WITHYHEDGE LANDFILL

CELL 8 CAPPING AND RESTORATION SCHEME

Specification & Construction Quality Assurance Plan

Report Number 2431r1v1d0324

Commissioned by

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1 INTRODUCTION

1.1 General Detail

This specification and CQA Plan covers the capping works for Cell 8 at Withyhedge Landfill as part of the progressive landfill restoration.

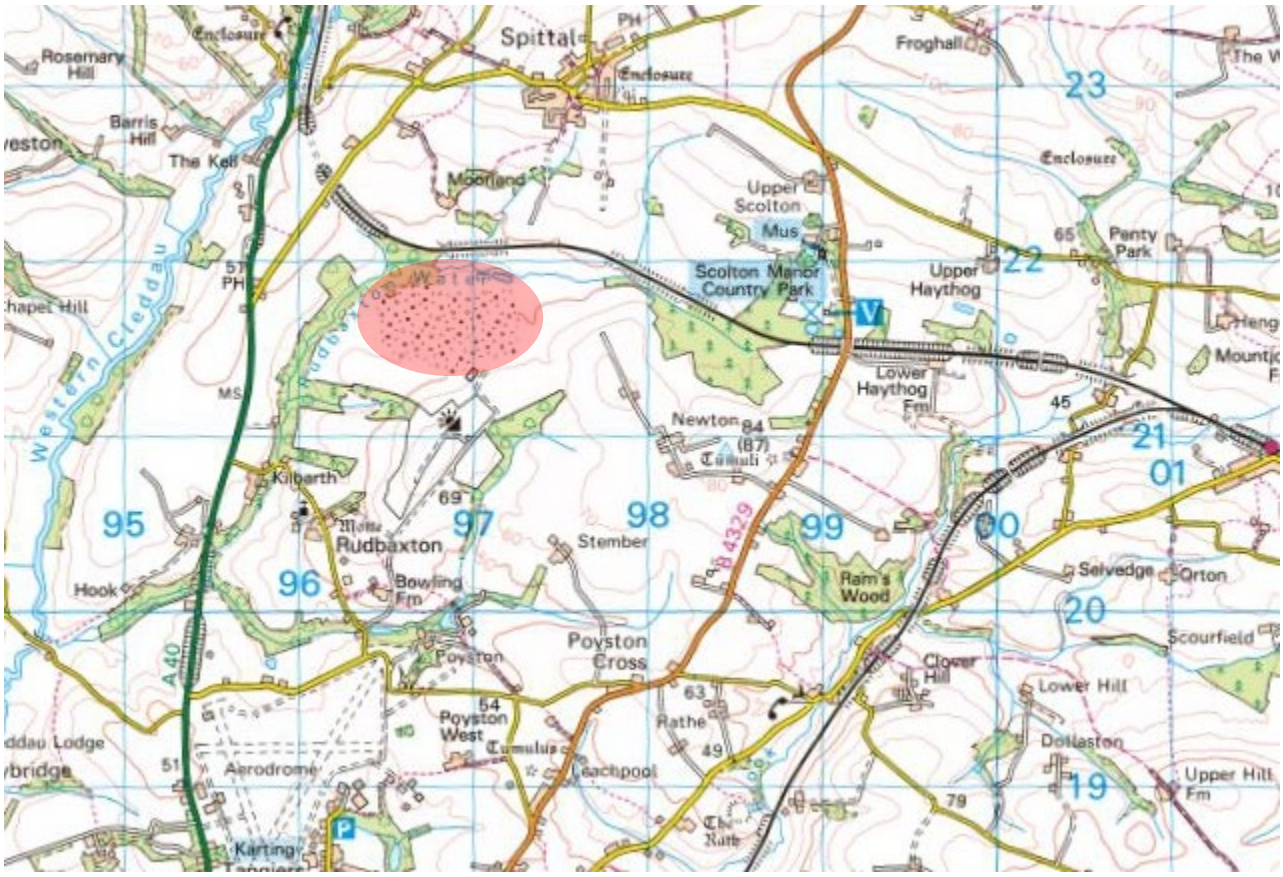
The preparation and capping of the cell will comprise:-

- Placement of a regulating layer over the reprofiled waste.
- Installation of a 1mm LLDPE cap over the area.
- Installation of 7S250D/NW8 surface water drainage geocomposite over cap.
- Placement of restoration soil over the area.

1.2 Cell 8 Location

The location of Withyhedge landfill is shown on Figure 1-1 whilst the location of the cell within the landfill is shown on Drawing 1. The areas to the north and east of Cell 8 are occupied by restored landfill whilst the land to the west is currently undeveloped but lies within the permit area and will eventually be covered with future landfilling. A temporary LLDPE cover may be placed over these slopes to exclude oxygen from the wastes and to reduce infiltration and leachate production. The requirement for a temporary capping system will be dependant on anticipated filling rate of proposed Cell 9. The temporary cover lies outside the scope of this CQA document which is for the permanent capping area.

Figure 1-1 Site Location Plan



1.3 The Works

The works comprise the capping of the available part of Cell 8. Because of the necessity to create side slopes the capping for Cell 8 is only partly over the footprint of Cell 8, with parts of it over earlier cells. It is anticipated that the whole of this area will be available for capping in the autumn of 2024, though the northern part may be available sooner as it is intended to progressively cap the cell from north to south. The oblique aerial view of the site on Figure 1-2 shows the Proposed Cell 8 Capping area in red with the 2024 capping of Cells 6 & 7 shown in Blue.

Figure 1-2 Cell 8 Works Area

1.4 The Engineer

The Designer and Engineer for the Works as appointed by Resources Management UK Ltd is Ewan Thomas, Geotechnology Limited, Ty Coed, Cefn-yr-Allt, Aberdulais, Neath. The Engineer has delegated day to day supervision and quality responsibility to the CQA Engineer.

1.5 Construction Quality Assurance

This method statement forms part of the Specification for the construction of a landfill liner and leachate drainage system for the Cell 8 capping scheme.

The measure of a successful outcome for the project is acceptance of CQA validation of the Works by the Natural Resources Wales (NRW). The CQA Engineer shall undertake the tasks specified in this document to ensure that the highest standards of performance are met, and that the lining system is satisfactory in every respect.

This CQA statement describes the functions of the CQA Engineer for the construction of the liner system including the minimum required quality assurance testing regime. The Engineer has developed a suitable CQA approach which is practical, achievable and ensures the highest standards of environmental protection. The Engineer shall ensure that a qualified CQA Engineer is present on site to provide full time supervision and quality assurance of the capping works in accordance with this CQA statement to confirm compliance with the Specification.

The Engineer will produce and submit a validation report upon completion of the whole or part of the proposed Works as required.

Staff from Geotechnology shall act as the CQA Engineer and shall carry out Construction Quality Control during the construction of the cell. All personnel shall have relevant experience in landfill construction and earthworks control. The anticipated personnel to be involved in the works are listed below:

Ewan Thomas
Arwel Jones
Ben Rees
Keir Thomas

The CVs of the proposed Geotechnology CQA engineers are included in Appendix A.

The main duties of the CQA Engineer shall be:

- to supervise the construction of the cell liner to confirm compliance with all conformance aspects of the Specification;
- to assess the Contractor's documentation for material suitability and arrange CQA testing
- to undertake all surveying or other such procedures involved in the lining system control;
- to keep full records of all site operations, testing and site conditions.

Only staff approved by NRW shall form the CQA Team. Proposed changes to the CQA staff shall be notified to the NRW along with CC's and will not attend site until approved.

The CQA Engineer shall refer any design changes and changes to drawings to the NRW for approval.

The CQA Engineer shall inform the NRW prior to the commencement of work on site.

The CQA Engineer shall review the Contractor's method statements for each element of the works, provide acceptance to the Contractor following any revisions that may be necessary.

The Geotechnology CQA Engineer shall report daily to the Engineer and report any unusual or unexpected occurrences immediately for discussion and/or direction.

The CQA Engineer shall keep and maintain a daily record of the progress of the Works, which shall include but shall not be confined to the list of items below. The records will be made available for inspection by representatives of NRW.

a. date
b. weather conditions
c. delivery of materials
d. plant and labour
e. roll numbers deployed
f. panels installed
g. areas of non-conformance
h. clay placement/compaction/in situ testing
i. samples taken
j. repairs
k. CQA installation checklist
l. site meetings
m. progress photographs (which shall record all major construction elements of the project)

The daily records shall be used to provide certification of the preparatory and engineering works and shall be made available to NRW when required.

Staff from NRW shall be given the opportunity to visit the site throughout the work to appraise themselves of progress and check any of the items being measured. The CQA Engineer shall keep NRW updated as to the progress of work on site upon request. The CQA Engineer shall liaise with visiting NRW staff.

All laboratory testing shall be undertaken by laboratories specifically accredited by UKAS for the test being undertaken unless otherwise agreed by the CQA Engineer and NRW

2 GENERAL SPECIFICATION

2.1 Scope of Works

The Works will be completed within a strict Construction Quality Assurance framework. The Contractor shall take all necessary measures to enable the Engineer to make a successful submission to Natural Resources Wales. The Contractor shall facilitate any requirement in this Specification for the Engineer/Inspector to undertake tasks which ensure that the highest standards of performance are set, and that the lining system is satisfactory in every respect.

2.2 Programme of Works and Constraints

The Works shall be carried out in general accordance with the programme set out below:

- Deposition of wastes to meet proposed waste profile.
- Placement of a regulating layer over the profiled waste.
- Installation of a 1mm LLDPE cap over the area.
- Installation of 7S250D surface water drainage geocomposite over cap.
- Placement of restoration soil over the area.

