdale Farms effluent pond at Dobbie Road, Seaward Downs, Southland (Auth. 204751).

The assessment was carried out to determine the stability of the constructed pond. The assessment involved:

- Site visit (Dairy Green)
- Scala penetrometer and hand auger investigation (Dairy Green)
- Drop test (GeoSolve)
- Slope stability and structural assessment and report (RJHall and Associates Ltd)

2. Pond Background

The site visit was undertaken in February 2017, and incorporated a walkover of the pond, and hand auger and Scala Penetrometer testing. The pond is sited approx. 250 m west of Dobbie Road, on flat topography. Scala penetrometer and hand augers were carried out for existing pond on the embankment crest.

The pond is in cut and in situ soils comprise of silt (loess). The investigation also confirmed that the pond was lined with silty / clay loess. The pond was constructed of materials sourced from site. No details on pond construction such as rolling have been provided.

The pond size is approximately 28 m in width and 66 m in length measured from outer extents of the batters. The internal batters of the pond are typically 2:1 (horizontal:vertical). The pond is fully in cut and therefore there was no external batters or top of embankment. At the time of the investigation the embankment materials were moist.

A drop test completed from 7-10 April 2017 indicates that the pond permeability is less than 2 mm per 24 hours and therefore complies with Rule 35 (b)(iii)(2) of the proposed Environment Southland Land and Water Plan.

During the site walk over by Dairy Green Ltd holes in the embankment were observed. These holes were caused by rats burrowing into the banks, they are presented in Figure 1. The damage to the embankment caused by the rats needs to be repaired as part of the pond maintenance schedule.

The water level at the time of the site visit was approximately 0.3 to 0.4 m below top bank height (and below the rat holes), with and approximate 2.1 m depth of effluent.

Figure 1: Holes in the internal embankment of the pond

3. Geotechnical testing

Four Scala penetrometer tests were carried out by Dairy Green Ltd on the pond crest. The four augers were carried out on the pond walls at the Scala penetrometer test locations. These were undertaken to assess the relative density of the embankment and fill material. Scala penetrometer results are appended to this report.

Scala penetrometers were carried out to a depth of 2.0 m below the embankment crest. Minimum Scala penetration values were 0 blows per 100 mm which corresponds to the level of a rat hole. Otherwise, typical values were in the order of 4 to 8 blow per 100 mm range.

The hand augers results all returned top soil to a depth of 200 mm followed by silts. It was noted that the silts could not be rolled into a cylindrical shape indicating non plastic soils and very low clay content.

Review of the published geology for the area indicates that the area is underlain by late Pleistocene alluvial deposits, overlain by loess. The loess has been used in this case for the construction of the pond.

4. Recommendations for Remediation of Embankment

Damage has been caused to the embankment by rat warrens and could lead to minor slumping of the banks and effluent leakage. The damage to the embankment need to be remediated as part of the pond maintenance schedule.

The basic recommended remediation strategy outlined is:

1. Draw down pond, Dairy Green to inspect banks during draw down;
2. Scrape back and set aside top soil;
3. Scrape back silt soil until all damage from rats has been removed;
4. Reinstate silt soil and compact. Perform a nuclear densometer test to confirm suitable compaction has been achieved (min 95% MDD for that material); and,
5. Replace top soil (min 300 mm overlay) to seal embankment, prevent cracking and protect against wave action.
6. Install rat traps and bait regularly

The construction should be overseen by Dairy Green Ltd to provide quality control of the proposed works.

5. Slope Stability Modelling

Slope stability assessment of the embankment was carried out to estimate the stability of the embankment. The embankment was modelled in Slope W for static stability.

The slope stability assessment was carried out for a grade of 27˚ (2:1) on the internal bank only. The external bank was not assessed as the pond is 'dug in'. The conditions of the soil were modelled with a phreatic surface from the base of the pond as non saturated conditions were found during the auger investigation.

Soil parameters used in the assessment are presented in Table 1. These were based on long term loading of silt material. The values were estimated using indicative internal angle of friction and cohesion values presented in Bowles (1982) and Jowett (1992) thesis on loessial materials.

Table 1 Soil Properties for engineered fill

Soil Type	Internal Angle of Friction (Φ) (˚)	Cohesion (C) (kPa)	Unit Weight (γ) (kN/m³)
Embankment (clay / silt)	30	1	17.0

The stability analysis, showed the embankment to be stable for static long term loading. The assessment indicates that the Factor of Safety (FOS) for the internal and external batters, were in excess of 1.6 for a loss of freeboard in the effluent pond. A FOS greater than 1.2 for all conditions, indicates that the pond walls are stable from catastrophic failures.

Table 2 Stability Results

Location	Batter Angle (h:v)	Min. Factor of Safety* (FOS)	General Factor of Safety** (FOS)
Internal Batter	2:1	1.6**	2.88
*Minor instability – cosmetic movement stability (very unlikely) **Loss of freeboard slope failure			

Bowles (1982), Foundation analysis and design indicates that embankment slopes shall have a minimum factor of safety (FOS) of 1.2, this is supported by the NZSOLD Dam Safety Guidelines (2015) for loss of freeboard. Analysis of the internal and external embankment shows the slopes are adequately stable against loss of freeboard and cosmetic damage.

6. Results and Conclusions

The site testing indicated that the pond embankment is generally constructed of silt.

The site investigation and site walkover showed no signs of slumping or cracking on the embankment or internal batters or leakage from the embankment. Rat warrens were present in the freeboard zone of the pond. This damage needs immediate attention. Repair procedures are outlined in Section 4 of this report and shall be carried out with supervision by Dairy Green Ltd.

Pond seepage is within Environment Southland regional plan limits.

The stability assessment for the embankment shows that the embankment wall of the pond is structurally stable against slippage. A minimum factor of safety of greater than 1.6 was found for minor slope failures (cosmetic) of the internal batter.

It is opined that the stability of the pond will not change provided the pond is well maintained. It is recommended that the Owner shall undertake regular visual of the pond to and maintenance is carried out on the pond if distress is noted.

If you have any queries with regards to this letter or the involvement RJ Hall and Associates Ltd on this project please call or email with the contact details below.

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Site	Dobbie road
Client	Firdale Dairy Pond
Test Date	28-02-17
Job Num	Storage pond

Dairy Green Ltd

	DCP BLOW COUNT (BLOWS/100mm)			
Orientation	N	W	S	E
Eastings	1275933	1275912	1275915	1275935
Northings	4858150	4858128	4858085	4858102
Depth (m)	DCP1	DCP2	DCP3	DCP4
-0.1	2	1	2	3
-0.2	2	0	1	2
-0.3	1	0	2	1
-0.4	2	1	0	0
-0.5	2	1	0	0
-0.6	2	1	1	1
-0.7	4	3	2	2
-0.8	3	2	2	3
-0.9	3	2	1	3
-1.0	4	3	2	3
-1.1	5	5	4	5
-1.2	5	5	5	5
-1.3	6	6	6	6
-1.4	6	6	5	5
-1.5	5	7	5	5
-1.6	6	7	6	5
-1.7	8	9	6	6
-1.8	7	9	7	7
-1.9	8	10	6	7
-2.0				
-2.1				
-2.2				
-2.3				
-2.4				
-2.5				
-2.6				
-2.7				
-2.8				
-2.9				
-3.0				

Notes: