APPENDIX 2H

OUTLINE CONSTRUCTION QUALITY ASSURANCE PLAN

ROADSTONE DUBLIN LIMITED

REMEDIATION OF UNAUTHORISED LANDFILL SITES AND DEVELOPMENT OF ENGINEERED LANDFILL, BLESSINGTON, CO. WICKLOW

OUTLINE CONSTRUCTION QUALITY ASSURANCE PLAN

December 2004

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1.0 GENERAL

1.1 Introduction

This document presents the Construction Quality Assurance Plan and Specification for the development of the lining and capping works up to completion of the site, for the landfill cell at Blessington, County Wicklow. This CQA Plan has been prepared to detail the liner installation and testing quality control procedures that will be followed during the lining works. A detailed installation specification for each element of the lining system is included in the Appendix I.

1.2 Definitions

For the sake of clarification the following definitions are given:

Construction Quality Assurance (CQA) – A planned and systematic pattern of all means and actions designed to provide confidence that items or services meet contractual and regulatory requirements, and will perform satisfactorily in service.

Construction Quality Assurance refers to means and actions employed by the CQA Engineer, to assure conformity of the lining system preparation, production, and installation to this CQA plan, the Contract Drawings and Specifications. Biffa shall appoint a CQA Consultant prior to commencing each phase of Construction.

Construction Quality Control (CQC) – Those actions which provide a means to measure and regulate the characteristics of an item or service to contractual requirements.

Construction Quality Control refers to those actions taken by Manufacturers, Installers, Contractors, or the Employer to ensure that the materials and the workmanship meet the requirements of the Contract Drawings and Specifications.

Employer means the person or persons, firm or company or other body who own and have responsibility for the facility. For the works undertaken at Blessington the employer is Roadstone Dublin Limited. The Employer has entered/will enter into a contract with a Contractor for the execution of the works detailed in the Specification and Contract Drawings. The Employer may be represented on site by personal representatives or other parties, e.g. the CQA Engineer or Supervisor (dependant upon form of contract).

Contractor means the person or persons, firm, company or other body to whom the Contract has been/will be awarded by the Employer, and includes the Contractor's personal representatives or other parties, e.g. Sub-contractors, Manufacturer. The Contractor will undertake the execution of the Works under the terms of the Contract.

Specification means that part of the Contract entered into between the Employer and the Contractor which sets out the Employer's detailed requirements as to how the works should be constructed, tested, measured and quality assured. The Specification forms part of this CQA Plan and is included in Appendix I.

1.3 Responsibilities

The CQA Project Team will comprise the following:

"CQA Project Manager" who will be office based and will be present at the start of construction. The CQA Project Manger:

- attends selected progress or liaison meetings and is the key contact with regulatory officers;
- reviews all designs, plans and specifications;
- reviews other site-specific documentation, including proposed layouts, method statements and Contractor's qualifications;
- administrates the CQA program;
- reviews all changes to the design, plans and specifications;
- oversees and reviews the CQA Certification Report.

"CQA Engineer" who is a representative of the CQA Project Manager and is located full time at the site. The CQA Engineer:

- acts as the on-site (resident) representative of the CQA Project Manager;
- is familiar with all CQA requirements for the project;
- oversees the daily activities of the Contractors;
- attends all CQA-related meetings (e.g. Pre-construction and Progress);
- prepares, or oversees the ongoing preparation of the Record Drawings;
- assigns locations for testing and sampling;
- keeps daily reports and logs;
- reports to the CQA Project Manager, and logs in his daily report any relevant observations;
- oversees the collection and shipping of all samples for laboratory testing;
- reviews results of laboratory testing and makes appropriate recommendations;
- reports any unresolved deviations from this CQA Plan to the CQA Project Manager;
- provides all logs and relevant data to the CQA Project Manager for the preparation of the final report;
- reviews all Certifications and Documentation from the Contractor and makes appropriate recommendations; and
- notes and brings to the attention of the Contractor any on-site activities that could result in damage to the Liner system.

"CQA Monitor" who is a representative of the CQA Project Manager and is located full time at the site. The CQA Monitor:

- undertakes all on site CQA testing of lining materials;
- notes and brings to the attention of the CQA Engineer any non conformances of the lining system test results.
- keeps detailed records of all lining materials testing and reports these results to the CQA Engineer.

2.0 SCOPE OF CONSTRUCTION WORKS

The design concepts for the Lining and Site Capping works, were developed to accord with the Waste Management Licence for the site.

The position of the proposed development is shown on Drawing No. 1, General Site Layout.

Construction of the lining system shall generally involve:

- The excavation and filling to achieve formation preparation;
- Installation of a low permeability clay liner of maximum permeability $1x10^{-9}$m/s;
- installation of a geosynthetic clay liner;
- Installation of a 2mm thick HDPE geomembrane;
- Installation of a geotextile protector and 300mm thick granular leachate drainage blanket; and
- Installation of leachate collection pipework and extraction risers.
- Construction of the site capping system shall generally involve:
- Installation of the leachate recirculation system pipework;
- Preparation of final waste levels to receive the capping system;
- Installation of the gas venting system including a gas collection layer and gas wells
- Installation of a geosynthetic clay liner;
- Installation of 1mm VFPE welded cap;
- Installation of a 500mm thick drainage layer
- Installation of a Geotextile Protector.
- Placement of restoration soils.

A full Specification detailing the requirements for the above elements is included in the Appendix I. Due to the timescales involved in undertaking the works detailed in the Specification, the works will be constructed over a number of contracts. For each contract, the Contractor shall be responsible for producing method statements for approval by the CQA Engineer. Upon satisfactory review by the CQA Engineer copies of these shall be forwarded to the Environmental Protection Agency for appraisal with details of the products proposed.

3.0 AS BUILT TOPOGRAPHIC SURVEYS

Prior to commencing each phase of the construction works associated with the lining and capping, and throughout the Construction Quality Assurance programme, a number of topographic surveys will be undertaken to confirm that construction is taking place in accordance with the Specification and Waste Licence conditions. Specifically, surveys shall be undertaken to provide details at the following stages of construction:

Lining Works

(i) Prior to commencing earthworks
(ii) On completion of basal formation excavation and filling works
(iii) On completion of clay lining works
(iv) As built geosynthetic clay liner panel survey to include defect and repairs locations
(v) As built geomembrane panel survey to include defect and repairs locations
(vi) As built geotextile protector panel survey
(vii) On completion of leachate drainage blanket installation and associated works. This shall also include the location of target pads, the invert of all pipework and confirm the required cover thickness to the pipes

Site Capping Works

(i) Prior to commencing earthworks
(ii) On completion of waste surface preparation
(iii) On completeion of the gas venting system installation
(iv) As built geosynthetic clay liner panel survey to include defect and repairs locations
(v) As built geomembrane panel survey to include defect and repairs locations
(vi) As built geotextile protector panel survey (if required)
(vii) On completion of the drainage layer
(viii) On completion of restoration soils placement

The above survey documentation shall be incorporated into the post construction Certification Report (See Section 4). Surveys shall be undertaken on a fixed 20m grid in order to verify thickness, with further survey points included identifying construction details on the As-Built drawings. All drawings shall be referenced to Ordnance Datum (Malin).

Due to the likelihood of settlement of waste beneath the cap, confirmation of clay cap thickness may be undertaken by the excavation of trial pits or hand augured holes.

4.0 CERTIFICATION REPORT

Upon completion of the lining works and/or capping works the CQA Engineer will prepare a Certification Report summarising the works undertaken and including all CQA documentation prepared. As a minimum this shall include:

- Description of Works
- Completed Proformas detailing the installation of each element of the works
- Contractor's Documentation
- Test (Laboratory and Field) Reports
- As Built Drawings: Topographic (see Section 3) and Panel Layout
- Photographic Record of the Construction
- Daily Diaries
- Relevant Environment Agency Inspectors Reports
- Description of Non-conformances and the Subsequent Remediation

The above report will confirm that the works have been carried out in accordance with the Specification as incorporated in this Construction Quality Assurance Plan. The report will be certified by the CQA Project Manager.

APPENDIX 1

ROADSTONE DUBLIN LIMITED

REMEDIATION OF UNAUTHORISED LANDFILL SITES AND DEVELOPMENT OF ENGINEERED LANDFILL, BLESSINGTON, CO. WICKLOW

DRAFT SPECIFICATION

December 2004

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1.0 INTRODUCTION

1.1 Description of Works

1.1.1 This Specification details the requirements for the construction of the site infrastructure, lining system, and capping and restoration for the proposed non-hazardous engineered landfill to be constructed on Roadstone Dublin's landholding at Dillonsdown, Blessington, County Wicklow. A site location plan is presented on Drawing No. 1 and a general site layout is presented on Drawing No 2.

1.1.2 Roadstone Dublin Limited will appoint an Independent Consultant (the CQA Engineer) to supervise all aspects of quality assurance of the contract. The Consultant shall supply a Supervisor, who has suitable previous experience of supervising all aspects of the lining works. On site the Supervisor will ensure that all requirements of the Specification relating to quality are met.

1.1.3 The construction shall generally involve:

Lining Works

- Excavation and filling to achieve formation levels;
- Formation preparation of basal area;
- Installation of a 1m thick clay liner, extending over the base, side slopes and intercell bund, of maximum permeability 1 x 10^{-9} m/s;
- Installation of a Geosynthetic Clay Liner
- Installation of a 2mm thick double textured HDPE geomembrane;
- Installation of a geotextile protector and 500mm thick granular leachate drainage blanket over the basal area and extending 2m vertically up sideslopes; and
- Installation of a vertical leachate extraction riser.