The following Site working hours shall be applicable to this contract:

0700 to 1900	Monday to Friday
0700 to 1730	Sat, Sun and Bank Holiday

2.3 List of Contract Drawings

The Works shall be executed in accordance with the following Drawings:

Table 2-1 Drawings

2350/1	Existing Topography
2350/2	Proposed Top of Waste Contours

If deemed necessary, the Engineer shall issue extra drawings to clarify any part of the Works. In the event of a drawing revision, the Contractor shall forward written confirmation notifying the Engineer that his site staffs are working to the latest revision. In the event that the Drawings, Bill of Quantities and/or Specification conflict then the Contractor must notify the Engineer immediately in writing requesting clarification on how to proceed. Upon receipt of such request the Engineer shall instruct the Contractor within 48 hours as to how to proceed, with the Contractor acknowledging said instruction in writing within 7 days.

2.4 Survey Management and Control

The Contractor shall be responsible for ensuring that the Works are completed accurately to the Drawings provided using a combination of conventional dgps topographic survey and gps machine control technology. The CQA Engineer will undertake surveys to confirm that the Works have been installed to the Specification.

The Engineer reserves the right to carry out any surveys he sees fit to check the accuracy of the Contractor's work.

The Contractor shall state the gps machine control equipment he plans to use and shall state the tolerances to which the system works.

Twice the vertical tolerance shall be added to the requirement for layer thicknesses in order to ensure that a minimum of the correct thickness is obtained.

All surveys shall be related to the National Grid.

The Engineer shall provide to the Contractor on Site survey control information and digital surface models of:

- Top of Waste
- Top of Regulating Layer
- Top of Restoration Soil (beneath topsoil)

Permanent Ground Markers have been established within the Site boundaries but outside the area of the Works or landfill operations, such that they are not affected by the Works. The co-ordinates and level values shall be established and agreed with the Engineer.

The Contractor shall ensure that his operations do not interfere with, or damage, the Permanent Ground Markers.

The CQA Engineer shall keep updated schedules and drawings of all Permanent Ground Markers related to the Ordnance Survey National Grid used in setting out.

The following surveys shall be required and will be undertaken by the CQA Engineer before acceptance of the successive layer:

Table 2-2 Topographic Survey Requirements

	Location	Frequency	Timescale	Format
1	Topographical survey prior to earthworks	All survey features to accurately represent the Site prior to works commencing.	Results shall be given to the Engineer within 48 hours of the survey taking place	3 dimensional .dwg file or 3D topographic model on Propeller system
2	Top of Waste	Points on a 10 metre square grid plus all valleys, ridge lines and changes in gradient.	Results shall be given to the Engineer within 48 hours of the survey taking place	3 dimensional .dwg file or 3D topographic model on Propeller system
3	Top of Regulating Layer	Same points on a 10 metre square grid as used in survey 2 above plus all valleys, ridge lines and changes in gradient.	Results shall be given to the Engineer within 48 hours of the survey taking place	3 dimensional .dwg file 3 dimensional .dwg file or 3D topographic model on Propeller system
4	As built layout surveys for FML and Geocomposite	To be agreed with the Engineer on Site but to include material extent, all panel edges, patch repairs, anchor trenches, changes in slope gradient	Results shall be given to the Engineer within 48 hours of the survey taking place	3 dimensional .dwg
5	Top of Restoration Soil	Same points on a 10 metre square grid as used in 2 above and every 10 metres	Results shall be given to the Engineer within 48 hours of the survey taking place	3 dimensional .dwg file or 3D topographic model on Propeller system

The Contractor shall note that no progress shall be allowed on subsequent capping elements until proof is received that the total thickness of the layer being considered is approved.

The CQA Engineer shall undertake the surveying of the cell construction utilising a TopCon rtk dGPS system operating from a fixed local base station or a Network correction. In the event that a network correction is being used the survey shall be immediately preceded by a survey of the control stations and a further control station observation shall be made at the end of the survey.

2.5 Liner Interface Testing (Large scale Shear Box)

The CQA Engineer shall be provided with interface shear and adhesion tests comprising large scale shear box tests (to standard ASTM D5321, D6243) on the following interfaces of the lining and drainage system:

Regulating Layer / Engineered Liner
Engineered Liner / Restoration Soil

The Contractor shall arrange for testing at three different normal pressures. The interface tests shall be completed at three different moisture contents when one interface is a clay material. If clay sources change during the Works or multiple sources are proposed further testing shall be completed.

If construction proceeds in advance of receipt of the testing results, it shall be entirely at the Contractors risk.

2.6 Services/Installations

All known services and utilities will be removed by the site operator prior to the works.

2.7 Environmental Considerations

2.7.1 Mud

The Contractor shall use their best endeavours to ensure that the Site entrance, site haul roads, private and public highways remain free from the deposition of mud from his vehicles. The Contractor's vehicles shall use the existing wheelwash facility. Notwithstanding this should any of the Contractor's vehicles deposit mud in any of the above areas the Contractor shall arrange for its immediate removal.

2.7.2 Dust

The Contractor shall use their best endeavours to ensure that all working areas, temporary haul roads, Site entrance, private and public highways remain free from dust. Water bowsers and mechanical road sweepers shall be deployed during prolonged periods of dry weather and at the Engineer's discretion.

2.7.3 Noise on Site

The Contractor shall employ the best practicable means as defined in the Control of Pollution Act 1974 to minimise noise and vibration resulting from his operations. Particularly the Contractor shall ensure that all vehicles, plant and machinery used during the operations are fitted with effective exhaust silencers and that all parts of such vehicles, plant and machinery are maintained in good repair. Additionally, the engines of vehicles and plant which will be out of use for a period exceeding 15 minutes shall be turned off, or where this is impracticable, shall be throttled back to a minimum.

2.7.4 Water

The Contractor shall ensure that all areas of the Works remain free from surplus water impoundment, by providing the Contract with appropriate pumps and ancillary equipment. Casual standing water shall be pumped to the adjacent Lagoon via a route agreed with the Engineer on site.

The Contractor shall ensure that no runoff from his works is discharged from the Site untreated.

The Contractor shall undertake adequate temporary works to protect the leading edges of the lining system. Damage caused to the lining system caused by a lack of protection shall be repaired at the Contractors expense.

2.7.5 Nuisance to Residents

The Contractor shall use his best endeavours to prevent his operations becoming a nuisance to the local residents. If, for any reason, complaints from the local residents occur, these shall be duly recorded and brought to the immediate attention of the Contractor who shall agree with the Engineer to review, and if appropriate, revise his method of working.

2.7.6 Escape of Leachate

The Contractor shall exercise extreme care when working adjacent to the existing Cells and shall not cause extra perforations to occur within any capping / lining materials. Should there be any issues of leachate the Contractor shall manage the issues by collecting the leachate and pumping it to Cell 8 or such other location as may be approved by the Engineer.

2.8 Site Security

The Contractor shall be responsible for organising any security which they deem to be necessary. Resources Management UK Ltd will not be employing a watchman to attend the Site during all non-working hours. A night watchman shall be permitted access to the Contractor's compound and Portacabin. The Contractor's security arrangements shall not compromise the Resources Management UK Ltd security system. All arrangements including nominated Site gate key holder, name of security company, hours of cover and procedures shall be agreed with the Engineer in writing.

2.9 Contract Organisation/Definition of Site Area

The Contract shall be organised as follows:

Employer	Resources Management UK Ltd
Design Engineer	Geotechnology Ltd
Engineer	Ewan Thomas, Geotechnology Ltd
CQA Engineer	Nominated staff, Geotechnology Ltd
Main Contractor	To be announced
Lining Sub-contractor	Celtic Lining Ltd

The Engineer shall make arrangements with Resources Management UK Ltd for the Contractor to have sole possession of the area of the landfill site in which the Works are taking place for the duration of the Works. However, the Contractor shall note that there will be areas of the landfill site into which he may be required to enter for the purposes of carrying out works under this Contract, which are and will remain under the control of Resources Management UK Ltd.

The Contractor shall ensure that operatives under his control conduct themselves according to the procedures and safety rules in force on those areas. The Contractor and his staff shall participate in joint safety inductions, which shall be arranged by Resources Management UK Ltd for landfill site procedures and the Contractor shall arrange joint inductions for his staff and Resources Management UK Ltd staff for construction site procedures.

The area of the Site under the control of the Contractor shall be delineated using high visibility bunting or similar material approved by the Engineer supported on road pins or wooden fence posts. All this material shall be removed at the end of the Contract.

The Contractor shall afford full and free access to the Employer or any of his agents or contractors employed in carrying out any supplementary works on the Site. The Contractor shall note that in matters of judgement on compliance of any of the Contractor's activities with the Waste Management Site Licence the Site Manager shall have absolute authority and his decision will be final.

No claim will be entertained in respect of any delay suffered by the Contractor due to his nonexclusive use of parts of the Site or his non-compliance with the Environmental Permit.

The Contractor shall provide a Site Supervisor with adequate experience of similar works who shall control all aspects of the Contractor's operations on site for the duration of the Contract and shall liaise on a daily basis with the Engineer's Representative on site.

Progress meetings shall be held weekly, or such other frequency as agreed. The meetings shall be attended by the Employer, Engineer, Contractor and relevant subcontractors, if appropriate, to discuss both formally and informally the progress of the Works so as to ensure good communications and the smooth running of the Contract. These meeting shall be minuted by the Engineer and actions allocated accordingly.

2.10 Accommodation for the CQA Engineer

The Contractor shall supply suitable site accommodation for the use of the CQA Engineer.

