

**CONSTRUCTION QUALITY ASSURANCE
VALIDATION REPORT**

**CONSTRUCTION OF CELL 3 WESTERN SIDEWALL LINER
(UPPER SECTION)**

HAFOD LANDFILL SITE



Prepared for
CORY ENVIRONMENTAL (CENTRAL) LIMITED



Stratus Environmental Limited
Suite 5a, Rossett Business Village
Llyndir Lane
Rossett, Wrexham
LL12 0AY

Project Quality Assurance
Information Sheet

CQA Validation Report for the Cell 3 Western Sidewall Liner (Upper Section) Construction

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Prepared for : Cory Environmental (Central) Limited
Hafod Landfill
Bangor Road
Johnstown
Wrexham
LL14 6ET

Issued by : Stratus Environmental Limited
Suite 5a, Rossett Business Village
Llyndir Lane
Rossett, Wrexham
LL12 0AY

Prepared by :

Richard Clarke
Principal Engineer

Approved by :

Andrew Coxon
Engineering Director

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1 INTRODUCTION

- 1.1.1 Stratus Environmental Limited (Stratus) were requested by Cory Environmental (Central) Limited (Cory) to carry out Construction Quality Assurance (CQA) supervision and testing during the construction of Cell 3 Western Sidewall (Upper Section) at Hafod Quarry Landfill Site.
- 1.1.2 The construction works were carried out in accordance with the CQA Plan Version 1.0 dated September 2013, later superseded by Version 2.0 dated August 2014.
- 1.1.3 The works were undertaken using plant and labour resources provided by Cory, who undertook the construction work in two phases (February 2015, and March 2015).
- 1.1.4 The construction works incorporated the following elements:
- (i) clearance of vegetation and unsuitable materials from the existing sidewall;
 - (ii) installation of groundwater collection system, comprising a cusped drainage geocomposite, with a collection drain at the base of the sideslope;
 - (iii) placement of suitable engineering fill to design formation profile;
 - (iv) installation of 1000mm minimum thickness engineered clay liner as an artificially established geological barrier (AEGB); and
 - (v) installation of 1000mm minimum thickness engineered clay liner as an artificial sealing layer (ASL).
- 1.1.5 The two Stratus CQA Engineers who provided supervision and quality assurance for the works were Jim Gibson (February 2015) and Andy White (March 2015).
- 1.1.6 Survey control and recording was provided throughout the project by StafSurv, an independent survey company appointed by Cory.
- 1.1.7 This CQA Validation Report represents a record of the site works undertaken at Hafod Quarry Landfill Site, and includes a record of all the in-situ and laboratory testing undertaken.
- 1.1.8 The extent of construction covered by this document is shown on the as-built drawing presented in Appendix 1.

2 THE SITE

- 2.1.1 Hafod Quarry Landfill Site is situated approximately 4km southwest of Wrexham, at National Grid Reference SJ311458.

3 PREPARATORY WORKS

3.1 Formation Works

- 3.1.1 The existing quarry face was cleared of vegetation and loose/unsuitable material prior to installation of the groundwater collection system.

3.2 Installation of Groundwater Drainage System

- 3.2.1 The groundwater drainage system comprised a drainage geocomposite laid across the prepared formation, discharging to a collection drain at the base of the slope.

3.3 Drainage Geocomposite

- 3.3.1 The groundwater collection geocomposite comprised Protexia FC6-2, a cusped drainage geocomposite manufactured by Geofabrics Limited. A total of fourteen rolls of FC6-2 were delivered to site in October 2013, with eight being used within the construction of the lower section of the sideslope (in Autumn 2014). Of the remaining six rolls, five were used within the upper section works that are the subject of this report, with the remaining roll being placed into storage. Each roll had dimensions of 4.8m x 100m, giving a gross installed area (including anchor trenches and overlaps) of 2,400m².
- 3.3.2 The geocomposite was delivered to site before Stratus had mobilised to site, and were offloaded and placed into storage on a prepared area at the side of the tarmac access road by Cory personnel. The CQA Engineer subsequently supervised handling and deployment of the geocomposite. The CQA Engineer inspected the rolls of geocomposite and confirmed that no damage had occurred to them during transportation to site and unloading/storage.
- 3.3.3 The CQA Engineer obtained the manufacturer's quality control and product data sheets that accompanied the batch of rolls delivered to site, and assessed these as acceptable against the requirements of Table 1 of the Specification. The MQC data sheets and delivery note are presented in Appendix 3.
- 3.3.4 The sub-grade on which the geocomposite was deployed was prepared using a hydraulic excavator fitted with a ditching bucket. The CQA Engineer inspected successive areas of the subgrade, to ensure that no potentially deleterious materials would be in contact with the geocomposite. Throughout the geocomposite installation, the surface was deemed to be satisfactory.
- 3.3.5 The geocomposite was deployed using the hydraulic excavator. The CQA Engineer oversaw placement of the drainage geocomposite and ensured that the edges were correctly butted together. Panels were installed with no significant wrinkles.