Site Capping Works

- Placement of a 300mm thick gas drainage layer;
- Installation of a geosynthetic clay liner/1mm VFPE welded geomembrane composite cap;
- Installation of a geotextile protector;
- Placement of a 500mm thick drainage layer; and
- Placement of up to 850mm of subsoils and 150mm of topsoil.

Site Infrastructure Works

- Excavation and lining of surface water channels and settlement lagoons
- Construction of temporary site haul roads and hardstanding areas
- Installation of weighbridge / temporary wheelwashes and temporary site infrastructure

2.0 GENERAL ITEMS

2.1 Materials

2.1.1 Goods and materials used in the execution of this Contract shall, where possible, have been produced in Ireland or the European Union. Where a specification issued by the National Standards Authority of Ireland or British Standards Institute is current and is appropriate, goods and materials used in the execution of this Contract shall be in accordance with the specification. The Contractor shall name all sources of materials to be supplied to site for approval of the CQA Engineer. Any material condemned or rejected by the CQA Engineer will be removed immediately from the site at the Contractor's expense. All materials will be stored and transported in such a manner as to preserve their quality and integrity. All materials used in the construction of the Works, which can be detrimentally affected by the weather, are to be removed, covered or sealed at the end of every working period.

2.2 Personnel and Relevant Experience

2.2.1 Prior to commencement of the Works, the Contractor shall provide a list of key personnel he proposes to employ together with a resume of their experience and qualification. The list of key personnel shall include the name of the full-time Contractor's Agent. The list will be accompanied with a chart showing the key personnel on the project and who / what they are responsible for.

2.3 Hours of Work

2.3.1 The hours of work shall be within those allowed by the Waste Licence, as indicated below:

Monday to Friday	07:00 - 19:00*
Saturday	07:00 - 17:00*
Sunday, Bank Holidays and Public Holidays	Not without RDL permission**

* Working hours may not be increased outside of those indicated above without the agreement of the Local Authority / Environmental Protection Agency.

** Works to be restricted to those directly related to geomembrane liner deployment.

2.4 Plant and Equipment

2.4.1 The Contractor shall use plant of suitable and appropriate capacity to carry out the work in accordance with the Specification. Each item of plant will be maintained and operated in a safe manner. A chart detailing the plant required to excavate the works, time required on site, forecasted earthmoving capability of tonnes per day, etc shall be submitted to the CQA Engineer prior to commencement of the works. No claim will be entertained for mechanical breakdown, theft, vandalism or punctures. Plant operators are to be trained and certified by an approved body for the plant they are operating. The Contractor will consider the potential safety hazards of his proposed works and adopt plant and vehicles accordingly.

2.5 Contractors Superintendence

2.5.1 The Contractor shall give or provide all necessary superintendence during the execution of the Works and as long thereafter as the CQA Engineer may consider necessary. Such superintendence shall be given by an experienced person having adequate knowledge of the operations to be carried out (including the methods and techniques required, the hazards likely to be encountered and the methods of preventing accidents) as may be requisite for the satisfactory construction of the Works.

2.6 Contractors Agent and Personnel

2.6.1 The Contractor or a competent and authorised agent or representative, approved of in writing by the CQA Engineer (for which approval may at any time be withdrawn) is to be constantly present during the Works and shall give his whole time to the superintendence of the same if required by the CQA Engineer. The Contractor will only employ staff competent to undertake the required works. At all times during the contract a trained First Aider must be present on site.

2.7 Site Facilities

2.7.1 The Contractor shall provide, maintain and remove on completion of the works, suitable site offices for the sole use of the Contractor's Agent and the CQA Engineer, and furniture appropriate to their functions. All buildings, sheds and other temporary structures that the Contractor may erect for his own or the CQA Engineer's purpose shall (in respect of location, design and sanitary arrangements) meet with the approval of the CQA Engineer.

2.7.2 The Contractor must provide suitable washing and welfare facilities for all site personnel. Washing facilities should also be used on completion of each days work and prior to leaving site.

2.7.3 The Contractor shall provide temporary accommodations for the CQA Engineer with a minimum floor area of $10m^2$. The office shall be ready for use by the CQA Engineer within 7 days of the Date of Commencement of the Works.

2.7.4 The office shall have controllable ventilation, adequate natural lighting and windows fitted with shutters and locks. The external door shall be fitted with a mortise lock with three keys and shall be clearly marked 'CQA Engineer'. The office shall be provided with electrical lighting, power points and space heating adequate to maintain accepted office accommodation standards.

2.7.5 The following furniture, fittings and fixtures shall be provided new or in approved condition. The equipment may be second-hand, but if it fails to function satisfactorily, it shall be replaced by new equipment.

1	No.	Desk with lockable drawers
2	No.	Stacking chairs
1	No.	Steel filing cabinet with lock and four drawers
2	No.	Table approximately 2m long x 1m wide
3	No.	Hat and coat hooks
2	No.	Shelves
1	No.	First aid kit
1	No.	Fire extinguisher (water)
1	No.	Maximum / Minimum thermometer

The Contractor's rates should allow for all mobilisation, set up maintenance and demobilisation of the above.

2.7.6 Immediately on completion of the Works, or at such other times as the CQA Engineer may determine that they are no longer required, all temporary buildings, offices, sheds, huts, stores and other accommodations put up by the Contractor shall be removed by him.

2.8 Site Cleanliness

2.8.1 The Contractor shall confine his operations to the minimum area of ground required for correct execution of the Works and access thereto. The Contractor shall at all times keep the working area and area surrounding all site temporary buildings clean and tidy. The Contractor shall be responsible for the disposal of all mud, water, chippings, soil or other waste products resulting directly or indirectly from the works. The Contractor shall take all precautions necessary to prevent pollution or contamination of streams, waterways and watercourses.

2.8.2 The Contractor shall take all reasonable steps to minimise dust nuisance during the Construction of the Works. The CQA Engineer may direct that water bowsers are permanently on the site during the Contract period to hose down areas of the Works causing a dust nuisance.

2.8.3 Upon instructions from the CQA Engineer, when the Works have been satisfactorily completed, the Contractor shall leave the working area and the access thereto in a clean and tidy condition. The Contractor shall repair any damage he may have caused whether in the vicinity of the works or on the access route thereto to the satisfaction of the CQA Engineer. The Contractor shall indemnify and keep indemnified the Employer against all claims arising from any such pollution, contamination, loss or damage.

2.9 Site Electricity Supply

2.9.1 The Contractor shall be required to provide a suitable electricity supply to suit his own requirements and those of the CQA Engineer.

2.10 Site Water Supply

2.10.1 The Contractor shall be responsible for locating a suitable water supply and for providing and paying for all temporary plumbing and connection of the water supply to site. Where a suitable water supply is not available in the locality, the Contractor shall make arrangements for carrying and storing water in quantities as necessary for the Works. All costs incurred in this respect shall be borne by the Contractor. The Contractor is responsible for its sensible use and for the care and the maintenance of his pipework from the supply point.

2.11 Existing Structures and Services

2.11.1 The Employer may provide the CQA Engineer and Contractor with details of any such services known or likely to affect or be affected by the works. The supply of this information to the Contractor does not absolve the Contractor from his responsibilities to ascertain more accurately the location of any service apparatus within the site using all reasonable care and attention.

2.12 Health, Safety and Welfare at Work Act 1989, etc.

2.12.1 It is a condition of Contract that the Contractor and all Sub-Contractors engaged by the Contractor shall comply with the provisions of the Health, Safety and Welfare at Work Act 1989 and all regulations made there under, and indemnify the Employer against all liabilities and claims whatsoever arising from the said Act and Regulations.

2.12.2 It is a further Condition of Contract that in accepting the Contract, the Contractor and all Sub-Contractors engaged by him, shall be deemed to have granted to the Employer the aforementioned indemnity and to have accepted liability for obtaining from Sub-Contractors engaged by him, undertakings, in writing, that they will comply with the provisions of the said Act and regulations and similarly indemnify the Employer against the said liabilities and claims.

2.12.3 The Contractor shall ensure that any incomplete or temporary works are covered and secure at the end of every working day. It is essential that the Works are covered at the end of each working period. The Contractor is responsible for provision of security for his works.

2.12.4 Contractors should note that smoking and naked flames are prohibited outside at all times. Smoking may be permitted inside the Contractors cabin or messing facilities, subject to the agreement of the Site Manager. Anyone seen to disregard the no smoking policy will be removed from site without delay. Contractors must show they are complying with all relevant health and safety guidelines pertaining to all materials, and plant and personnel involved in this project.

2.12.5 The following safety equipment is obligatory:

A safety helmet conforming to BS 5240 Part 1: 1987
A reflective safety jacket or waistcoat conforming to BS 6629: 1985 (Class G and Class B respectively).
Safety footwear with steel toe caps and mid soles.
Personnel protective clothing such as dust mask, goggles and gloves etc. will be worn when the appropriate works require it.

2.12.6 The Contractor shall not undertake any operations which contravene or conflict with the Waste Licence conditions as set out in Appendix A or the safety policy of the Employer. The Contractors attention is drawn to the potential presence of landfill gas within the works area (due to nearby unauthorised landfill). Gas levels will be monitored by the Contractor to demonstrate to the CQA Engineer that levels are sufficiently low to permit working.

2.13 Inclement Weather

2.13.1 When weather conditions are such that the quality of the Works may be impaired or the conditions of the materials impaired, then the Works will be stopped with the agreement of the CQA Engineer. Inclement weather may comprise high winds, rain, snow, freezing, excessive temperatures or a combination of the above.

2.13.2 Where, in the opinion of the CQA Engineer, any works carried out in inclement weather conditions have been adversely affected, these works shall be removed and made good at the Contractor's expense.

2.13.3 Following adverse weather conditions, any standing water on the surface of the works shall be removed at the earliest opportunity.