2.11 Technical Query Register

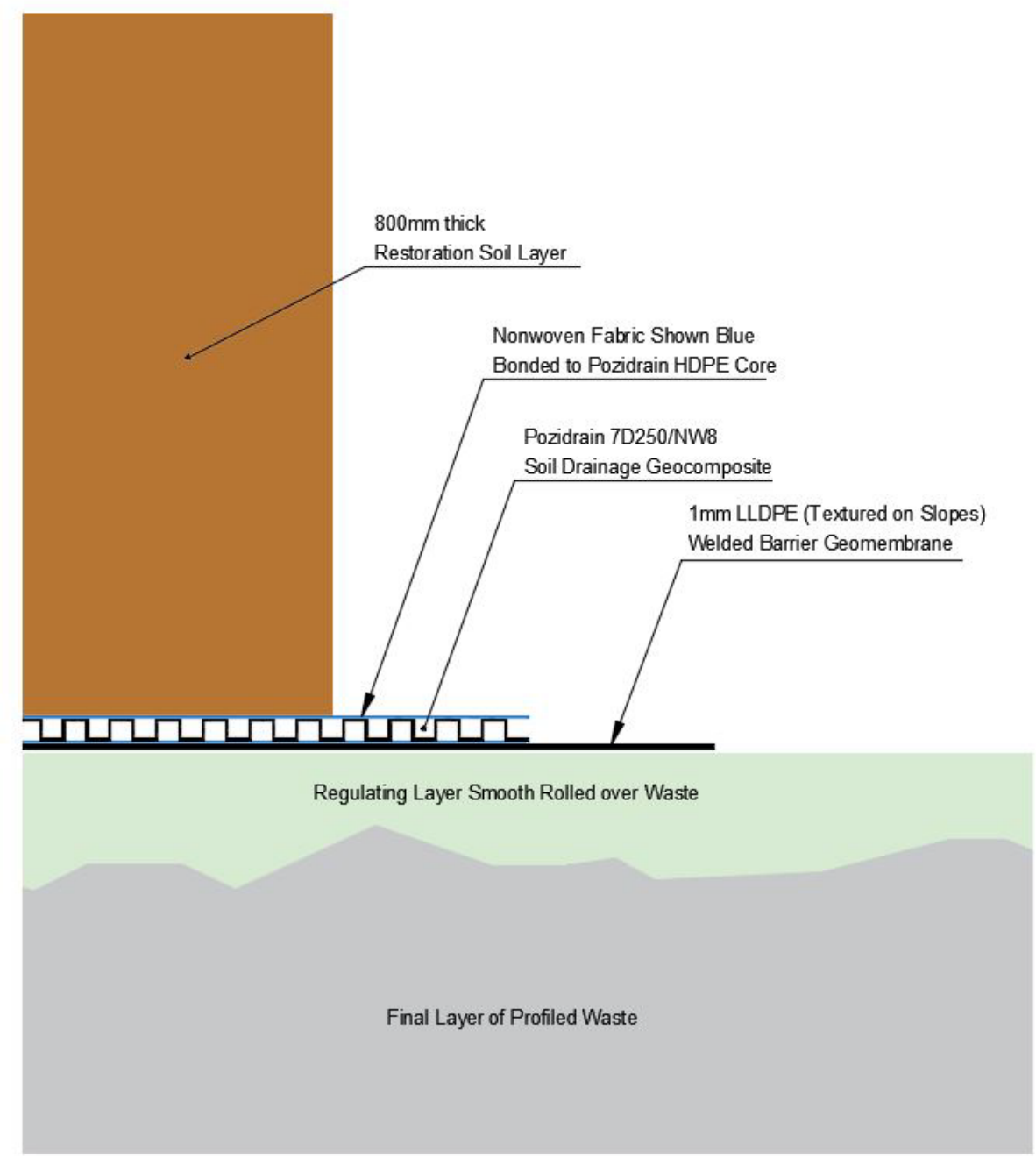
The Contractor shall prepare a Technical Query register. This register shall be the early notification device for all construction queries, requests for additional information and notifications of any intention for claims for extensions of time etc.

3 MATERIAL SPECIFICATION

This section contains a specification for the material properties of each component of restoration capping works.

Each element of the design is described in sequential order with respect to the construction of the platform and overlying cap, based on a bottom-up construction. It therefore commences with the profiling earthworks, infilling (where required), the placement of the regulating layer, capping geo-synthetics, surface water collection system and finally the restoration soils. Where required, the pre-installation testing regime for the materials is also specified.

Figure 3-1 Schematic Cross Section Through Cap



3.1 Fill Materials

Where the pre-commencement topographic survey has revealed the need for filling, fill materials will be placed to achieve the capping design levels. The fill will comprise fresh wastes.

3.1.1 Testing

No testing is required of the waste fill.

3.2 Regulating Layer

The regulating layer will be placed over the top of waste surface, covering the waste mass. The regulating layer is required to form a blinding over the underlying wastes to provide a smooth surface onto which geo-synthetic materials can be placed.

The regulating layer will comprise natural weathered shale excavated from the on-site borrow pit.

The following materials will not be accepted within the regulating layer:

a) peat, timber, or any other organic material (<5%)
b) frozen materials
c) waste
d) metal, plastic and any other man made materials likely to degrade the finished surface.

3.2.1 Testing

Regulating layer testing will comprise particle size distribution. The testing will be undertaken on samples recovered from the surface in accordance with BS EN 933-1 1997 as indicated in Table 3-1 at a frequency of 1 test per 1000 tonnes of fines used.

Table 3-1 Regulating Layer Specification Requirements

PROPERTY	TEST STANDARD	BS TEST SIEVE(mm)	TYPICAL PERCENTAGE PASSING (%)
Particle Size Distribution	BS EN 933-1 1997	63	100
		40	50-100
		10	50-100
		2	30-100
		0.063	10-70

3.3 Capping Geomembrane

The capping geomembrane for Cell 8 will comprise 1mm LLDPE. The membrane should be free from all blemishes, abrasion or other surface imperfection and conform to the requirements set out in Table 3-2 below.

Table 3-2 Specification for Textured LLDPE Membrane

PROPERTY	TEST METHOD	REQUIREMENTS	MQC TEST FREQUENCY
Thickness (min)	ASTM D5994	0.95mm (min. ave) 0.90mm (lowest of 8 of 10) 0.85mm (lowest individual of 10)	Per roll
Density (max)	DIN EN ISO 1183-1/A	0.939g/ml (maximum)	Per 90,000kg
Asperity Height (min)	GRI-GM 12	0.2mm (min. ave)	Every second roll
Tensile Properties average of 5 MD and 5 XMD Strength at Break (min) Elongation at Break (min)	DIN EN ISO 527-3 (Type 5:100mm/min; Lo = 50mm)	 12 MPa 250% (min. ave)	 Per 90,000kg Per 90,000kg
Tear Resistance (min. ave)	DIN ISO 34-1/B	100N (min. ave)	Per 20,000kg
Puncture Resistance (min. ave)	ASTM D4833-07	300N (min. ave)	Per 20,000kg
Carbon Black Content (range)	ASTM D1603 (ASTM D4218 if correlation with D1603 can be established)	2.0% min to 3.0% max	Per 20,000kg
Carbon Black Dispersion (min)	ASTM D5596	9 of 10 in Category 1 or 2 and 1 in Category 3	Per 20,000kg
Oxidative induction time (min)	Standard OIT by ASTM D3895	100minutes (min. ave)	Per 90,000kg
UV Resistance	High pressure OIT by ASTM 5885, GRI-GM11	35% retained after 1600hrs (min. ave)	Per batch

3.3.1 Proposed Material Datasheet

The Contractor shall supply all the technical information from the geomembrane manufacturer for the geomembrane he wishes to use. This information shall be forwarded to the CQA Engineer for approval, prior to any material being purchased. The geomembrane shall meet or exceed the minimum Specification given in Table 3-2.

3.3.2 Manufacturers Quality Control Data

Prior to installation, the manufacturer shall provide test results for all batches of materials delivered to the site demonstrating compliance with the Specification.

3.3.3 Geomembrane Conformance Testing

Geomembrane materials delivered to site shall be tested as described in Section 4.2 to confirm conformance with the specification requirements.

3.4 Drainage Layers

The drainage layers will comprise a geo-composite material for the collection of water percolating through the restoration soil.

3.4.1 Drainage Geo-composite

The design of the cap requires the placement of a drainage geo-composite placed on top of the 1mm LLDPE capping geomembrane layer. Prior to the placement of the final restoration soil, the drainage geo-composite will be placed directly on top of the 1mm geomembrane. The material will also serve as a protection layer to the capping geomembrane from the overlying restoration soil and mechanical damage during soil placement.

The geo-composite layer shall comprise Pozidrain 7S250D/NW8 manufactured by ABG Limited. The suffix D relates to the fact that the cuspated core is bonded on both sides to a geotextile. The Pozidrain will be placed on the slopes around the plateau areas.

The drainage geo-composite shall have the following properties:

Table 3-3 Drainage Geo-composite Properties

PROPERTY	STANDARD	UNIT	TYPICAL MEAN VALUE	ALLOWABLE TOLERANCES TO MATERIAL PROPERTIES
Thickness @ 2kPa	BS EN ISO 9863-1	mm	8.8	+/-10%
Static CBR Puncture resistance	BS EN ISO 12236	N	3900	-20%
In plane Water Flow (md) @ 100 Kpa Pressure – Hydraulic Gradient = 1.0	BS EN ISO 12958	l/m/sec	1.9	-0.35%

i) Proposed Material Datasheet

The Contractor shall supply a technical datasheet from the geo-composite manufacturer. This information shall be forwarded to the CQA Engineer for approval, prior to any material being purchased. The geo-composites shall meet or exceed the Specification given in Table 3-3.

ii) Manufacturers Quality Control Data

When approved, but before it is brought to site and prior to it being installed, the manufacturer shall provide test results for all batches of materials that will be delivered to the site demonstrating compliance with the Specification. This is deemed to be the Manufacturer's Quality Control data. The MQC documentation shall include the following:

- Roll identification Number
- Geotechnical Properties and Testing Frequency
- Mechanical Properties and Testing Frequency
- In Plan Water Flow Properties and Testing Frequency

iii) Geo-composite Conformance testing

When delivered to site geocomposite materials will be sampled and tested in accordance with Section 4.3 to demonstrate conformance with the specification.