3.3.6 Two samples of the geocomposite were taken from randomly-selected rolls during deployment and despatched for testing at BICS Laboratory in Huddersfield. Testing was undertaken to confirm:

- (i) tensile strength;
- (ii) CBR puncture resistance;
- (iii) in-plane water flow;
- (iv) thickness;
- (v) geotextile permeability; and
- (vi) geotextile pore size.

3.3.7 The laboratory testing was undertaken under UKAS accreditation for all the tests carried out. The laboratory results are presented in Appendix 5, and confirm that both samples of geocomposite were in accordance with the specified values; the results are summarised in Appendix 4.

3.4 Collection Drain

3.4.1 The panels of geocomposite discharged to a collection drain excavated at the base of the current lift, comprising a 150mm twinwall pipe installed in a 450mm wide x 750mm deep trench. The pipework was connected using push-fit collars. The collection drain flows northwards at a nominal gradient of 1:50, and discharges to an open ditch at the northern extremity of the current works.

3.4.2 One roll of NW9 filtration geotextile was used within the works to line the collection ditch, having dimensions of 4.5 x 100m. The CQA Engineer took a sample of this material and submitted it to the laboratory for testing in accordance with the requirements of Table 2 of the Specification.

3.4.3 The geotextile test certificate are presented in Appendix 5 and summarised in Appendix 4. For the primary parameters of puncture resistance, pore size, perpendicular permeability and elongation at break, the material was found to be in accordance with the specified requirements; the reported value for tensile strength is discussed within Section 6 below.

3.4.4 The drainage gravel used within the collection drain was taken from the stock of material delivered to the previous works, which has already been subject to laboratory conformance testing and found to be in accordance with the Specification in respect of the ten percent fines strength and horizontal permeability. The reported value for the particle size distribution was marginally outside the specified range; this was discussed in the Validation Report for the lower section works and was determined as acceptable.

4 ENGINEERED FILL

4.1 General

- 4.1.1 Selected engineered fill was placed in layers above the installed geocomposite in accordance with the requirements of the Specification for Highway Works Tables 6/1 – 6/4, using a Bomag BW213DH self-propelled padfoot roller. The fill material was categorised as being in accordance with Class 2A (wet cohesive) of Table 6/1, and was subject to nine passes of the roller working in 250mm layers (compacted thickness). The thickness of fill material placed varied across the works, with a maximum of ~1.2m.
- 4.1.2 Survey control was employed to ensure a resultant profile of 1:3 was achieved, in accordance with the design and stability risk assessment review (SRAR).

5 ENGINEERED CLAY LINER (ECL)

5.1 Acceptance Criteria

The acceptance criteria were derived from laboratory test results undertaken prior to commencement of the works as part of the source evaluation prepared by Egniol Limited in 2008. The acceptance criteria are essentially an envelope within which the field dry density and moisture content results should fall in order to achieve the desired in-situ permeability. The boundaries of the envelope for the acceptance criteria are above the 5% air voids line, and between the upper and lower moisture content limits.

- 5.1.1 The lower moisture content limit was set at 12% and the upper moisture content was set at 20%.
- 5.1.2 The 5% air voids line was calculated using the average particle density derived from the collection of laboratory results within the source evaluation (2.63 Mg/m³).
- 5.1.3 The minimum clay content was set at 10%, with a maximum particle size of 125mm.