2.13.4 Earthworks placement operations following inclement weather conditions shall not proceed without prior approval of the CQA Engineer.

2.14 Surface Water Control

2.14.1 The Contractor shall ensure that water does not accumulate on or adjacent to the surfaces of the Works. To ensure this temporary watercourses, ditches, drains, pumping or other means of maintaining the Works free from water, shall be provided by the Contractor. The Contractor will be deemed to have allowed for this in his rates.

2.14.2 On no account will any unauthorised discharge be permitted to leave the site without prior consent of the CQA Engineer in consultation with the Environmental Protection agency and / or Local Authority.

2.15 Fuelling of plant

2.15.1 Fuel tanks and drums used by the Contractor will be stored at a location approved by the Employer's Site Manager in conjunction with the CQA Engineer. All such tanks will be bunded with a containment volume equal to 110% of the total quantity of fuel present at any one time. All fuel spillages will be remediated in a safe and controlled manner by the Contractor at his expense. Empty oil and grease containers shall be disposed of properly.

2.16 Parking of Plant and Siting of Ancillary Equipment

2.16.1 The Contractor shall be allowed to establish an area at a location to be agreed by the Employer, for parking of plant overnight. The Employer accepts no responsibility for damage or theft incurred as a result of the presence of the plant on site.

2.17 Daily Journal

2.17.1 The Contractor will be required to keep a detailed daily journal recording all plant and labour present, quantities of materials delivered and placed, dimensions and locations of materials placed, weather conditions, details of meetings and details of testing results, remedial works and any other relevant information. The Contractor will give the CQA Engineer reasonable access to the daily journal which will, if necessary, be made available to the CQA Engineer, Environmental Protection Agency and Local Authority during and after completion of the Works if required. The Contractor will forward copies of the daily journals on a weekly basis to the CQA Engineer.

2.18 Site Operations and Traffic Management

2.18.1 It is the responsibility of the Contractor not to interfere with the day to day routine of the site. The Contractor must liase with the Employer, its Site Manager and CQA Engineer, and must make all due provision for completing the works without interfering or detrimentally affecting site operations, and for complying with the Waste Licence and specific Site Rules.

2.18.2 All access and site roads within Roadstone Dublin's landholding are subject to a speed limit of 20 miles per hour. This speed restriction should not be exceeded and must be observed at all times. Drivers seen to disregard the site speed limit or drive without regard for other road users shall be removed from site without delay.

2.19 Disposal of Soil

2.19.1 All superfluous soil, subsoil, rubble, rock cuttings and waste or any other material accumulated on the surface or disturbed by contracting activities must be correctly and tidily disposed of. Any cost incurred in this respect will be borne by the Contractor.

2.20 Independent Quality Assurance Supervision

2.20.1 Roadstone Dublin will appoint an independent Consultant to supervise all aspects of quality assurance of the contract. The Consultant shall supply a CQA Engineer, who has suitable previous experience of supervising all aspects of the lining works. On site the CQA Engineer will ensure that all requirements of the Specification relating to quality are met.

2.20.2 The CQA Engineer's responsibilities are detailed below:

- Acts as the on-site (resident) representative of the Engineer?
- Attends all CQA related meetings (e.g. Pre-construction and Progress)
- Prepares or oversees the ongoing preparation of the Record Drawings
- Assigns locations for testing and sampling in accordance with the Specification
- Reports to the Engineer, and logs in his daily report any relevant observations
- Oversees the collection and shipping of all samples for laboratory testing
- Reviews results of laboratory testing and makes appropriate recommendations
- Reports any unresolved deviations from the Specification for consideration by the Engineer, Roadstone Dublin and the Environmental Protection Agency
- Provides all logs and relevant data for the preparation of the final CQA report
- Reviews all Certifications and Documentation from the Contractor and makes appropriate recommendations
- Notes, and brings to the attention of the Contractor, any on-site activities that could result in damage to the liner system

2.20.3 The CQA Engineer shall be empowered by the Engineer to enforce compliance with health and safety legislation, deviations from the specification not impacting on end product quality and to assist in controlling the contract to the requirements of Roadstone Dublin's Waste License.

2.20.4 The Contractors attention is drawn to the requirement, under the Waste License, that material non-conformances with the Specification and departures from the Contractor's method statement will require formal approval by the Environmental Protection Agency. The Contractor should recognize that formal approval of any non-conformances and revised methods of working, if considered acceptable, may take a period of weeks.

2.20.5 Upon completion of the installation of the leachate drainage system a leak detection survey shall be undertaken to identify the location of any holes in the geomembrane. Details of the leak location survey are detailed in Section 7.6 of this Specification.

2.21 Highways to be Kept Clean

2.21.1 No debris or material resulting from the Works shall be allowed to fall onto any public highway. It is the sole responsibility of the Contractor to ensure that all mud, soil, waste and other residual materials are not allowed to accumulate on the public highway or asphalted or concrete roads within the site. The Contractor will make due provision for the cleaning of roads.

2.22 Adherence to the Site Waste Management Licence and Site Rules

2.22.1 Prior to commencement of the Works, the Contractor, his Site Agent and Site Engineer will attend a pre-contract meeting with the Employer, CQA Engineer and Site Manager to discuss the Works and to familiarise the Contractor with the potential hazards of the Works, the Waste Licence issued by the Environmental Protection Agency and Roadstone Dublin's Site Rules.

2.23 Covering of Vehicles

2.23.1 The Contractor will ensure that any load being transported to or from the site which is capable of generating dust, ash, litter or other wind blown material is sheeted in an appropriate manner.

2.24 Noise and Disturbance

2.24.1 All work shall be carried out without unreasonable noise and disturbance. The Contractor shall indemnify the Employer against any liability for damages on account of noise or any other disturbance created while or in carrying out the work and from and against all claim demands proceeding damages costs, charges and expenses whatsoever in regard or in relation to such liability.

2.25 Existing/Final Ground Levels

2.25.1 The Contractor will establish temporary benchmarks, referenced to Ordnance Datum (Malin), on or near the site to which all levels shall be referred. As soon as the Contractor takes possession of the site bench marks must be established at a ratio of one per hectare area of the site. Levels will be agreed with the CQA Engineer and a list supplied to him. The topographic survey already carried out is shown on Drawing No. 2.

2.25.2 The Contractor should verify for himself the accuracy of all survey data. He will be required to agree original ground levels with the CQA Engineer prior to commencement of site works. The agreed original ground levels shall provide a basis for measurement purposes.

2.25.3 The Contractor shall carry out construction surveys to determine ground elevations at each of the following stages of earthworks and during construction and at other times as may be necessary to measure quantities for evaluation purposes:

Lining Works

(i) Prior to commencing earthworks
(ii) On completion of basal formation excavation and filling works
(iii) On completion of clay lining works

(iv) As built geosynthetic clay liner panel survey to include defect and repair locations
(v) As built geomembrane panel survey to include defect and repairs locations
(vi) As built geotextile protector panel survey
(vii) On completion of leachate drainage blanket installation and associated works. This shall also include the invert of all pipework and confirm the required cover thickness to the pipes

Site Capping Works

(i) Prior to commencing earthworks
(ii) On completion of gas drainage layer
(iii) As built geosynthetic clay liner panel survey to include defect and repair locations
(iv) As built geomembrane panel survey to include defect and repairs locations
(v) As built geotextile protector panel survey
(vi) On completion of restoration soils placement

2.25.4 The surveys will be used as a basis for confirming layer thickness. Each survey should be carried out on a fixed grid of points to facilitate this process. The Contractor shall agree a fixed 20m grid arrangement with the CQA Engineer, prior to the undertaking of any surveys. Further details such as crests and toes of slopes, in addition to the grid points, will be required for the production of as built drawings.

2.25.5 An onsite record of the formation and top of clay levels shall be maintained and updated, by the Contractor. Placement of overlying layers shall not proceed without supporting survey information to demonstrate the minimum thickness has been achieved. Proceeding with installation of an overlying layer prior to confirmation that the thickness requirements of the preceding layer has been attained as calculated by survey, is at the Contractor's own risk.

2.25.6 The Contractor shall give sufficient notice of the intention to survey to enable the CQA Engineer to conduct a joint survey or check the Contractor's survey.

2.25.7 The Contractor shall forward a paper and disc copy of each survey within one week of undertaking the survey, at a scale of 1:500.

2.26 Tolerance Limits

2.26.1 The tolerance limits for the works shall be as follows;

(i) Positions in plan shall be within 75mm of the true positions as shown on or calculated from the drawings
(ii) Slopes shall be sensibly plane and within 1% of the gradient shown on the Drawings
(iii) The prepared subgrade in the base shall be within –15/+30mm of the required elevation
(iv) Depths and thickness of the clay liners and leachate blankets shall be within –0/+50mm of the dimensions shown on the Drawings.

2.27 Method Statements

2.27.1 The Contractor shall produce, having due regard to the Health Safety and Welfare at Work (Construction) Regulations 1995 and 2001, method statements for each element of the works. Method statements shall detail how the works are to be undertaken, in a safe manner, in order to meet the Specification.

2.27.2 The Contractors attention is drawn to the fact that all method statements and risk assessments are to be reviewed by the CQA Engineer, Employer, Project Supervisor and Environmental Protection Agency . Method statements shall be provided to the CQA Engineer for distribution to the other parties for comment, at least 1 week prior to commencing the specific element of the works. Each element of the works will not proceed until a method statement is in place and agreed by all parties.

3.0 FORMATION REQUIREMENTS

3.1 Definitions

3.1.1 The following definitions shall apply to this Specification wherever reference is made to the defined material.

"Suitable fill material" – shall comprise of all that which is in accordance with the Contract for use in the Works, and deemed by the CQA Engineer to be suitable. "Suitable fill material" is sub divided into two categories "general fill material" and "clay liner material".