3.5 Restoration Soils

The soil used to form the restoration layer shall be a natural geological material (soil or crushed rock) and shall conform with the requirements contained in Table 3-4 below. In the event that available sources have coarser constituents then either the soils will be placed above a blinding layer meeting this grading or a cylinder test will be undertaken to evaluate suitability. Soils may be site won or imported. In the event that the materials are imported from sites that are not greenfield sites then the chemistry of the soils shall be shown to be suitable for the proposed works by a review of source contamination reports.

Table 3-4 Restoration Soil Requirements

Material Property	Test Method	Requirement
Particle Size Distribution	BS 1377 Part 2 Method 9	Material passing sieve: 125mm 100% 63mm 80 to 100% 40mm 60 to 100% 10mm 20 to 100% 2mm 10 to 70% 0.6mm 10 to 50%

3.5.1 Testing

No testing of site won soils is proposed but imported soils shall be shown to confirm conformance with Table 3-4 by sampling in accordance with Section 4.4

4 SAMPLING AND TESTING REQUIREMENTS

4.1 Regulating Layer Fill Material

The potential source of the regulating layer fill shall be evaluated by undertaking a series of three source evaluation tests. Should the material conform with Section 3.1 then the material can be brought to site and thereafter sampled at a frequency of 1 sample per 1000 tonnes delivered.

The regulating layer fill shall be tested in accordance with the requirements of Table 4-1.

Table 4-1 Regulating Layer Testing Requirements

Material Property	Test Method	CQA Test Frequency
Particle Size Distribution	BS EN 933-1 1997	1/1000 tonnes

4.2 Geomembrane Conformance Sampling and Testing

The Contractor will be required to cut 1m wide conformance samples from the full width of rolls:

- At a frequency of 1 sample per 5000m^2 of membrane delivered to site from within the same batch
- So that rolls from every batch of membrane are sampled

The contractor will be required to submit one part of each sample to an approved independent laboratory for quantitative analysis and will only be permitted to incorporate materials into the works if this testing reveals that the material meets the Specification in Section 3.2 The laboratory shall be independent of the Contractor and shall be UKAS accredited for each individual test to be undertaken. All of the parameters listed in Table 4.2 shall be tested at the frequency stated. The Contractor shall furnish to the CQA Engineer a copy of the laboratory test results immediately on receipt.

In the event that a conformance test fails to meet the requirements of the Specification that roll shall be rejected and will not be incorporated into the works. The rolls numbered numerically on either side of the failed sample will then be subjected to conformance testing. This procedure will continue until the extent of the sub-specification material has been determined by bracketing. The contractor will supply any replacement rolls at his own cost. Construction of the capping membrane will not commence until the results of the conformance tests are known and have been accepted by the CQA Engineer.

Table 4-2 Textured LLDPE Geomembrane Testing Requirements

Properties	Test Method	CQA Test Frequency/Value
Thickness (min)	ASTM D5994-10	1/5000m^2
Density (max)	ASTM D1505-10/D792	1/5000m^2
Asperity Height (min)	GRI GM 12	1/5000m^2
Tensile Properties average of 5 MD and 5 XMD	ASTM D6693, Type IV 50mm gauge length at 50 mm/min	1/5000m^2
Strength at Break (min)		1/5000m^2
Elongation at Break (min)		1/5000m^2
Tear Resistance (min)	ASTM D1004-13	
Puncture Resistance (min)	ASTM D4833-07	1/5000m^2
Carbon Black Content (range)	ASTM D1603-12 (ASTM D4218 if correlation with D1603 can be established)	1/5000m^2
Carbon Black Dispersion (min)	ASTM D5596-03	1/5000m^2
Oxidative induction time (min)	Standard OIT by ASTM D3895-07	1/5000m^2

4.3 Geomembrane Seam Non-destructive Sampling and Field Testing

The Contractor shall perform non-destructive testing along the entire lengths of all field seams including patches and repairs. The Contractor shall submit to the CQA Engineer, for approval, a Method Statement detailing his proposed non-destructive test technique or techniques.

The non-destructive testing shall include as a minimum:

- Double track fusion welds – air pressure test carried out on all welds
- Extrusion welds – vacuum box test carried out on all welds

During air pressure tests the channel between the two tracks of the fusion welder shall be inflated to a pressure of between 1.9 and 2.2 bar. After an initial stabilisation period of 1 minute the pressure shall not decrease by more than 10% in 5 minutes. The pressure will be released from the opposite end of the channel to the inflation needle to verify seam continuity.

During vacuum tests a vacuum of -0.4 bar shall be applied after the box is seated over the prepared seam. The seam will be viewed for a full 30seconds before releasing the vacuum and moving along the seam. A minimum overlap of 50mm is required between adjacent box positions along the seam.

In the event of a field seam failing non-destructive testing (including the air pressure continuity test), the Contractor shall identify and repair the failed area. The Contractor shall then subject the repair to further non-destructive testing. Seams will not be accepted until they pass the non-destructive test, the qualitative destructive test and the quantitative destructive test (if relevant).

The Contractor shall advise the CQA Engineer when non-destructive testing is ready to commence and shall not perform any testing in the absence of the CQA Engineer.

4.4 Geomembrane Seam Qualitative Destructive Sampling and Field Testing

The Contractor shall cut a 25mm wide field tab from the beginning and end of each field seam and subject it to qualitative destructive testing in peel and shear modes using a suitable field tensiometer or hand tools.

The field seam will be deemed to have passed the qualitative destructive testing if:

(a) the failure occurs solely in the parent material and does not enter the seam.

The seam will be deemed to have failed qualitative destructive testing if:

(a) any of the failure enters the seam.

If the seam fails the qualitative destructive testing, the Contractor shall either:

(a) reconstruct the seam between two field tabs which have been shown to pass the qualitative destructive testing: or
(b) take further qualitative tests to identify the area of the field seam that is deemed as inadequate.

The Contractor shall undertake further qualitative testing by cutting further tabs on either side of the location of the failed field tab. The additional tabs shall be taken approximately 3 metres from the location of the failed tab. These further field tabs shall be subjected to qualitative destructive testing in accordance with the Method Statement. If both tabs pass the qualitative destructive testing, then the Contractor shall cut a laboratory sample from a section of the passed seam. If either sample fails, the Contractor shall cut and test further field tabs approximately 3 metres from the location of the failure until he can identify an area bounded by two passed field tabs.

The Contractor shall reconstruct the failed seam between the locations of the passed tabs in accordance with the Method Statement.

The CQA Engineer reserves the right to request the cutting and destructive testing of further field tabs at any locations along the length of a seam.

4.5 Geomembrane Seam Quantitative Destructive Sampling and Laboratory Testing

The Contractor shall cut laboratory samples from the field seams when instructed by the Engineer and in any case at a frequency of not less than 1 sample per 200m of seam performed by an individual machine. Where instructed by the CQA Engineer, the Contractor shall cut two samples from the field seam at the same location and provide one sample to the CQA Engineer for retention.

The Contractor shall without delay despatch a sub-sample to an approved geosynthetic laboratory for destructive testing in accordance with the Specification. The laboratory shall report quantitative results and the mode of failure for the tests carried out. The Contractor shall issue copies of the test result certificates to the CQA Engineer immediately upon receipt.

The seam will be deemed to have passed quantitative destructive testing if the:

(a) failure occurs solely in the parent material and does not enter the seam;
(b) peel strength exceeds or equals the tensile strength indicated in the specification;
(c) shear strength exceeds or equals the tensile strength indicated in the specification.

The seam will be deemed to have failed quantitative destructive testing if:

(a) any laboratory tabs fails an individual test;
(b) any of the failure enters the seam;
(c) the peel strength is less than the tensile strength indicated in the Specification;
(d) the shear strength is less than the tensile strength indicated in the Specification.

If a seam fails the quantitative destructive testing, the Contractor shall investigate the seam to each side of the failed sample. The Contractor shall cut further laboratory samples from each side of the failed section and perform laboratory tests upon them until the failed seam is bounded by two passed locations. The Contractor shall then reconstruct the failed seam in accordance with the approved Method Statement.

Table 4-3 Geomembrane Seam Sampling and Testing Requirements

Properties	Test Method		CQA Test Frequency
Shear Strength	ASTM 6392	N/mm	1 per 200m
Shear Elongation	ASTM 6392	%	1 per 200m
Peel Strength	ASTM 6392	N/mm	1 per 200m
Peel Separation	ASTM 6392	%	1 per 200m

4.6 Geocomposite Drainage Materials

The Contractor will be required to cut 1m wide conformance samples from the full width of rolls at a frequency of 1 sample per 2500m^2 of geocomposite delivered to site.

The contractor will be required to submit one part of each sample to an approved independent laboratory for quantitative analysis and will only be permitted to incorporate materials into the works if this testing reveals that the material meets the requirements of Section 3.3. The laboratory shall be independent of the Contractor and shall be UKAS

accredited for each individual test to be undertaken. All of the parameters listed in Table 4-4 shall be tested at the frequency specified. The Contractor shall furnish to the CQA Engineer a copy of the laboratory test results immediately on receipt.

Table 4-4 Geocomposite Drainage Layer Testing Requirements

PROPERTY	STANDARD	UNIT	CQA Test Frequency
Thickness @ 2kPa	BS EN ISO 9863-1	mm	1/5000m2
Static CBR Puncture resistance	BS EN ISO 12236	N	1/5000m2
In plane Water Flow (md) @ 100 Kpa Pressure – Hydraulic Gradient = 1.0	BS EN ISO 12958	l/m/sec	1/5000m2

In the event that a conformance test fails to meet the requirements of the Specification that roll shall be rejected and will not be incorporated into the works. The rolls numbered numerically on either side of the failed sample will then be subjected to conformance testing. This procedure will continue until the extent of the sub-specification material has been determined by bracketing. The contractor will supply any replacement rolls at his own cost. Construction of the drainage layer will not commence until the results of the conformance tests are known and have been accepted by the CQA Engineer.