5.2 Field Trial

- 5.2.1 Prior to the commencement of construction of the engineered clay liner, a compaction trial was carried out on 18 February 2015 with the CQA Engineer in attendance, in accordance with the Specification for Highway Works Tables 6/1 – 6/4 to confirm that the proposed compaction and construction methodology would achieve the required specification.
- 5.2.2 The methodology for carrying out the trial was as follows:
 - (i) deposition of selected suitable clay on the trimmed surface of the formation;
 - (ii) blading out the clay material to a uniform nominal uncompacted thickness of 300mm; and
 - (iii) compaction of the clay using a Bomag BW213DH self-propelled vibratory padfoot roller, to determine the number of passes required to achieve the necessary dry density;
 - (iv) On completion of placement and sampling of the first layer, a second layer of clay was placed and compacted before being sampled.
- 5.2.3 The field trial was carried out on an area at the southern end of the works area. On completion of testing and review of the results, it was determined that eight passes

of the Bomag roller were required to achieve compliance with the air voids criterion.

5.2.4 Following completion of the field trial, the CQA Engineer excavated through the trial section to check for adequate interlayer bonding between the first and second layers. The CQA Engineer was satisfied that adequate bonding had been achieved within the field trial construction.

5.2.5 The material used within the trial pad was then removed for re-use in the works.

5.3 Assessment of Field Trial

5.3.1 The field trial was constructed in accordance with the requirements set out in the CQA Method Statement. The field trial confirmed that the selected cohesive material could be successfully placed and compacted to form an engineered clay liner.

5.4 Compacted Mineral Liner Construction

5.4.1 The mineral lining works were undertaken by placing and compacting selected suitable cohesive material in a progressive manner.

5.4.2 All engineered clay liner construction work was carried out using the method confirmed by the field trial. A total of eight layers of clay were placed to provide the 2m minimum clay thickness required for the artificially-established geological barrier (AEGB) and artificial sealing liner (ASL).

5.4.3 Before placement of a subsequent layer, the CQA Engineer ensured that the surface of the previous layer was suitably scarified, to provide adequate inter-bonding between the layers.

5.4.4 For construction of the tie-in to the existing sidewall liner, and where construction joints within the proposed liner were necessary, the CQA Engineer ensured that off-set (stepped) joints were employed.

5.4.5 Throughout the works the only unsuitable materials identified were occasional oversize materials (brickbats and tile fragments), and small quantities of material that became saturated due to heavy rain. All unsuitable materials were removed from the works to the satisfaction of the CQA Engineer.

5.5 Monitoring, Testing and Sampling

5.5.1 A programme of intensive monitoring, testing, and sampling was undertaken by the CQA Engineer during the construction period to check compliance with the requirements of the CQA Plan.

- 5.5.2 Quality control testing consisted of moisture content and density measurements of the emplaced material using core samples which were processed using a site oven and balance. In-situ shear strength measurements were recorded using a hand shear vane. Additional cores of compacted clay were taken and subjected to constant head permeability, moisture/dry density and undrained shear strength testing in the laboratory, while bulk samples were taken for classification testing.
- 5.5.3 The in-situ testing and sampling was undertaken at random locations (within a 20m x 20m reference grid) over the cell and are considered representative of the entire thickness and area of emplaced liner. The total volume of clay placed to the engineered clay liner (AEGB + ASL) was approximately 5,000m³. The in-situ testing and material sampling was undertaken in accordance with the testing and sampling frequencies stated in Table 4 of the CQA Plan.

TABLE 1 : ASSESSMENT OF CONFORMANCE TEST FREQUENCY ACHIEVED (FOR 5,000m ³)			
Test Property	Test Frequency	Number of Tests Required	Number of Tests Undertaken
Liquid Limit	1 / 500 m ³	10	10
Plastic Limit			
Plasticity Index			
Particle Size Distribution			
Clay Content			
Compaction Core	1 / 250 m ³	20	23
Air Voids	1 / 250 m ³	20	23
Permeability	1 / 1000 m ³	5	4*
Hand Shear Vane	1 / 250 m ³	20	48
Undrained Shear Strength	1 / 1000 m ³	5	3*

* See Section 6

- 5.5.4 The CQA Engineer did not allow placement of subsequent layers of clay until the previously placed layer had demonstrated the requisite shear strength.

5.6 Assessment of Testing

- 5.6.1 Site and laboratory testing of the compaction core samples yielded dry density results of between 1.82 and 2.01 Mg/m³, together with moisture contents between 11% and 16%. Air voids range from –2.8% to 7.0% (based on a particle density of 2.63 Mg/m³). The moisture content and density results are summarised in Appendix 4 and presented in Appendix 6.