"Unsuitable material" shall mean material other than suitable materials and shall include but is not exclusive to:

(i) Peat, material from swamps, marshes and bogs
(ii) Logs, stumps and perishable material
(iii) Material in a frozen condition
(iv) Material susceptible to spontaneous combustion
(v) Any industrial, commercial or domestic waste
(vi) Cobbles and boulders with a minimum dimension greater than 0.15m and maximum dimension no greater than 2/3 of the lift thickness.
(vii) Materials having a moisture content greater than the maximum or less than the minimum permitted for such materials in the Contract unless otherwise permitted by the CQA Engineer
(viii) Clay of liquid limit exceeding 80% and/or plasticity index exceeding 55%.

Materials of Class (vii) above if otherwise suitable shall be classified as suitable when wetted or dried sufficiently as appropriate.

"Rock" shall mean those geological strata indicated in the Contract to be regarded as such and other masses of hard material which cannot be removed from an excavation up to 4m deep with a Caterpillar 325 or equivalent excavator in good working order.

3.2 Excavation Requirements

3.2.1 The general excavation levels as shown on Drawing No. 3 is required to achieve formation levels.

3.2.2 The general excavation is anticipated to generate topsoil, subsoil, and silty sandy gravel, but possibly some construction and demolition waste, which may be present in discrete pockets. Site investigation data for the area of the landfill is included in Appendix B.

3.2.4 The Contractor shall, unless otherwise agreed by the CQA Engineer, carry out the excavation in such a manner that the materials are excavated separately for use in the Permanent Works without contamination by mixing of materials. All materials shall be immediately transported to a stockpile location agreed with the CQA Engineer or placed directly within the Works.

3.2.5 The Contractor shall ensure that the stockpiles are rolled / sealed at the end of each shift or at the onset of rain.

3.2.6 Topsoil and subsoil materials produced from the excavation to achieve formation levels may be temporarily stockpiled by agreement with the Employer's Site Manager and CQA Engineer. The stockpile of topsoil and subsoil shall not exceed 3m and 5m in height respectively, and shall be graded to prevent the ingress and ponding of surface water.

3.2.7 The Contractor shall inform the CQA Engineer without delay, should unsuitable material be encountered within the excavation.

3.3 Formation Preparation of Excavated Surfaces

3.3.1 The final excavated formation shall be rolled to provide a clean even, firm foundation sufficient to permit the movement of vehicles without causing rutting or other deleterious effects. The formation shall have no sudden sharp or abrupt changes in grade and shall be free from areas excessively softened by high water content. Prior to installation of the clay liner, the Contractor shall seek approval from the CQA Engineer as to the adequacy of finished rolled general fill surface.

3.3.2 Any soft spots identified in the formation surface shall be excavated to the satisfaction of the CQA Engineer and backfilled with suitable material placed and compacted in accordance with Section 3.4.

3.4 General Fill Placement and Compaction Procedures

3.4.1 General fill shall be sourced either from stockpiled materials, the removal of the existing cap or from excavation to achieve the formation levels.

3.4.2 General fill shall be placed in accordance with the Specification for Road Works (SRW), (Section 612 Compaction of Fills) published by the National Roads Authority (NRA).

3.4.3 The Contractor shall submit with his Completed Tender, a method statement detailing the plant and compaction techniques he proposes to use.

3.4.4 Prior to compaction, each discrete (loose) lift will be visually inspected by the Contractor and all unsuitable material as detailed in Section 3.1.1 shall be removed.

3.4.5 If material to be placed is in or attains a condition (e.g. as a result of inclement weather), such that it cannot be placed or compacted in compliance with the specific requirements set out in Section 3.4.2 then one of the following courses of action shall be undertaken:

a) the affected material shall be removed and discarded and/ or stored until it attains a suitable condition;

or

b) the material shall be treated by wetting or being allowed to dry as appropriate

3.4.6 Haulage of suitable materials to the areas of placement shall only proceed when sufficient spreading and compaction plant is operating at the place of deposition. There shall be minimum delay between placement and compaction.

3.4.7 No earthmoving or other plant which could damage the compacted material shall be allowed onto the surface of the material following satisfactory compaction.

3.5 Formation Preparation of Filled Surfaces

3.5.1 The final filled general formation shall be rolled to provide a clean even, firm foundation sufficient to permit the movement of vehicles without causing rutting or other deleterious effects. The formation shall have no sudden sharp or abrupt changes in grade and shall be free from areas excessively softened by high water content. Prior to installation of the clay liner, the Contractor shall seek approval from the CQA Engineer as to the adequacy of finished rolled general fill surface.

3.5.2 Any soft spots identified in the formation surface shall be excavated to the satisfaction of the CQA Engineer and backfilled with suitable material placed and compacted in accordance with Section 3.4.

4.0 CLAY LINER AND INTERCELL BUND

4.1 General

4.1.1 The clay liner is to be constructed on the perimeter slopes, base, and intercell bund. Drawing No. 4 details the top of liner levels and sections through the lining system.

4.1.2 The Contractor shall import into the site a suitable clay liner material sourced by Roadstone Dublin at its Huntstown Quarry. Appendix C presents a source characterisation report for the imported clay material.

4.1.3 The constructed clay liner on the base and perimeter slopes, must have a minimum thickness of 1.0m measured at right angles to the slope.

4.1.5 In addition to the general requirements of Section 3.1 the placed clay liner shall meet the following requirements:

Permeability < 1 x 10^{-9} m/s (BS1377: 1990: Part 6)
Fines content (< 0.075mm) > 20% (BS1377: 1990: Part 2)
Particle Size Distribution >70% passing 5mm sieve (BS1377: 1990: Part 2)
Plasticity Index <65% (BS1377: 1990: Part 2)
Liquid Limit <90% (BS1377: 1990: Part 2)

4.1.6 A vibratory sheepsfoot roller or other suitable compaction plant approved by the CQA Engineer shall be used for construction of the clay liner. The surface of compacted clay shall be sealed with a smooth roller after each shift. The smooth surface is then to be scarified before the next lift of clay is placed. The Contractor shall submit a method statement detailing the plant, conditioning and compaction techniques he proposes to use.

4.2 Field Trials

4.2.1 To assess the Contractor's proposed placement and compaction procedures a Field Trial of clay liner construction will be carried out. The trial should be carried out in an area not less than 10m x 10m and shall be carried out on an area of side slope and base that shall form part of the lining works.

4.2.2 The purpose of the Field Trials is to provide field verification of the moisture / density / permeability relationships as determined from the characterisation testing. The following aspects of the clay liner installation shall be evaluated for each layer of the field trial:

- Material handling and placement requirements
- Compaction equipment and procedures
- Number of passes of equipment necessary to achieve the required results
- Correction factors for moisture / density testing by NDG (if applicable)
- Materials testing to confirm previous characterisation results
- Permeability achieved in the laboratory

Testing of the clay shall be undertaken after each lift has been placed and compacted.

4.2.3 During the field trial the following tests shall be undertaken.

Layer One.	3 No. In situ density and moisture content 1 No. Particle Size Distribution 1 No. Plastic Index
Layer Two.	3 No. In situ density and moisture content 1 No. Permeability
Layer Three.	3 No. In situ density and moisture content. 1 No. Particle Size Distribution 1 No. Plastic Index

Layer Four. 3 No. In situ density and moisture content
1 No. Permeability

If a nuclear density gauge (NDG) is to be used to measure in situ density/moisture content, then a minimum of 6 No. core cutter samples shall be taken adjacent to NDG test locations, in order to establish whether or not a correction factor can be applied. Moisture content samples will be taken against all other NDG test locations. All laboratory tests shall be in accordance with Section 4.4.

4.2.4 If the results of Field Trials are satisfactory the area may be incorporated into the permanent works. If unsatisfactory, the Field Trial area shall be excavated and removed. The Contractor shall then submit his proposals for a revised procedure to the CQA Engineer, for approval before continuing with further field trials.

4.3 Placement Procedures and Compaction Requirements

4.3.1 The clay liner materials shall be placed and compacted in accordance with the general fill placement procedures as detailed in Section 3.4.

4.3.2 The acceptance envelope for the compacted clay liner material, based upon the findings of the source characterisation report is given in Appendix C. The limits of the acceptability criteria are as follows:

Minimum Moisture Content	10%
Maximum Moisture Content	16%
Maximum Air Voids	10%

The CQA Engineer may alter the above criteria based on the findings of the investigation and field trial. Any such alterations will require approval by the Environmental Protection Agency.

4.4 Compliance Testing

4.4.1 The Contractor shall inform the CQA Engineer when he has an area of clay liner ready for compliance testing. Tests shall be undertaken in accordance with the following frequencies:

Test	Test Method	Frequency
In situ dry density/moisture	see Section 4.4.3	1 per 20m grid of each lift
Laboratory permeability tests	BS1377: 1990, Part 6	1 per 500m^3
Grading Analysis (to clay size)	BS1377: 1990, Part 2	1 per 500m^3
Plasticity Index	BS1377: 1990, Part 2	1 per 250m^3

Note: These frequencies may be altered based upon the findings of the trial pit investigation and in agreement with the Environmental Protection Agency.

4.4.2 All laboratory testing shall be undertaken by an ILAB or UKAS (NAMAS) accredited laboratory, approved by the CQA Engineer. The frequency of testing may be increased should the CQA Engineer consider the material to be variable.

4.4.3 The in situ field dry density shall be measured using either the sand replacement method, core cutter method or by a nuclear density gauge. If a nuclear gauge is used the readings will be verified by core cutter or sand replacement at a minimum of 1 per 5 nuclear gauge readings or at least 1 per day of testing. Initially all moisture content readings from the nuclear density gauge shall be checked at each location by moisture content samples dried and weighed on site. Should an acceptable correlation be established for either moisture content or bulk density readings be established, then these frequencies may be reduced, with the agreement of the Environmental Protection Agency.