4.7 Restoration Soil

The potential source of restoration soils shall be evaluated by undertaking a series of three source evaluation tests if the materials are not site won restoration soils from previously restored areas. Site won materials from new sources shall be subject to three tests to confirm compliance with the grading requirements and then at a frequency of one test per 2000tonnes. For imported soils the soils shall be subject to a source evaluation report, meeting the chemical and physical properties of the scheme. If accepted for import, the soils shall be sampled and tested for physical and chemical properties at one test per 2000t.

The restoration soils shall be tested in accordance with the requirements of Table 4-5.

Table 4-5 Restoration Soil Testing Requirements

Properties	Test Method	Testing Requirements
Particle Size Distribution (all soils except existing capping soils)	BS1377 Part 2 Method 9	1/2000 tonnes
Chemical Test (imported soils only)	Inert WAC	1/2000 tonnes

5 MATERIAL STORAGE AND HANDLING

This section details the storage and handling of the materials specified in Section 3.

5.1 Fill Material, Regulating Layer and Restoration Soils

5.1.1 Established Practice

Typically soil materials are to be excavated, stored and placed according to established earthworks practice. Unacceptable material may include natural materials including peat, vegetative matter, frozen soils, combustible matter and highly plastic clays or man-made materials which are considered to be contaminated or hazardous, or any materials that do not conform with the specification set out in Section 3.

The Contractor shall employ only plant and working methods which are suited to the materials to be handled and traversed. The Contractor shall also be responsible for maintaining the nature of the acceptable material so that when it is placed and compacted it remains acceptable in accordance with the Contract.

The haulage of material to areas where they are required shall only proceed when sufficient spreading and compaction plant is operating at the place of deposition to ensure compliance with Clause 612 of the Specification for Highway Works.

5.1.2 Segregation

If, during the capping works, a combination of acceptable and unacceptable materials is found, a clear segregation of both shall be made in terms of their placement and storage. Only acceptable materials significantly free of contamination from unacceptable materials shall be included into the permanent works.

5.1.3 Identification

The identification of acceptable materials (for the appropriate end use) shall be made on site, in conjunction with the CQA Engineer. Where appropriate, the required testing shall be made to ensure the materials conform with that detailed in Section 3.

Once the acceptable materials have been identified, classification can be made in accordance with the Specification for Highway works Table 6/1 and a method related compaction applied in accordance with Table 6/4.

5.1.4 Soil Stockpiles

Soils recovered from previous capping areas (certain areas are to be stripped of previous capping soils to facilitate extension of the waste mass into new cells) may be stockpiled within the site. Site won previously unused soils will be used direct from their current location. Imported soils are to be stockpiled in a designated area to keep them segregated from other soils. They will remain in the segregated area pending receipt of the validation tests results. The imported restoration soil stockpile may be a tax free zone, subject to WRA approval.

5.2 Capping Geomembrane

The membrane liner shall be transported to site, handled and stored in accordance with the manufacturer's recommendations. A copy of the manufacturers handling and storage requirements will be made available to the CQA Engineer prior to or upon delivery of the material. Membrane rolls shall be lifted only by using spreader bars linked to a roll spindle. The use of lifting straps, chains, or direct lifting by a forklift are all strictly prohibited. Rolling along the ground surface is not permitted.

All rolls of delivered geomembrane shall be accompanied by summary documentation stating the details below. The capping geomembrane shall be delivered in the manufacturers packaging and each roll of membrane delivered to site must have affixed to it a label, complying with BS EN 30320, detailing the following:-

- The manufacturers name, address and telephone number.
- Product identification (product manufacturer's name address and telephone number, production plant location, product name and type).
- The geomembrane batch and roll number.
- The roll length and width in metres.
- The roll weight in kilograms.
- The polymer type.

Rolls shall be stored on prepared flat, even ground, surfaced with a blinding of clean sand dust. Each roll of geomembrane delivered to site shall be identified with the name of the manufacturer, the product name and type, the thickness, the batch number, the length and the date of manufacture. Each roll shall have a unique identification number. The rolls shall be logged and inspected as they are offloaded at the site and recorded on a roll goods inspection sheet.

A visual inspection of the rolls shall take place immediately after delivery. Any damaged rolls will be clearly identified and regarded as a non-conforming product. Complete records of all damaged rolls (on delivery) shall be made and copies provided to the CQA Engineer. Partially damaged rolls, on later inspection may be incorporated into the permanent works, only on the basis that the damaged portion is cut-off or removed. Details of such action would be agreed with the CQA Engineer.

5.3 Drainage Geo-composites

The geo-composite shall be transported to site, handled and stored in accordance with the manufacturer's recommendations. A copy of the manufacturers handling and storage requirements will be made available to the CQA Engineer prior to or upon delivery of the material. Membrane rolls shall be lifted only by using the lifting straps provided.

All rolls of delivered geo-composite shall be accompanied by summary documentation stating the details below. The geo-composite shall be delivered in the manufacturers packaging and each roll of composite delivered to site must have affixed to it a label, complying with BS EN 30320, detailing the following:-

- The manufacturers name, address and telephone number.
- Product identification (product manufacturer's name address and telephone number, production plant location, product name and type).
- The geo-composite batch and roll number.

- The roll length and width in metres.
- The roll weight in kilograms.

Rolls shall be stored on a prepared ground surface which should be flat, even ground, surfaced with a blinding of clean aggregate material. Each roll of geo-composite delivered to site shall be identified with the name of the manufacturer, the product name and type, the batch number, the length and the date of manufacture. Each roll shall have a unique identification number. The rolls shall be logged and inspected as they are offloaded at the site and recorded on a roll goods inspection sheet.

A visual inspection of the rolls shall take place immediately after delivery. Any damaged rolls will be clearly identified and regarded as a non-conforming product. Complete records of all damaged rolls (on delivery) shall be made and copies provided to the CQA Engineer. Partially damaged rolls, on later inspection, may be incorporated into the permanent works, only on the basis that the damaged portion is cut-off or removed. Details of such action would be agreed with the CQA Engineer.

6 CONSTRUCTION OF THE WORKS

6.1 Setting Out

The CQA Engineer shall be responsible for setting out the Works using the dGPS RTK Rover with a digital terrain model of the works on the field controller. Plant and equipment used for profiling works and for the spreading of soils will be controlled by GPS machine control.

6.2 Profiling Works

Profiling will comprise localised cutting and filling to achieve the profile as shown on Drawing 2.

6.2.1 Waste Profiling

Waste will be profiled by excavating where the survey reveals them to be too high and filling where levels are too low. Wastes will be placed with the gps controlled dozer to the correct levels before covering with regulating layer materials. The completed section will then be compacted with a smooth drum compactor to establish a firm, unyielding, smooth regulating layer surface to accept the membrane barrier.

6.2.2 Final Layer Acceptance

The wastes will be graded to the levels shown on Drawing 2. The material used to infill areas shall be compacted to form a tight surface able to accept the regulating layer using the Bomag landfill compactor.

The waste fill is generally not prone to derogation due to inclement weather or additional handling.

Prior to the placement of the regulating layer the surface shall be inspected by the Contractor and CQA Engineer and signed off as being satisfactory. No testing is required.

The finished waste surface shall be surveyed prior to the placement of the regulating layer.

6.3 Regulating Layer

The regulating layer shall be placed over the waste prior to compaction with a smooth roller.

Prior to placement of the LLDPE capping geomembrane, the regulating layer shall be inspected by the Contractor and CQA Engineer and signed off as being satisfactory.

6.3.1 Regulating Layer Acceptance

The regulating layer will be a smooth, unyielding surface for ready for the placement of the capping geomembrane. A final survey of the regulating layer shall be made. Key to placement (and acceptance) of the regulating layer will be the lack of abrupt changes in level and the presence of any protrusions. Geomembrane placement shall not commence until the area is released by the CQA Engineer for lining works.

6.4 Capping Geomembrane

The Contractor shall have considerable experience of installing geomembrane of the type specified for the Works. The Contractor shall submit a summary of their experience with the specified materials including an estimate of the total area installed by him in the United Kingdom over the past 12 months. The foreman of the lining crew shall have deployed no less than 50,000m^2 in a supervisory capacity. Each of the crew shall have welded no less than 10,000m^2 of LLPE membrane. Written confirmation of the foreman and crews experience is required prior to works commencing, as is the provision of copies of the proposed welder's membrane welding certificate.

6.4.1 Provisional Layout

The Contractor shall submit a sketch showing the proposed panel layout for the geomembrane. The sketches will show the Contractor's proposed start point and proposed direction of working. The Contractor shall arrange the panels so that seams are aligned parallel to the line of maximum slope (i.e. normal to contours), whenever practicable, in accordance with accepted good practice.

In order to clearly identify each panel (as laid) the installing Contractor shall use coloured markers, written in permanent ink compatible with the LLPE.

Every field LLDPE panel shall be given a unique number commencing with the nomenclature P1 for Panel 1. The installation Contractor shall ensure that the correct correlation between panel number and manufactured roll number is maintained. This is to be done by a reference table or chart completed as the LLDPE rolls are deployed.

6.4.2 Weather Conditions

Capping geomembrane deployment shall not proceed at an ambient temperature below 4.5^{0}C or above 30^{0}C. Placement and seaming shall not be performed during any precipitation, in the presence of moisture or in an area of ponded water. No deployment shall take place during periods of excessive winds, typically 20 mph in the working area. Deployment in wind speeds greater than this may take place after liaison between the foreman and the CQA Engineer. The overriding issue for capping geomembrane deployment shall be the health and safety of the installation staff and of surrounding operatives.