- 5.6.2 With one exception (11%), all core samples were reported at or above the minimum moisture content of 12% and are therefore deemed acceptable; the core at 11% was taken from the trial pad, and as that material was removed and reworked, can be disregarded.
- 5.6.3 A number of samples indicate negative air voids percentages (up to -2.8%), which is likely to be due to slight variations in the particle density above the average value taken for plotting the air voids lines.
- 5.6.4 Hand shear vane testing of the compacted clay gave results of between 85 kPa and 120 kPa. All the test results are greater than the specified minimum in-situ shear strength of 55 kPa, and were therefore deemed to be acceptable. Hand shear vane measurements are summarised in Appendix 4 and presented in Appendix 6.
- 5.6.5 Atterberg Limits testing demonstrated an average plasticity index of 19%, which is within the normally-specified range of >10% and <65%. The average liquid limit of 36% was also below the specified maximum of 90%. The range of plastic limits recorded by the laboratory testing is 15% to 19%.
- 5.6.6 Particle density results ranged from 2.68 Mg/m³ to 2.73 Mg/m³.
- 5.6.7 Particle size distribution analyses indicated an average clay content of 24%, ranging from 20% to 26%. This is greater than the 10% minimum required, and is therefore deemed acceptable. No particles greater than 37.5mm were recorded.
- 5.6.8 The laboratory results of the classification testing demonstrate that the material is of a consistent nature, and meets the requirements of the CQA Plan. The laboratory results for the classification testing are summarised in Appendix 4 and presented in Appendix 7.
- 5.6.9 The laboratory results of the constant head permeability tests from core samples taken from the emplaced clay at locations within a grid across and throughout the full depth of the liner, range between $k=1.10 \times 10^{-10}$ m/s and $k=5.0 \times 10^{-10}$ m/s. These results demonstrate that the target permeability of $k=1.0 \times 10^{-9}$ m/s was achieved in the field. The results of the constant head permeability testing are summarised in Appendix 4 and presented in Appendix 8.

5.7 Assessment of Procedures

- 5.7.1 The CQA Engineer monitored all lining material placement and compaction, and was satisfied with the placement methodology and the final quality of the engineered clay liner.
- 5.7.2 The working procedures adopted throughout the duration of the works, in terms of layer thickness and the numbers of passes of the compaction plant, were in

accordance with the CQA Plan and the compaction field trial, and therefore were deemed satisfactory. All the clay mineral material utilised in the construction of the engineered clay liner was placed satisfactorily. All the laboratory testing was undertaken at a laboratory with UKAS accreditation for the tests undertaken. The laboratory details are included with each result sheet presented in the respective appendices.

- 5.7.3 The CQA Engineer ensured that the engineered clay liner was constructed to the lines and levels shown on the design drawings in conjunction with Cory's appointed surveyor. A topographical survey of the works area was undertaken prior to, and following construction of the ECL. The surveys confirm that a minimum perpendicular thickness of 2000mm of clay has been laid on the side slopes of the cell in accordance with the CQA Plan. The maximum vertical height of the emplaced liner is 9m. The thickness of the clay is shown on the as-built drawing presented in Appendix 1.

6 NON-CONFORMANCES AND THEIR TREATMENT

6.1 Filtration Geotextile

- 6.1.1 The sample of filtration geotextile failed to achieve the specified tensile strength of >20kN/m, with a value of 9.5kN/m reported by the laboratory); the reported values for elongation at break, puncture resistance, pore size and perpendicular permeability are all in accordance with the Specification.
- 6.1.2 It is considered that little or no tension within the geotextile is likely to be experienced in service, as the material will be supported within a drainage trench; damage from placement and subsequent minor settlement of the drainage gravel should be accommodated by the material's puncture resistance. The provision of a high tensile strength would have consequential negative effects on both the pore size and permeability of the geotextile, and as these are considered the primary parameters on which the geotextile should be selected, such effects would be counter to the design function. The filter geotextile is therefore deemed acceptable for use in this situation.