4.4.4 Undisturbed samples shall be taken for permeability testing. Samples shall be taken under the supervision of the CQA Engineer. Samples shall be immediately sealed, labelled and sent to a laboratory approved by the CQA Engineer for determination of permeability. In the event of a sample failing to meet the permeability criteria, a second undisturbed sample shall be taken and the cause of the initial failure investigated.

4.4.5 If the field testing demonstrates that the compaction requirements are not being attained the Contractor must carry out the following at his own expense:

a) Undertake additional works on the layer as necessary such that subsequent testing of the layer meets the required compaction requirement. This may include such measures as wetting up or drying of placed materials, additional passes of the compacting plant or other measures as deemed;
or
b) Remove the part of the layer demonstrated to have not met the required compaction requirement and replace it to the satisfaction of the CQA Engineer.

The Contractor's attention is drawn to the fact that permeability testing may take several weeks to complete on receipt of the samples at the laboratory. Proceeding with the works prior to receipt of permeability testing is at the Contractor's own risk.

4.4.6 As part of the construction quality assurance programme, the CQA Engineer must verify the clay liner thickness. Thickness shall be calculated from the survey data described in Section 2.25. The Contractor should ensure all survey data is passed to the CQA Engineer within 1 week of undertaking the survey.

4.4.7 All perforations made in the clay liner for testing shall be remediated either of the following methods:

a) The area immediately around the perforation shall be excavated to a nominal depth of 200mm, to loosen the soils. The area will then be recompacted with the same number of passes, as determined by the field trial;

or

b) The perforation shall be backfilled with a mixture of sand and bentonite. The materials shall be mixed at a ratio of 3 parts sand to 1 part bentonite, i.e. 25% bentonite.

4.5 Inclement Weather Conditions

4.5.1 No materials shall be placed or compacted in the engineered earthworks during inclement weather conditions, if in the opinion of the CQA Engineer, trafficking over compacted or uncompacted material would prove detrimental to the construction. Any such trafficking damage caused by the Contractor shall be repaired in accordance with the Contract at the Contractor's expense. Inclement weather conditions may include rain, snow, freezing conditions or excessive heat as indicated by the CQA Engineer on site.

4.5.2 Following wet weather conditions, any standing water on the surface of the construction must be removed. If instructed by the CQA Engineer, the Contractor shall remove to spoil heaps any material rendered unsuitable by wetting. Earthworks placement operations following inclement weather conditions shall not proceed without the prior approval of the CQA Engineer.

4.5.3 Any borrow material frozen in stockpiles shall be removed and put to one side until thawed. Previously compacted material that has become frozen shall be removed from the Earthworks and stockpiled until suitable for re-use.

4.6 Subgrade Preparation for GCL Placement

4.6.1 Surfaces to receive the GCL (see Section 5) shall be smooth and free from debris, roots, angular or sharp rocks exceeding 19mm in diameter and any other deleterious materials that may cause damage to the system. Any such deleterious material shall be removed from the surface and any resulting depression repaired to the CQA Engineer's satisfaction.

4.6.2 The surface shall be rolled and compacted such that in any event it provides a firm unyielding foundation sufficient to permit the movement of vehicles and welding equipment over the surface without causing rutting or other deleterious effects. The surface shall have no sudden sharp or abrupt changes in grade in excess of 25mm, and shall be free from areas excessively softened by high water content. A continuous fall shall be maintained towards the sump, with no areas of ponding or backfalls on the surface.

4.6.3 The Contractor's attention is drawn to the susceptibility of the clay liner material to wetting and drying. The Contractor shall protect the surface from desiccation, flooding and freezing. Surfaces containing desiccation cracks exceeding 25mm deep or exhibiting swelling, heaving or other similar conditions shall be replaced or reworked by the Contractor at his expense to the approval of the CQA Engineer to remove these defects.

5.0 GEOSYNTHETIC CLAY LINER

5.1 Manufacture

5.1.1 The Geosynthetic Clay Liner (GCL) shall comprise a layer of bentonite distributed over a highly porous reinforcing layer, sandwiched between two layers of polypropylene fabric, jointed by either stitch bonding or needle punching.

5.1.2 The manufactured GCL shall be available in roll form and shall possess the properties listed in Appendix D.

5.1.3 Prior to installation, the Contractor shall obtain the following information:

- The origin (suppliers name and location of material source) and identification of the bentonite used for production of the GCL;
- Copies of dated Quality Control information issued by the bentonite supplier;
- Results of Quality Control tests conducted by the GCL manufacturer to verify that the bentonite supplied met the GCL manufacturer's specifications;
- Copies of dated Quality Control information provided by the geotextile manufacturer;
- A specification for the GCL which contains all properties contained in the project specification for GCL's;
- Written certification that the minimum values given in the project Specification are guaranteed by the Manufacturer.
- Quality Control certificates, signed by a representative party employed by the manufacturer. Each Quality Control certificate shall include roll identification numbers, testing procedures and results of Quality Control tests. At a minimum, results shall be given for the properties listed in Appendix D.
- Proposed GCL panel layout.

5.1.4 The GCL shall be installed in accordance with the details presented on Drawing No. 4.

5.2 Supply, Delivery, Storage and Handling

5.2.1 The GCL shall be stored in accordance with the manufactures recommendations in its original unopened packaging to prevent premature hydration. Each roll of GCL shall be fitted with straps to facilitate safe unloading of the geomembrane and to prevent damage during unloading. Rolls must always be stored lying flat, continuously supported and never standing on one end. Storage on blocks or pallets shall be avoided to eliminate the risk of localised point loading. In order to protect the GCL from the weather, all rolls shall be covered by waterproof sheeting. Rolls may be stacked upon one another provided they are placed in a manner that prevents them from sliding and rolling from the stack. The recommended maximum stack height is 3 rolls.

5.2.2 A visual examination of the shipment should be made in order to identify any damage that may have occurred in transit to the site. Any visible or suspected damage must be recorded and opened; such rolls should be tagged, marked and segregated for further investigation. Rolls which are delivered without full packaging labelling and documentation will be tagged, marked and segregated for inspection by the CQA Engineer. Any small tears to packaging should be immediately repaired using tape and plastic sheeting.

5.3 Conformance Tests

5.3.1 Upon delivery of the rolls, the Engineer shall remove conformance test samples from selected rolls at the frequency given in Appendix D. Conformance testing in accordance with Appendix D shall be carried out by a laboratory approved by the CQA Engineer. The results shall be obtained, together with the batch or consignment numbers to which they relate. Materials not conforming shall be re-tested. If the materials fail the re-test they shall be rejected.

5.4 Installation

5.4.1 The Contractor shall install the GCL in accordance with the manufacturers recommendations and shall also provide a Method Statement for carrying out the work covered by this Specification and samples of the records used for process parameters and ambient conditions during installation, particularly with respect to the arrangements for temporary anchorage of the individual geosynthetics included in the lining system.

5.4.2 The method of installation of the GCL shall ensure that the following are complied with:

- On slopes, the GCL shall be securely anchored and the GCL material then deployed perpendicular to slope contours in such a manner as to keep the GCL panel in tension. The GCL will be placed the full height of the bunds. The dimensions of the anchor trenches are to be nominally 0.50m by 0.50m;
- Seams shall be placed perpendicular to the line of slope. Horizontal seams shall only be permitted on the face of the slope with the express approval of the CQA Engineer. The minimum overlap shall be 300mm and joined by the addition of bentonite powder or paste at a rate of 0.4kg/m, in accordance with the manufacturer's recommendations, unless the GCL has impregnated surfaces along sheet edges. The Engineer shall take samples of bentonite from the seams at a frequency of 1 per 50m of seam, to ensure that the required weight of bentonite has been provided;
- The Contractor shall take all necessary precautions to prevent damage to the underlying subgrade during placement of the GCL;
- During placement of the GCL, care shall be taken not to entrap beneath the GCL, any stones, excessive dust or moisture that could damage the GCL. The Contractor's attention is drawn to Section 4.6 regarding preparation of surfaces to receive geosynthetic materials. The Contractor shall not place any GCL without the prior approval of the subgrade by the Engineer;
- After installation, a visual examination of the GCL shall be carried out to ensure that no potentially harmful foreign objects, contaminated soil or damaged areas are present; and
- Excess loss of bentonite on edges during deployment should be minimised.

5.4.3 No more GCL material will be deployed during one working day than can be covered by the end of that day by the overlying geomembrane. GCL deployment shall not be undertaken during precipitation. The Contractor shall ensure full protection is afforded to the GCL so that premature hydration does not occur.

5.5 Repair Procedures

5.5.1 Any portion of the GCL exhibiting flaws shall be repaired. Prior to the acceptance of the installed GCL, the Contractor shall locate and repair all damaged areas of the GCL. Defects or damage can be identified by rips, tears, premature hydration of the GCL or delaminating of the Geotextile.

5.5.2 Rips or tears in the GCL shall be covered by another piece of GCL material meeting the project Specification. The material shall extend over the entire damaged area with a minimum overlap of 300mm in all directions, or in accordance with the manufacturers recommendations. Addition of bentonite on the joints shall be in accordance with Section 5.4.2.

5.5.3 Where the GCL has been exposed to moisture and has prematurely hydrated prior to placement of overlying material, an inspection of the GCL shall be undertaken. If the inspection deems the GCL to be damaged, dependent on the condition of the subgrade, the presence/absence of delamination or any loss of bentonite, the material may be removed and replaced with new material meeting the Specification.