Weather conditions shall be recorded by the CQA Engineer as will ambient temperatures in the working area. Any significant change in weather conditions during one single day will result in additional trial seam testing.

6.4.3 Temporary Surcharge

The Contractor shall be responsible for the geomembrane at all times during the Contract and shall adopt whatever measures are necessary to ensure its stability and prevent it from wind damage.

These measures shall include the use of sufficient temporary surcharge in the form of durable sandbags, tyres or similar weights without sharp protrusions placed on the geomembrane immediately after laying and before seaming in order to prevent slipping and damage by wind or other agents prior to covering. Any problems arising from the

Contractor's failure to secure the geomembrane during the Contract shall be remedied at the Contractor's expense.

The contractor's attention is specifically drawn to the phenomenon of liner uplift caused by suction resulting from wind. Even when completed, the liner will still require ballasting to prevent wind damage.

After placement of the liner a single width of Pozidrain shall be placed over the membrane to allow a 1m deep finger of restoration soil to be placed to ballast the membrane into place.

6.4.4 Acceptable Seaming Methods

All seaming shall conform to the methods detailed in the EPA Technical Guidance Document "The Fabrication of Polyethylene FML Field Seams (No EPA/530/SW- 89/069, September 1989)".

The Contractor shall include method statements detailing the following as a minimum:

- Proposed seaming technique or techniques and their proposed applications.
- Proposed seaming machinery.
- Proposed acceptable temperature ranges for extrudate and/or hot wedge.
- Proposed acceptable maximum seaming speed if automated machinery to be used.

Acceptable seaming methods include extrusion and fusion welding only. Only apparatus that has been specifically approved by make and model shall be used. The installation Contractor shall submit all details of the seaming equipment he proposes to use for approval prior to commencing the works.

The installation Contractor shall maintain on site a number of spare sets of operable seaming apparatus to ensure no delays are caused by machine breakdown.

i) Extrusion Welding

Any extruding equipment is to be purged prior to its use to ensure that all heat degraded extrudate has been removed from the barrel. The LLDPE welding rods to be used in the extrusion process are to be dry and clean and comply with the membrane Specifications in Table 3-2.

Grinding and preparation is to be completed well in advance of the welding, and dry wiped of any excess materials. Any grinding processes are to be carried out perpendicularly to the line of the weld.

Typically, the membrane panels should be aligned to allow for an overlap of 100mm for extrusion welding. Sufficient overlap should be available to allow peel tests to be undertaken. Failure to maintain the minimum overlap may be cause for rejection of the seam.

No solvents or adhesives are to be used to temporarily adhere the membrane prior to the extrusion process.

ii) Fusion Welding

The installation Contractor shall log details with respect to the ambient temperature and seaming equipment during the fusion welding process.

A moveable protective layer should be used by the installing Contractor directly below the two LLDPE sheets that are to be welded in order to prevent debris collecting around the pressure rollers.

Typically, the membrane panels should be aligned to allow for an overlap of 125mm for fusion welding. Sufficient overlap should be available to allow peel tests to be undertaken. Failure to maintain the minimum overlap may be cause for rejection of the seam. No solvents or adhesives are to be used to temporarily adhere the membrane prior to the fusion process.

6.4.5 Daily/Intermittent Start-up Welds

The Contractor shall perform trial seams with each seaming machine and operator at least at the start of each shift, after every five hours of operation and also following any period of machine shutdown or change of operator. The date, time, speed, setting and temperature shall be marked on the trial seam.

The trial seams shall be at least 2m long in the case of extrusion seams and at least 3.5m long in the case of fusion seams. On completion of the trial seam the Contractor shall cut a total of six 25mm wide field tabs normal to the weld at 150 mm centres and subject the tabs to field destructive testing. Three specimens shall be tested in peel and three in shear.

If a trial seam fails field destructive testing as specified above, then the seaming machine and the operator shall not be allowed to perform field seaming until the deficiencies are corrected and both machine and operator have achieved passing trial seams. Trial seaming and destructive testing must be observed by the CQA Engineer.

6.4.6 Capping Geomembrane Placement

The capping geomembrane shall be placed using only the manufacturer's recommended method, typically an appropriately sized spreader bar. The equipment shall be verified by the CQA Engineer of its suitability for the capping geomembrane deployment. All staff and personnel will not be allowed to smoke and must wear non-damaging footwear whilst working on the geomembrane.

The membrane shall be unrolled so as to prevent scratching the underside of the liner by drag after deployment. The method used to unroll the membrane shall not cause excessive scratches or crimps and should not damage the underlying sub-grade. The method used to place the panels shall minimise wrinkles and "fish mouths".
Sufficient temporary surcharge to load the capping geomembrane before welding shall be placed on top, which is not likely to cause damage to the underlying liner. Typically, sandbags and tyres would be suitable to prevent uplift due to wind. Trafficking over the capping geomembrane is prohibited.

6.4.7 Seam Construction and Testing Requirements

The Contractor shall perform field seams only after satisfying trial seam conditions as specified in 6.6.5. The Contractor shall ensure that all pre-treatment measures (e.g. grinding and cleaning), as specified in EPA/530/SW-891069 are carried out and that extrudate and/or wedge temperatures are maintained within a range approved by the CQA Engineer.

6.4.8 Non-destructive Seam Testing Requirements

Field seams will be subjected to rigorous non-destructive testing on site, and destructive testing both on site and in the nominated geo-synthetic laboratory. The Contractor shall perform non-destructive testing along the entire length of all field seams including patches and repairs. The Contractor shall issue a method statement detailing their proposed non-destructive test technique or techniques and their proposed applications.

The Contractor shall advise the CQA Engineer when he is ready to commence non-destructive testing and shall not perform non-destructive testing unless the CQA Engineer is in attendance. The installation Contractor shall record all of the results obtained for each non-destructive seam test undertaken and forward the results to the CQA Engineer.

The installation Contractor shall note and mark the results of the test onto the capping geomembrane, to allow subsequent examination. Where feasible, the marking shall take place at the crest.

i) Air Pressure Testing Fusion Welds

For air pressure tests the channel between the two wedge tracks of the fusion welder shall be inflated to a minimum pressure of between 1.6 and 2.0 bar. After an initial stabilisation period of 1 minute the pressure shall not decrease by more than 10% in 10 minutes.

ii) Vacuum Box Extrusion Welds

Vacuum box testing will be completed to test extruded seams. During vacuum tests a vacuum of -0.4 bar shall be applied after the box is seated over the prepared seam. The seam will be viewed for a full 30 seconds before releasing the vacuum and moving along the seam. A minimum overlap of 50mm is required between adjacent box positions along the seam.

iii) Non Destructive Test Failures

In the event of a field seam failing non-destructive testing the Contractor shall identify the cause of the failure and repair the failed area in accordance with this Specification. The Contractor shall then subject the repair to further non-destructive testing until a passing test is achieved.

6.4.9 Destructive Seam Testing Requirements

i) Destructive Field Testing

The Contractor shall cut a 25mm wide field tab from the beginning and end of each completed field seam and shall subject it to qualitative destructive testing in peel and shear modes using a tensiometer.

The seam will pass qualitative destructive testing if the failure occurs solely in the parent materials and does not enter the seam. The seam will fail qualitative destructive testing if any of the failure enters the seam. Conventional destructive sample test codes shall be used and the results should be confirmed and submitted to the CQA Engineer.

If a field tab fails destructive testing, the installation Contractor shall either:

- reconstruct the seam between an up weld tab and a down weld tab that have passed qualitative destructive testing.

- cut further tabs from 3m to each side of the failed tab and subject these to field destructive testing. If these tabs pass field destructive testing the Contractor shall cut a laboratory sample from the passed area in accordance with this Specification and reconstruct the seam between the passed locations in accordance with this Specification. If either sample fails, the Contractor shall cut and test further field tabs until he can identify an area bounded by two passed locations. The Contractor shall then reconstruct the failed seam in accordance with this Specification.

The CQA Engineer reserves the right to request the cutting and destructive testing of further field tabs at any locations along the length of a seam.

ii) Destructive Laboratory Testing

The Contractor shall cut laboratory samples from the field seams when instructed by the CQA Engineer and in any case at a frequency not exceeding 1 sample per 200m of seam performed by an individual fusion machine, and 1 sample per 150m of seam performed by an individual extrusion machine.

It is likely that the majority of the welding within this capping scheme will be fusion welding. In accordance with LFE 5 the number of welds (and therefore repairs) shall be kept to a minimum. Destructive test locations shall be undertaken away from key areas including the base of slopes, sump areas, or complex panel intersection arrangements.

The Contractor shall divide the sample into 3 and release sub-sample C to the CQA Engineer for archiving. Sub-sample A shall be kept by the installation Contractor. The Contractor shall without delay despatch sub-sample B to the CQA Engineer or at the CQA Engineers written instruction, to the nominated geo-synthetic laboratory for destructive testing in shear and peel.

The dimension of each sample shall be a minimum of 300mm by 500mm. The Contractor should note that five tabs should be cut and taken for peel tests and five tabs for shear tests.

The laboratory shall report quantitative results and the mode of failure for the tests carried out. Mode of failure shall be described in accordance with industry convention. Copies of the test results certificates shall be issued to the CQA Engineer within 24 hours of issue by the laboratory.

The seam will pass quantitative destructive testing if all five of the tabs pass in the following modes:

- the failure occurs solely in the parent material and not seam.
- the peel strength exceeds 190N/25mm for 1mm Smooth and DRS LLDPE for both fusion and extrusion welds.
- the shear strength exceeds 263N/25mm for 1mm Smooth and DRS LLDPE for both fusion and extrusion welds.

If a seam fails quantitative destructive testing, the Contractor shall investigate the seam to each side of the failed sample as stated in this Specification. The Contractor shall cut further laboratory samples from each side of the failed section and perform laboratory tests upon them at their own expense until the failed seam is bounded by two pass locations.