6.2 Drainage Gravel

- 6.2.1 The sample of drainage gravel submitted for PSD analysis as part of the lower section of sideslope works in 2014 was found to be slightly below the grading envelope specified in Table 3, with 78% passing the 40mm sieve (permitted range 30–65%) and 35% passing the 31.5mm sieve. The results for horizontal permeability and ten percent fines were in accordance with the Specification.

6.2.2 Whilst the material tested was found to be slightly outside the grading envelope, it is recognised that a particularly coarse grading specification has been proposed. In comparison with the Guidance grading parameters for a 40–20mm drainage gravel (for use in a leachate drainage blanket), or with Type B filter media (used in highway drainage systems), the recycled aggregate is found to be well within grading limits. The high permeability reported (1.7×10^{-1} m/s, compared with $> 1 \times 10^{-4}$ m/s required) in combination with the resistance to crushing demonstrated by the high ten percent fines value achieved (230kN) further confirms that the material will provide acceptable levels of drainage when in service, and can therefore be considered acceptable.

6.3 Engineered Clay

6.3.1 Reference to Table 1 above shows that insufficient tests were undertaken for the volume of engineered clay placed for assessing the permeability and undrained shear strength of the material.

6.3.2 A total of four permeability samples were tested, one short of the five required by the Specification. Five cores were taken by the CQA Engineer, but one was lost in transit to the laboratory. Review of the characterisation data and the four permeability results reported for the upper section works, and comparison of these with the data reported for the lower section works, suggests that the engineered clay material is consistent in nature, and has yielded a total of fourteen sample results (including cores taken from the two trial pads) whose permeabilities are in the range 5.0×10^{-10} m/s to 8.1×10^{-11} m/s. On the basis of the reported data, it is felt that there is a high degree of probability that the fifth core would have returned a result below the 1×10^{-9} m/s maximum permeability. The engineered clay liner (comprising the AEGB and ASL) is therefore deemed acceptable.

7 LIAISON WITH AUTHORITIES AND REPORTING

- 7.1.1 Natural Resources Wales (NRW) was informed of the commencement of work on site and were given the opportunity to visit the site throughout the works to check any aspects of the works. NRW was kept regularly informed of the site development.
- 7.1.2 Informal progress meetings were held between Stratus and Cory site personnel, at which construction, design, and CQA issues were discussed.
- 7.1.3 As a visual record of the works, the CQA Engineers supervising the works kept on-going photographic records. Appendix 9 represents a selection of photographs showing different aspects of the construction works.
- 7.1.4 The CQA Engineers maintained daily records throughout the duration of the works. These daily records highlighted any problems encountered, the solutions adopted, and the detailed day-to-day site operations. The daily records are presented in Appendix 10.

8 CONCLUSIONS

- 8.1.1 PREPARATORY EARTHWORKS – The preparatory earthworks were carried out to the lines and levels indicated on the Design Drawings, and the formation was prepared in accordance with the CQA Plan.
- 8.1.2 GROUNDWATER COLLECTION SYSTEM – The groundwater collection system was installed in accordance with the Design Drawings. The manufacturer's quality assurance certificates and results of laboratory testing show that the geocomposite incorporated into the works conforms to the requirements of the CQA Plan.
- 8.1.3 ENGINEERED CLAY LINER – The engineered clay liner has been placed and compacted in accordance with the CQA Plan. All compliance testing indicates that the emplaced clay liner achieves the values specified in the CQA Plan.
- 8.1.4 The construction of Cell 3 Western Sidewall (Upper Section) at Hafod Quarry Landfill Site has been carried out satisfactorily and in accordance with the approved CQA Plan.

APPENDIX 1 : AS-BUILT DRAWINGS

APPENDIX 2 : NRW CORRESPONDENCE

APPENDIX 3 : MATERIALS RECEIVED AND MQC CERTIFICATES

APPENDIX 4 : CQA RESULTS SUMMARY

APPENDIX 5 : GEOSYNTHETIC CONFORMANCE TESTING RESULTS

APPENDIX 6 : ENGINEERED CLAY LINER – ON-SITE TESTING RECORDS

APPENDIX 7 : ENGINEERED CLAY LINER – LABORATORY CLASSIFICATION RESULTS

APPENDIX 8 : ENGINEERED CLAY LINER – LABORATORY PERMEABILITY RESULTS

APPENDIX 9 : PHOTOGRAPHIC RECORD

APPENDIX 10 : DAILY SITE RECORDS