5.6 Contractor's Experience

5.6.1 The Contractor shall have considerable experience of installing geomembrane of the type specified for the Works. The Contractor shall include with his completed Tender a summary of his (or his sub-contractor's) experience with the specified materials including an estimate of the total geomembrane area installed by him in Ireland and/or within the European Union over the past 12 months.

6.0 HDPE GEOMEMBRANE LINER

6.1 Geomembrane Materials

6.1.1 The geomembrane shall consist of high density polyethylene (HDPE) unlaminated material. Geomembrane shall be 2mm thick double textured HDPE. The material should be produced from new resins and containing no fillers, plasticisers or additives of any kind with the exception of carbon black.

6.1.2 The geomembrane shall be placed on the side slopes, base and intercell bund. It shall be anchored within trenches around the perimeter of the landfill in accordance with the details presented on Drawing No 4.

6.1.3 The geomembrane material shall meet the minimum requirements set out in Table 1 of Appendix E. The geomembrane shall be free from cuts, holes, blisters, abrasions or other surface blemishes or defects. The Contractor shall include with his completed Tender a statement of which manufacturer of material he proposes to use and shall include a schedule of results of independent laboratory testing which show that the minimum requirements set out in Table 1 of Appendix E can be met by typical material of the type to be used.

6.2 Delivery, Handling and Storage

6.2.1 The material shall be delivered, unloaded, handled and stored in accordance with the manufacturer's recommendations taking care to protect the material from damage and contamination. 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. Any protective coatings shall not be removed until the material is ready to be incorporated into the works. Each individual roll will be supplied with straps to facilitate unloading. The straps will have a sufficient strength to enable safe lifting of the entire weight of the roll.

6.3 Manufacturer's Quality Control

6.3.1 The Contractor shall include with his completed Tender a summary of quality control procedures undertaken by the manufacturer at his production facility. The summary shall include the parameters checked and the frequency of the checks.

6.3.2 The Contractor shall supply certificates detailing the quality control testing undertaken by the manufacturer for each batch of material delivered to site. The certificate shall contain the following information as a minimum.

	Parameter	Test Specification
i.	Thickness	ASTM D1593
ii.	Carbon Black Content	ASTM D1603
iii.	Carbon Black Dispersion	ASTM D5596
iv.	Density	ASTM D1505A
v.	Tensile properties	ASTM D638, Type IV, 2 ipm
	Stress @ yield	
	Stress @ break	
	Elongation @ yield	
	Elongation @ break	

6.4 Conformance Testing

6.4.1 As soon as practicable after the delivery of geomembrane to site the Contractor shall label and cut a sample 1m wide across the entire width of selected rolls under the direction of the CQA Engineer. Samples shall be selected at a frequency of 1 per 5,000m^2 of material delivered to site.

6.4.2 The Contractor will be required to submit samples described in Section 6.4.1 to a geosynthetic laboratory approved by the CQA Engineer for laboratory conformance testing. The Contractor shall include with his completed tender a statement of which geosynthetic laboratory he proposes to use. All of the parameters listed in Table 1 of Appendix E will be tested. The Contractor shall furnish to the CQA Engineer a copy of the laboratory test results immediately on receipt and within seven days of samples being taken.

6.4.3 If testing shows that the geomembrane does not meet any one of the minimum requirements listed in Table 1 of Appendix E, then this may be cause for rejection of the material from that roll. The Contractor's attention is drawn to the need for a rapid turn round of laboratory results in this connection. Any repairs or other works occasioned by the failure of the geomembrane to meet the minimum requirements listed in Table 1 of Appendix E shall be carried out at the Contractor's expense.

6.4.4 The CQA Engineer, with the agreement of the Environmental Protection Agency as detailed in Section 2.20.4, may at his discretion accept material from elsewhere on that roll, if the Contractor can demonstrate through further laboratory testing at a geosynthetic laboratory approved by the Engineer that this material does meet the acceptance criteria contained in Table 1 of Appendix E.

6.4.5 Further testing of geomembrane shall be undertaken at the Contractor's expense.

6.5 Contractor's Experience

6.5.1 The Contractor shall have considerable experience of installing geomembrane of the type specified for the Works. The Contractor shall include with his completed Tender a summary of his (or his sub-contractor's) experience with the specified materials including an estimate of the total geomembrane area installed by him in Ireland and / or within the European Union over the past 12 months.

6.6 Geomembrane Deployment

6.6.1 The Contractor shall submit a detailed Geomembrane Panel Layout Plan showing the proposed layout and sequence of geomembrane placement not less than one week prior to commencing installation. Geomembrane panels shall be installed in accordance with the layout plan as approved by the CQA Engineer.

6.6.2 The Contractor shall arrange the panels lying on the perimeter slopes such that seams are aligned parallel to the line of maximum slope (i.e. perpendicular to contours), whenever practicable in accordance with accepted good practice. On the base of the cell, panels shall be laid with the up slope panels overlying the down slope panel ("rain flapped").

6.7 Temporary Surcharge

6.7.1 The Contractor shall be responsible for the geomembrane at all times during the Works and shall adopt whatever measures are necessary to ensure its stability and protect it from damage. These measures shall include the use of sufficient temporary surcharge in the form of durable sandbags, or similar weights without sharp edges or protrusions, to be placed on the geomembrane immediately after laying and before seaming 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 adequately during the contract shall be remedied at the Contractor's expense. In this regard the Contractor's attention is drawn to the need to provide adequate restraint at free edges of sheet material before anchoring or welding to the adjacent seam, in order to prevent uplift by wind. If tyres are used as temporary surcharge the contractor shall remove them off site at the completion of the installation works.

6.8 Thickness

6.8.1 As part of the project Construction Quality Assurance programme, the geomembrane thickness will be measured at intervals by the CQA Engineer for each panel. The thickness tolerances are given in Table 1 Appendix E. Variation of geomembrane thickness outside these tolerances may be cause for rejection of the affected geomembrane. The rationale for thickness acceptance shall be:

a) No single thickness measurement shall exceed the stated tolerances stated in Table 1 of Appendix E;

and

b) The average of the CQA Engineer's measurements across a given roll width shall be greater than the specified 2mm thickness

6.9 Seaming

6.9.1 General

6.9.1.1 The Contractor shall submit method statements for approval by the CQA Engineer not less than one week prior to commencing installation, detailing the following as a minimum.

- Proposed seaming technique or techniques and their proposed applications
- Proposed seaming machinery
- Overlap widths and overlap preparation prior to seaming
- Proposed acceptable temperature ranges for extrudate and / or hot wedge
- Proposed acceptable maximum seaming speed if automated machinery to be used
- Seam pre-treatment measures e.g. grinding and cleaning

6.9.1.2 The contractor shall submit his proposals for extrudate, wedge welding, leistering of geomembrane, geotextiles seam pre-treatments, with specific regards to the following aspects:

- Gas level monitoring
- Safe gas working levels
- Seam testing methodology

The Contractor shall be deemed to have included for safety precautions within his rates.

6.9.2 Trial Seams

6.9.2.1 The Contractor shall perform trial seams with each seaming machine and operator at least at the start of each shift, after every four hours of operation and also following any period of machine shutdown or change of operator.

6.9.2.2 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 four 25mm wide field tabs normal to the seam spaced along the seam length. The tabs shall be subjected to field qualitative destructive testing using a tensiometer. Three of the four tabs shall be tested in peel mode with the fourth sample tested in shear mode.

6.9.2.3 The trial seam will be deemed to have passed qualitative destructive testing if 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 any of the failure enters the seam. Appendix F shows the destructive sample test codes for both extrusion and fusion welding.

6.9.2.4 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 a passing trial seam. Trial seaming and destructive testing will be observed by the CQA Engineer.

6.9.3 Field Seams

6.9.3.1 The Contractor shall perform field seams only after satisfying trial seam conditions as specified in Section 6.9.2 of this Specification. The Contractor shall ensure that all pre-treatment measures (e.g. grinding and cleaning), as specified in his approved method statement in Section 6.9.1.1 are carried out and that extrudate and / or hot wedge temperatures are maintained within a range approved by the CQA Engineer.

6.9.3.2 The Contractor's attention is drawn to the fact that:

- Seaming will not be allowed during rain or snow unless proper precautions are made to allow the seam to be made on dry geomembrane materials.
- Seaming above saturated soil is not acceptable.
- Ponded water on the soil surface beneath the geomembrane is not acceptable.
- Seaming above frozen ground is not acceptable.
- Ambient air temperature for seaming should be above 5°C.

6.9.3.3 The Contractor shall advise the CQA Engineer when he is ready to commence seaming and shall not perform seaming unless the CQA Engineer is in attendance.

6.9.3.4 All field seams shall be completed to the back edge of the anchor trench, i.e. the edge furthest away from the slope or toe bund. Any seam defects falling within the anchor trench shall be repaired in accordance with Section 6.11.

6.9.3.5 During construction a minimum overlap of 100mm shall be clearly marked on the edge of the underlying sheet seam prior to seaming. Failure to maintain the minimum overlap may be cause for rejection of the seam.

6.10 Sampling and Testing

6.10.1 Non-Destructive Testing

6.10.1.1 The Contractor shall perform non-destructive testing along the entire lengths of all field seams including patches and repairs. The Contractor shall submit not less than one week prior to commencing installation a method statement detailing his proposed non-destructive test technique or techniques and their proposed applications.

6.10.1.2 For air pressure testing of fusion seams the test length should be sealed at both ends and an approved pressure feed divide inserted into the air channel. The channel should then be pumped to a pressure of between 25 and 30 psi (1.75 and 2.1 BAR) and allowed to stabilise for 1 minute. The test will have deemed to have failed if the loss of pressure exceeds 3 psi (0.2 BAR) over a 5 minute period following stabilisation. The test will have deemed to have passed if the loss of pressure is less than 3 psi over a 5 minute period. Pressure shall be released from the opposite end of the seam from the gauge.