The Contractor shall then reconstruct the failed seam in accordance with this Specification. The CQA Engineer may at their discretion observe the destructive testing, in which event the Contractor shall arrange permission for access to the nominated laboratory.

The Contractor shall furnish the CQA Engineer with a copy of the formal report from the independent testing laboratory detailing the procedures used for testing and including a summary of all results. This report shall be furnished to the CQA Engineer within three weeks of the completion of the Site Operations.

6.5 Defects and Repairs

All discontinuities in the geomembrane (whatever their cause) shall be identified, labelled (using a marker compatible with LLDPE), photographed and surveyed.

All discontinuities in the geomembrane (whatever their cause) shall be repaired by the Contractor in the following manner:

Point Defects

All discontinuities in the geomembrane (whatever their cause) shall be identified, labelled (using a marker compatible with LLDPE), photographed and surveyed.

The area shall be prepared by cleaning the surface, flattening any protrusions carefully and grinding a 3cm by 3cm area around the defect prior to applying a layer of extrudate.

Large Faults

All discontinuities in the geomembrane (whatever their cause) shall be identified, labelled (using a marker compatible with LLDPE), photographed and surveyed.

Large, damaged areas caused by trafficking, failed welds etc. shall be repaired using either fusion or extrusion welds. The method of repair shall be agreed on site between the installation Contractor and the CQA Engineer.

The faulted area shall be cut back to remove all imperfections and shall be overlain with a single piece of compatible geomembrane to give a minimum overlap of 100 mm for extrusion welding and 125 mm for fusion welding.

If necessary, an area will be required to be removed and re-welded (fusion) with a new FML section inserted.

Wrinkles

An inspection shall be made of the final as-laid capping geomembrane to ensure that no large wrinkles are present, prior to placement of the overlying materials. A wrinkle that requires to be repaired is defined by the fact that it can be folded over onto itself. As it is known that thermal expansion causes wrinkles, any wrinkles identified for repair shall be done so on a cold day.

The repair of wrinkles shall be kept to a minimum by the placement and rapid covering over of the capping geomembrane by the overlying materials as soon as is practicably possible.

Each repair shall be logged and then tested in accordance with Section 6.4.8.

6.5.1 Capping Geomembrane Acceptance

The CQA Engineer shall, during the course of the capping geomembrane placement undertake a full topographic survey of the liner, prior to the placement of any overlying materials. During the course of this survey the CQA Engineer shall undertake a visual examination of the capping geomembrane to ensure that all identified areas have been repaired, all seams have been tested, and no other defects are noted.

Each panel of the capping geomembrane shall then be signed off by the CQA Engineer as being completed and satisfactorily installed. It is the responsibility of the Contractor to ensure that the CQA Engineer "signs off" an area prior to overlying materials being placed. The pro-forma sheet for this is included as Form 9 of the CQA Plan.

6.6 Drainage Geo-composites

The Drainage Geo-composite will be placed directly onto the capping geomembrane to collect water percolating through the restoration soils. The geo-composite is a proprietary material and the manufacturers' installation guidance should be followed.

6.6.1 Deployment

Drainage geo-composite shall not be placed until the underlying capping geomembrane has been fully inspected and signed off.

The geo-composite may be temporarily weighted down with sandbags or tyres to provide wind resistance until the restoration soils advance over it.

Machinery shall not track directly over the geo-composite.

When placed, the geo-composite should be smooth, without creases or bumps. Any slack in the fabric should be pulled out manually. Machinery is not to be used for pulling the membrane. The membrane shall be cut using shielded knives only. Personnel involved in the

deployment of the geo-composite shall not smoke, use inappropriate footwear or engage in any other activity that could damage the geo-composite in any way.

The geo-composite shall be rolled down gradient, being continually in contact with the capping geomembrane.

During windy conditions, an adequate number of sandbags or other materials are to be available to weigh down the geo-composite and prevent lift-off. The sandbags should remain in place until adequate surcharge is applied on top i.e. the final restoration soils.

The geo-composite shall not be seamed during periods of precipitation. Seaming shall also take place immediately after deployment to ensure that the geotextile is in a dry condition during the seaming process.

6.6.2 Jointing

Adjacent panels of drainage Geo-composites should overlap by a minimum of 200mm. Typically a proprietary flap of geotextile is located at the edges of the rolls of the geo-composite and is specifically there to act as an overlap. This flap shall be heat welded onto the underlying geotextile bonded to the upper surface of the geo-composite. This fusion process shall use a handheld wedge welder or hot air gun placed between the overlapped geotextiles. As the wedge/gun is traversed along the overlap, pressure is applied via the use of a handheld roller to bond both surfaces of the geotextile together. The Contractor shall ensure that any equipment used in this process does not inadvertently damage the geotextile, by trafficking or leaking of any fuel.

6.6.3 Damage Repair

If remedial works are required which results in the geo-composite being cut, the cut area shall be covered on reinstatement by a patch of geo-composite, which measures 300mm over the defect in all directions.

6.6.4 Drainage Geo-composite Acceptance

Once placed, a final visual inspection of the geo-composite shall be carried out and any potentially damaging objects removed.

The geo-composite shall be signed off by the Contractor and the CQA Engineer. A pro-forma approval sheet is included as Form 9 of the CQA Plan.

6.7 Restoration Soil

The placement of the restoration soil shall take place as soon as practicably possible after the installation of the drainage geo-composite. The restoration layer shall be 800mm thick and shall be placed onto the geo-composite by casting with a machine which should be situated on a 500mm thick blanket. The use of a LGP dozer is not acceptable when the restoration soil thickness is less than 400mm. The contractor shall ensure that the restoration soil is in a suitable condition before it is placed.

Under no circumstances may any machinery track over the completed area when the soil thickness is less than 400mm. Plant may only move on soil layers in excess of 900mm or on a reinforced road placed over the 400mm restoration layer. If any vehicles are found to

have moved on a soil layer of less than 900mm thickness, the area shall be uncovered to an extent determined by the CQA Engineer. The liner shall be inspected and if necessary, remediated entirely at the contractor's expense.

The soil will be advanced over the drainage composite and the membrane as soon after laying as possible. To ensure the synthetics are protected from the wind, once an individual strip of membrane and drainage composite is laid, it will be immediately secured with restoration soil laid onto the drainage composite. The lining contractor shall be satisfied as to the adequacy of the soil placement before deploying the subsequent panel of synthetics.

During the placement of the soil, it must not be allowed to overspill from the drainage composite onto the LLDPE capping geomembrane. Any overspills should be cleaned off immediately with a plastic shovel and brush and the composite pulled back to allow inspection. The CQA Engineer shall be informed of overspill and no further placement shall take place until the spillage is cleared and the area has been inspected by the CQA Engineer.

The restoration soil should be laid to the correct falls and gradients as specified by the CQA Engineer and any depressions should be in-filled with suitable replacement soil. On completion of the placement of the restoration soil, a full survey will be undertaken of the restoration soil surface.

7 COMPLETION AND CERTIFICATION

7.1 A-Built Drawings

As built surveys of the site will be undertaken by the CQA Engineer and shall comprise the survey and recording of the following layers:

1) Existing surface survey – indicating all the main topographic features and ground levels prior to the commencement of any earthworks.
2) Finished regulating layer surface survey – indicating the new topographic profile and
3) Capping Geomembrane survey - comprising the number of all panels, welds, patches, repairs, destructive tests and any other areas of non-compliance issues or defects.
4) Drainage Geocomposite Panel layout.
5) Final restoration soil survey.

7.2 Monitoring and Testing Data

The records required to be kept by the Contractor are detailed in previous sections. All the information shall be forwarded to the CQA Engineer.

7.3 CQA Validation Report

A CQA validation report shall be prepared upon completion of the capping system. The report shall summarise the activities of the capping membrane installation and document all aspects of the CQA undertaken. The validation report shall include as a minimum the following information:

1) Parties and personnel involved with the project.
2) The scope of the work and outline of the project.
3) The quality assurance methods.
4) The CQA Engineers daily reports.
5) Any relevant contractors' daily field logs.
6) The test results, including all compliance tests and on site destructive and non-destructive tests.
7) All as built drawings
8) Confirmation that the installation has been constructed in accordance with the Specification noting any failures and deviations away from it.

The CQA Report will be compiled by the CQA Engineer.

7.4 Natural Resources Wales Authorisation

The Validation Report will be forwarded to NRW for approval.

Drawing Number 2431/01

Legend

- Prominent Contour (5.0m)
- Normal Contour (1.0m)
- Cell 6 & 7 Waste Reprofiling Area (Existing)
- Cell 8 Restoration Area (Proposed)
- Permanent Capping
- Potential Temporary Capping

Note

Digital survey model generated using Pix4D image processing software.

Imagery acquired by DJI Mavic 3E RTK photogrammetry survey on 17 January 2024.

Survey control installed using Topcon Hiper SR dGPS Network Rover.

OS Grid spacing at 100m

Rev	Date	Status/Ammendments

CLIENT

RML Resources Management UK Ltd

PROJECT

Withyhedge Landfill
Cell 8 Capping

TITLE

Area of Works

DRAWING NUMBER			REVISION
2431/01			0
SCALE AT A1	DATE	DRAWN	CHECKED
1:1000	03.24	KJT	ET

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GEO TECHNOLOGY

Drawing Number 2431/02

Legend

- Prominent Contour (2.5m)
- Normal Contour (0.5m)
- Cell 6 & 7 Waste Reprofiling Area (Existing)
- Cell 8 Restoration Area (Proposed)

Note

Contours show Approved Pre-Settlement Restoration surface extracted from Drawing: "DR1111-TOPO-02 Withyhedge Approved Restoration Contours"

Background Image Acquired by drone survey on 17 January 2024.