6.10.1.3 For vacuum box testing each section of the seam should be tested and observed for a period of not less than 10 seconds. In the case of extruded seams the Contractor may use spark testing to prove the integrity of the weld, however this will not be permitted along the tie-in details.

6.10.1.4 In the event of a field seam failing non-destructive testing the Contractor shall identify and repair the failed area in accordance with Section 6.11. The Contractor shall then subject the repair to further non-destructive testing until the seam shall pass the test.

6.10.1.5 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.

6.10.2 Qualitative Destructive Testing

6.10.2.1 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 mode using a tensiometer.

6.10.2.2 The seam will be deemed to have passed qualitative destructive testing if 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 any of the failure enters the seam.

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

a) reconstruct the seam

or

b) cut further tabs 3m along from the failed tab and subject it to qualitative destructive testing. If the tab passes qualitative destructive testing the Contractor shall reconstruct the seam from the passed location back to the end of the seam, in accordance with Section 6.11. If the 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 length of seam in accordance with Section 6.11 of this Specification.

6.10.2.4 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.

6.10.3 Quantitative Destructive Testing

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

6.10.3.2 The Contractor shall divide the sample as shown in Appendix G and release sub-sample C to the CQA Engineer for archiving. Samples shall be held by the CQA Engineer prior to dispatch to the approved laboratory.

6.10.3.3 The Contractor shall without delay dispatch sub-sample B to an approved geosynthetic laboratory for destructive testing in accordance with Table 2 of Appendix E. The Contractor should note that five tabs should be cut 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 the laboratory test procedure. The Contractor shall issue copies of the test results certificates to the CQA Engineer immediately upon receipt, within 48 hours of cutting the sample from the installation.

6.10.3.4 The seam will be deemed to have passed quantitative destructive testing if in five out of five of the tabs:

(i) The failure occurs solely in the parent material and does not enter the seam.
(ii) The peel strength exceeds that indicated in Table 2 of Appendix E
(iii) The shear strength exceeds that indicated in Table 2 of Appendix E

6.10.3.5 The seam will be deemed to have failed quantitative destructive testing if in one or more of the five tabs:

(i) Any of the failure enters the seam.
(ii) The peel strength is less than that indicated in Table 2 of Appendix E
(iii) The shear strength is less than that indicated in Table 2 of Appendix E

6.10.3.6 If a seam fails quantitative destructive testing the Contractor shall investigate the cause of the failure with the laboratory. Further tabs shall be cut from the sample and tested. If these samples pass and a valid cause determined, then the seam will be deemed to have passed. Should the subsequent tests fail or if a reasonable cause of failure cannot be determined

then the Contractor shall investigate the seam to each side of the failed sample as specified in Section 6.10.2. The Contractor shall cut further laboratory samples from each side of the failed section and perform laboratory tests upon them at his own expense until the failed seam is bounded by two passed locations.

6.10.3.7 The Contractor shall then reconstruct the failed seam in accordance with Section 6.11. The CQA Engineer may at his discretion observe laboratory destructive testing in which event the Contractor shall arrange permission for access to the approved laboratory.

6.10.3.8 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 one week of the completion of the Works.

6.11 Repairs, Patches and Cap-Strips

6.11.1 General

6.11.1.1 All discontinuities in the geomembrane (whether caused by damage, or failure of geomembrane or seams to conform with Specification, or of sampling or testing or other factors), shall be repaired by the Contractor in the following manner:

6.11.2 Point defects

6.11.2.1 The area shall be prepared in accordance with the Contractors approved method statement. Surface defects that do not puncture the geomembrane, but reduce the effective thickness shall be repaired by the application of an additional layer of extrudate. Point defects that that puncture the geomembrane shall be patched.

6.11.3 Large faults

6.11.3.1 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 100mm in all directions. The area shall then be prepared in accordance with the Contractors approved method statement and seamed in accordance with Section 6.9.

6.11.4 Seam faults

6.11.4.1 Faulted extrusion seams shall be overlain with a single piece of compatible geomembrane with a minimum overlap of 100mm in all directions to form a cap strip. The repair may then be completed as for large faults.

6.11.4.2 Faulted fusion seams shall be cut back to remove the upper flap, prepared in accordance with the Contractor's approved method statement, and extruded in accordance with Section 6.9.

6.11.4.3 The Contractor shall test all repairs in accordance with Section 6.10.1.

6.12 Construction Details

6.12.1 The geomembrane shall be installed to the grades shown on Drawing No 4. The anchor trenches shall be constructed in accordance with Drawing No 4.

6.12.2 Shoulders of the anchor trench shall be slightly rounded when a geomembrane adjoins the trench to minimise sharp bends. The geomembrane shall be installed and welded to the back of the anchor trench as shown on the drawing. Anchor trench backfill shall be selected excavated material and installed in lifts not exceeding 150mm and compacted with a vibrating compaction plate or other means approved by the CQA Engineer.

7.0 LEACHATE COLLECTION AND REMOVAL SYSTEM

7.1 General

7.1.1 The leachate collection and removal system (LCRS) shall incorporate a geotextile protector, granular drainage blanket, collection pipework, and a sideslope extraction system. Details of the LCRS are shown on Drawing No. 5.

7.1.2 The Contractor shall inspect the geomembrane for defects and seek approval from the CQA Engineer, prior to deployment of the protective geotextile.

7.1.3 The Contractor shall submit a full method statement to the CQA Engineer for approval for all aspects of the LCRS installation. The Contractor shall supply all materials for the LCRS.

7.1.4 The contractor shall submit a method statement to the CQA Engineer, as soon as practical, detailing how each element of the LCRS will be handled, stored and installed within the works. This method statement shall be submitted by the CQA Engineer to the EPA.

7.2 Protective Geotextile

7.2.1 The protective geotextile shall be installed directly above the geomembrane and anchored as shown on the Drawing No. 5.

7.2.2 The geotextile shall be non woven needle punched constructed from virgin fibres of polypropylene. The geotextile shall be suitably sized based upon the results of the cylinder test described below.

7.2.3 The proposed geotextile shall be subjected to a cylinder test with the proposed smooth geomembrane and leachate drainage blanket (see Clause 7.3). Values for the vertical load vary due to the changing depth of waste. The contractor should consider the possibility of using different grades of geotextile to reduce costs, to aid a cost benefit analysis. Where a combination of geotextiles is to be used, the Contractor shall produce a drawing, for approval by the CQA Engineer, which details the extent of each type of material to be installed. On site the extent of each material shall be set out by the Contractor and an as built panel layout maintained.

7.2.4 A load equivalent of 2.5 x the vertical load of waste (200x2.5=500kPa) shall be applied for a period of 100 hours (vertical load is equal to the depth x 1000kg/m^3 (16m), plus the 2m depth of restoration soils at 2000kg/m^3). The test procedure shall be in accordance with the UK Environment Agency's guidance on protectors for geomembranes, or similar. A typical cylinder test cell arrangement is presented in Appendix H. The Contractor shall include with his completed Tender, the name of the laboratory who he proposes to carry out the test. On completion of the test the geomembrane shall be visually inspected for defects, blemishes and damage to assess the effectiveness of the geotextile protector. The Contractor should seek to undertake this test as early as possible within the Construction programme. The results of testing undertaken by the geotextile manufacturer on the proposed product, prior to the contract, may be acceptable providing that the geomembrane and loading criteria are in accordance with this Clause.

7.2.5 The specific pass and failure criteria for the test should be agreed with the CQA Engineer following agreement on the specific test method. As guidance a specific strain value may be used for acceptance. The strain would be calculated as follows:

$$\text{local strain} = \frac{ld - lu}{lu}$$

where ld = undeformed length of depression extent in the lower lead sheet
lu = deformed length of a depression in the lower lead sheet

The allowable strain criteria for the test will be 0.25%.

7.2.6 The Contractor shall, upon receipt of a passing cylinder test result, inform the CQA Engineer as to which Manufacturer and which product he proposes to use as the protection. The contractor shall submit a copy of the manufacturer's data sheet for this product detailing the minimum average roll values (MARV) for the following parameters:

CBR puncture resistance {BS EN ISO 12236}	N
CBR puncture displacement {BS EN ISO 12236}	mm
Cone Drop perforation hole diameter {BS EN 918}	mm
Tensile strength {BS EN ISO 10319	kN/m
Thickness under 2 kPa{BS EN 964 - 1}	mm

7.2.7 Geotextiles shall be delivered to site in open top or curtain sided containers, in packaging which will protect the rolls from degradation by ultra violet light.

7.2.8 The Geotextile manufacturer shall provide production test certificates for rolls delivered to site. Certificates relevant to a batch of Geotextile shall be furnished to the CQA Engineer prior to that batch of Geotextile being incorporated in the works.

7.2.9 Conformance samples shall be taken from the rolls delivered to site at a frequency of 1 per 6,000m^2. Samples shall be 0.5m wide by the width of the roll. Samples shall be split into three: 1No for the CQA Engineer, 1No.for the Contractor and 1No for conformance testing. The Contractor shall supply prior to commencement of the works a statement of which geosynthetic laboratory he proposes to use. All of the parameters listed in Clause 7.2.6 will be tested to ensure the material shall conform to the quoted MARVs. The Contractor shall furnish to the CQA Engineer a copy of the laboratory test results immediately on receipt and within seven days of samples being taken.

7.2.10 Geotextiles shall be protected at all times against physical or chemical damage. Geotextiles shall be kept in the wrappings provided by the manufacturer until required for use in the works. The rolls of Geotextile shall be stored on level ground and stacked not more than five rolls high and no other materials shall be stacked on top of the Geotextiles.