Rev	Date	Status/Ammendments

CLIENT

Resources Management UK Ltd

PROJECT

Withyhedge Landfill
Cell 8 Capping

TITLE

Proposed Pre-Settlement Restoration Levels

DRAWING NUMBER			REVISION
2431/02			0
SCALE AT A1	DATE	DRAWN	CHECKED
1:2000	03.24	KJT	ET

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EWAN THOMAS

PROFESSIONAL PROFILE

POSITION Director and Principal Geotechnical Specialist, Geotechnology Ltd., Aberdulais, Neath

Date of Birth 9 February 1963

Ewan is a director of Geotechnology Ltd and is a geotechnical specialist with 35 years geotechnical consultancy and contracting experience. He is interested in, and actively involved in, a broad range of geotechnical work as well as his niche areas of expertise in landfill geotechnics. He has worked throughout the world undertaking various geotechnical projects in both technical and managerial roles with Geotechnology and Golder Associates.

Ewan has co-authored a number of scientific papers published in per reviewed journals and has delivered a number of presentations at professional and academic conferences. He is a Senior Lecturer in Geotechnical Engineering at Cardiff University where he is responsible for the delivery of vocational geotechnical training to postgraduates on the taught masters programme. Ewan is retained by the Civil Engineering department as an external geotechnical advisor and has also acted as external advisor to the academic syllabus team at Swansea University's Civil Engineering Department.

Ewan has been retained by the Environment Agency (and its successor in Wales, Natural Resources Wales) to advise on landfill geotechnical matters for the last 21 years. As part of this work Ewan regularly works with Compliance and Environmental Crime teams in preparing technical submission for Magistrate and Crown Court proceedings. He regularly acts as an expert witness in criminal trials and as an advisor in compliance disputes at Magistrates Court on matters related to geotechnical engineering, permit compliance and waste classification. Ewan has just authored its internal Guidance for waste quantification.

Ewan is a member of the Wales Ground Engineering Group (GEG) of the Institution of Civil Engineers. Ewan was its Chairman in 1998-2000. Ewan is also a Fellow of the Geological Society of London and is active in its Engineering Group.

Ewan has technical responsibility for the professional output of the practice. He liaises with clients that include national government, local government, government agencies, multinational and national industrial and commercial clients, national housebuilders and small developers. He has day to day contact with directors and senior staff within the client organisations and often prepares briefing notes for upper and middle management.

Ewans landfill experience includes the design and specification of Landfill Directive compliant Hazardous, Non-Hazardous and Inert Landfill and is called upon regularly by Regulators to assist with the investigation of engineering problems at regulated sites. He has designed complex steep wall lining systems using finite element modelling and has been used by the EA to review similar submissions. He has designed capping systems on hot landfills (83°C), specified CQA procedures on the Sellafield low level nuclear waste repository and has advised Tata and its successors on Numerous landfill developments across its portfolio as well as a number of other steelworks sites across the UK.

ARWEL JONES

PROFESSIONAL PROFILE

POSITION Director and Geotechnical Specialist, Geotechnology Ltd., Aberdulais, Neath

Date of Birth 12 May 1964

Arwel is a director of Geotechnology Ltd and is a geotechnical specialist with 32 years geotechnical consultancy and contracting experience. He is actively involved in a range range of geotechnical work which includes landfill geotechnics. Arwel has a broad experience of working within a geotechnical consultancy and has a wealth of experience in the management of geotechnical field activities. Arwel liaises with a diverse client base ranging from private individuals to multinational companies. He has worked in many areas of the United Kingdom and in overseas projects involving various geotechnical projects in both technical and project management roles with Geotechnology and Golder Associates.

Arwel has worked on numerous large scale multinational projects, including a major road construction project for a British construction company on the Oman / Yemeni border. The work entailed significant slope stabilisation in the form of multi-strand rock anchors, high tensile steel mechanical and resin bolting, shotcrete application and meshing.

South Wales has a legacy of historical coal mining, which has resulted in subsidence and stability issues. Arwel has been involved in a significant number of coal mining investigation and remediation projects comprising undertaking the initial coal mining risk assessment through to remediation of mine workings via pressurised grout stabilisation. Such work has often been part of a construction project and Arwel has completed a large number of site investigations to provide suitable foundation design recommendations for individual clients, large housebuilders and multinational industrial companies.

The construction and operation of landfills continues in many parts of the country and Arwel has significant experience in the investigation for design and provision of construction quality assurance to their completion. Arwel has been involved in the design and placement of a number of landfill lining projects where the use of bentonite enriched sands were used due to the lack of natural lining materials. Arwel also has significant experience in the use, testing and placement of geo-synthetic materials in landfill construction. Arwel has reviewed technical reports for the Environment Agency (and its successor in Wales, Natural Resources Wales) on landfill geotechnical matters for the last 18 years. Arwel is also a Fellow of the Geological Society of London and is active in its Engineering Group.

Arwel undertakes technical work for the practice which involves national government, local government, government agencies, multinational and national, industrial and commercial clients, national housebuilders and small developers. He has contact with technical staff from other companies and organisations when work is being implemented on specific projects.

BEN REES

PROFESSIONAL PROFILE

POSITION Director and Environmental Geochemist, Geotechnology Ltd., Aberdulais, Neath

Date of Birth 24 August 1975

Ben is a director of Geotechnology Ltd and is an Environmental Geochemist with 25 years consultancy experience. Since joining Geotechnology in 2008, Ben has been actively involved with a broad range of project work utilising his geochemical knowledge and wider geoscientific experience. In the UK, this has involved a wide selection of projects related to Phase I and II land quality assessments, environmental and human health risk assessments, design and implementation of environmental monitoring programmes, permit applications for a range of waste sectors, waste classification and landfill construction design and CQA supervision.

Specifically related to landfill, Ben has provided geochemical and waste classification input to Hydrogeological Risk Assessments (HRAs) and Gas Risk Assessments (GRA) for several active non-hazardous and hazardous landfills. In Wales, Ben continues to provide direct input to assessments at Palleg landfill in the Swansea Valley, Nantycaws in Carmarthenshire, Tir John in Swansea, Withyhedge in West Wales and Morfa Landfills in Port Talbot. In England, Ben has also completed assessments of several non-hazardous and inert facilities including sites where piggybacking has been proposed and unlined active gassing sites close to residential properties requiring detailed gas risk evaluation.

Ben has also contributed to the development of capping schemes and the development of long-term aftercare monitoring programmes at several closed landfill sites including East Waste Management Site and Southside Queensway at Llanwern Steelworks, Nantycaws and Wernddu in Carmarthenshire, Morfa Closed Landfill at Port Talbot Steelworks and Cwrt y Plyffin in Powys. Alongside colleague Ewan, Ben has also investigated several illegal waste deposits on behalf of Natural Resources Wales (NRW), providing Expert Witness services related to waste classification and environmental risk at Crown Court. Many of thee assessments have utilised specialist computer software programmes Landsim and Gassim and with colleagues Ewan and Keir, Ben was recently involved with training NRW personnel in the use of these models and the fundamental principles of landfill design.

Ben's involvement with landfill engineering also extends to the CQA supervision of new landfill cells and landfill capping at each of the sites mentioned above. This includes approving sub-grade ahead of geomembrane placement, monitoring geomembrane placement and jointing, monitoring the placement of drainage and gas collection geosynthetics and capping with restoration soils. Each job has required detailed record keeping and the compilation of CQA Verification reports.

KEIR JAMES THOMAS BSc. MSc. FGS.

PROFESSIONAL PROFILE

POSITION Geotechnical Engineer

DATE OF BIRTH 28 May 1988

Keir Thomas is a Geotechnical Engineer with 11 years industrial experience. He has a B.Sc. (Hons) in Geology and MSc. (Distinction) in Applied Environmental Geology from Cardiff University. He retains close links to the university and regularly assists in vocational field training for the MSc students.

During his time in industry, he has been actively involved in a wide variety of geotechnical and geo-environmental work. In his role as a Geotechnical Engineer, Keir is regularly involved in the planning, organisation, and supervision of site work; liaising with both clients and suppliers. He is highly experienced in site investigation, geotechnical monitoring, topographic surveying, geophysical surveying, landfill design, earthworks design and construction supervision.

Keir's landfill experience includes the design and specification of new landfill cells and capping schemes for both hazardous and non-hazardous landfills. He has also aided in the design of restoration schemes for historic industrial slurry lagoons. Keir has extensive experience in the supervision and CQA validation of the construction phase of these schemes. Post construction, he has also managed the ongoing environmental and geotechnical monitoring of both active and closed landfill sites.

Practical site work has given Keir expertise in the use of numerous pieces of field equipment; ranging from in-situ soil testing equipment to high end topographic and geophysical survey instrumentation. He is also experienced in the application and supervision of most conventional intrusive ground investigation techniques.

Keir has comprehensive experience and training in the use of several specialist software packages for applications including slope stability monitoring and analysis, digital terrain modelling, 3D modelling, volumetrics, earthworks design, and settlement analysis.

Keir is a qualified drone pilot with specialisation in the use of photogrammetry drones to carry out large scale topographic surveys, and volumetric assessments. He has undertaken topographic drone surveys for use in several sectors including earthworks, construction, the steel industry, renewable energy, waste management and regulation. He regularly uses drone surveys to complete the annual topographic survey and volume assessment at a number of local landfills.

Keir was elected a Fellow of the Geological Society of London in January 2010. He has an active involvement in the Southern Wales Regional Group of the society; serving on the committee since 2014, holding the position of Secretary from 2017-2019 and Chairperson from 2019 to present. He has also contributed on field trips organised by the Engineering Group of the Geological Society and given a talk to the Ground Engineering Group of the Institute of Civil Engineers. He won the Southern Wales regional heat of the Early Career Geologist Award in 2018.

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