7.2.11 The method of installation shall not impose stresses or strains likely to cause damage to the Geotextile. The method of installation shall ensure that the Geotextile is in continuous contact with the surface on which it is placed without stretching or bridging over humps or hollows. Construction plant must not operate directly on the Geotextile.

7.2.12 Joints shall be formed by either hot air welding or stitching. The material at the joints will overlap, by 300mm for hot air welding and by 150mm for stitching. The method of jointing is to be approved by the CQA Engineer.

7.2.13 A double layer of protection geotextile shall be provided beneath the leachate collection sumps as detailed in Drawing No. 5.

7.3 Leachate Drainage Blanket

7.3.1 The leachate drainage blanket shall be installed above the protective geotextile in accordance with Drawing No. 5.

7.3.2 The drainage blanket shall be a clean suitably sized granular material, nominally 10-20mm and shall be used in the cylinder test as described in Clause 6.2. The material shall not contain more than 5% finer than 10mm. The blanket shall have a permeability of greater than 1 x 10^{-3} m/s. The material is also required to have a 10% fines value of greater than 100 kN.

7.3.3 Leachate drainage stone shall be sourced by Roadstone Dublin and stockpiled at a location agreed with the Contractor. Handling of the material in the stockpile will be done in such a manner as to minimise the potential for increasing the fines content.

7.3.4 The Contractor shall carry out laboratory grading at a frequency of 1 per 250m^3 of material placed in the works. Carbonate content, permeability and 5% fines shall be tested at a frequency of 1 per 1000m^3 and shall be sampled from the quarry prior to the approval of the material to be used on site.

7.3.5 The blanket shall be installed to a minimum thickness of 500mm.

7.3.6 The blanket shall be installed such that no wrinkles are developed in the underlying geotextile and geomembrane. A minimum 1m thickness of drainage blanket material shall be maintained between the protective geotextile and haulage vehicles. The blanket shall be spread using a 360° excavator, of maximum weight 12 tonnes, and graded using a low ground pressure dozer which will be continually supervised such that any damage to the underlying materials are identified and repaired in accordance with Section 6.0.

7.3.7 The Contractor shall prevent any damage from occurring to the underlying protection geotextile during blanket installation.

7.4 Leachate Collection Pipework

7.4.1 The leachate collection pipework shall be installed in accordance with Drawing No. 5. The basal drains shall be 200mm internal diameter (minimum PE80 SDR11) perforated pipe, manufactured to DIN 8074, twin wall pipes shall not be acceptable. A lower grade of solid wall HDPE pipe may be acceptable if the Contractor can demonstrate compliance with Section 7.4.6 of this Specification.

7.4.2 All leachate pipework shall be laid upon a minimum of 50mm of drainage layer material and there shall be a minimum cover of 400mm of granular material to the 200mm diameter pipe.

7.4.3 The pipework shall be delivered, handled and stored in accordance with the manufacturer's quality control documentation. The pipes should be stored on an area flat enough to accommodate the entire length of the pipes and in such a way so that they are not damaged or deformed. The pipes shall not be stacked higher than 1m.

7.4.4 The Contractor shall prevent any damage from occurring to the underlying geotextile and geomembrane during pipe installation. Should the geotextile or geomembrane be damaged in any way the Contractor shall repair the damage at his cost according to Section 6 (geomembrane) or Section 7.2 (Geotextile) of this Specification.

7.4.5 For perforated pipework, perforations shall be not less than 10,000mm^2 of holes per meter length of pipe for the top 240° of the pipe. The lower 120° shall be solid to allow the flow of water to the extraction point. The perforations shall not reduce the pipe stiffness by more than 5%. Circular perforations shall not be greater than 12mm nor less than 8mm in diameter. Rectangular slots shall not be less than 5mm wide and 25mm long.

7.4.6 The Contractor shall submit calculations from the pipe manufacturer to demonstrate that the pipe meets the following requirements:

- Pipe deflection < 5%
- D85/hole diameter >1.0 (Circular perforations)
- D85/slot width >1.2 (Slot perforations)

Where D85 refers to the sieve size above which 85% of the granular material surrounding the pipe would be retained. The calculations shall be made using the ATV 127 Method (or similar approved method) with the following assumptions.

- Waste Density 1000 kg/m^3
- Maximum waste depth = 16m
- Soil stiffness of an uncompacted unconfined gravel surround

7.4.7 The Contractor shall submit his proposals for all PE80 pipes and fittings to the CQA Engineer for approval and shall provide the CQA Engineer with copies of all pipe manufacturers' quality control documentation.

7.4.8 All pipework will be butt fusion welded (Bead free technique) or connected using Electro-fusion couplings. The installation of welded pipes shall only be undertaken by experienced personnel. The Contractor shall supply the CQA Engineer with the following welding information for each welded joint:

- Date and time of weld,
- Weld number,
- Operator,
- Heater temperature, heat soak time,
- Bead pressure, fusion pressure,
- Actual and target cooling times.

7.4.9 The installation and welding of pipes shall only be undertaken by skilled and experienced personnel. The Contractor shall supply, prior to commencement of the works, a summary of his experience or that of his subcontractor with the materials.

7.5 Leachate Extraction Risers and Monitoring Points

7.5.1 The leachate extraction risers and monitoring points shall be installed in accordance with Drawing No. 5.

7.5.2 The leachate from the lowest point in the sump shall be extracted via a nominal 1000mm internal diameter riser, constructed from concrete manhole rings founded on a reinforced concrete pad. Within the concrete rings a 450mm diameter HDPE pipe shall be installed to allow a pump to access the sump. The annulus between the concrete rings and HDPE pipe shall be backfilled with leachate drainage stone.

7.5.3 Leachate levels will be monitored remotely from the sump at the locations indicated on Drawing No.5. The monitoring points shall comprise 1000mm diameter concrete rings, founded on a reinforced concrete pad within which a 200mm diameter HDPE pipe is installed. The annulus between the rings and pipe shall be backfilled with leachate drainage stone.

7.5.4 The risers and monitoring points shall be founded upon a 3m x 3m x 0.2m concrete pad reinforced with a layer of A252 reinforcing mesh or equivalent reinforcing steel bars. Concrete forming the pad and concrete rings shall have a sulphate resistance of class 4.

7.5.5 The concrete rings shall be founded on the concrete slab with the lower two rings being perforated. The Contractor shall supply sufficient concrete rings for the construction of the risers to the full depth of the waste. However, only the initial 3m of the riser shall be installed as part of the works.

7.5.6 At the base of the rise the HDPE pipe shall be fitted with a 800mmx800mmx50mm base plate and the lower 3m of the pipe shall be perforated. Above the section of perforated pipe, a plain HDPE pipe will extend up to the final waste levels. Only the perforated section of the HDPE pipe shall be installed as part of the contract. The remaining pipework (both HDPE and concrete) shall be installed in line with waste inputs by the operator.

7.5.7 Perforations shall be not less than 10,000mm^2 of holes per meter length of pipe. The perforations shall not reduce the pipe stiffness by more than 5%. Circular perforations shall not be greater than 12mm nor less than 8mm in diameter. Rectangular slots shall not be less than 5mm wide and 25mm long.

7.5.8 The sump area shall be back-filled with leachate drainage stone to a level above the perforated section of the concrete rings.

7.5.9 The Contractor shall prevent any damage from occurring to the underlying protection geotextile during pipe installation.

7.5.10 The Contractor shall submit his proposals for all pipe fittings to the CQA Engineer for approval.

7.6 Geomembrane Leak Location Survey

7.6.1 Upon completion of the leachate drainage system, a geomembrane leak location survey is to be undertaken, under a separate contract awarded by the Client. The survey will investigate the area of the geomembrane covered by the leachate drainage blanket.

7.6.2 The survey will require that the material above the geomembrane is electrically isolated from the 'outside world'. Usually this is ensured by leaving a strip of the geomembrane liner, of nominal width 500mm, exposed around the full perimeter of the survey area.

7.6.3 The Contractor will be responsible for maintaining the leachate drainage blanket moist throughout, during the period of the survey. In excessively dry conditions this may require that the material be doused before the survey can be performed.

7.6.4 In extremely wet conditions, any water pooling in the cell or on the exposed strip of line should be removed, as it can act as an electrical conduit reducing the sensitivity of the survey.

7.6.5 The survey will be undertaken on a grid arrangement with survey lines no greater than 1m intervals. The Contractor shall set out the grid prior to the arrival of the leak location team.

7.6.6 The Contractor will repair, at his own cost any damage to the underlying geomembrane and geotextile, revealed by the survey.

8.0 CAPPING WORKS

8.1 General

8.1.1 The capping works shall comprise the installation of a 300mm gas drainage layer, geosynthetic clay liner (GCL)/1mm VFPE welded geomembrane composite cap, 500mm thick drainage layer and 1000mm of restoration soils. The capping works shall also incorporate a gas extraction and leachate recirculation systems. The capping works shall be constructed in accordance with the details presented on Drawing Nos. 6 and 7.

8.2 Leachate Recirculation System

8.2.1 The leachate recirculation system is to be installed within trenches excavated within the final waste levels, as detailed on Drawing No.6. The system shall comprise pipework installed within trenches below the capping system, which allows leachate to be pumped from the leachate drainage system back into the waste.

8.2.2 500mm wide by 1000mm deep Trenches shall be excavated in the waste. The alignment of the trenches, as indicated on Drawing No. 6, may be altered by the CQA Engineer on site, to ensure that a fall is maintained along their length. Waste arising from the excavation of the trenches shall be disposed of within the landfill area.

8.2.3 A system of recirculation pipework shall be installed within the trenches, in accordance with the details presented on Drawing No. 6. Perforated pipe will run within the trenches and plain pipe extending up through the cap.

8.2.4 The trenches shall be backfilled with a free draining granular materials, nominal 20mm single size. A geotextile separator, non-woven Terram 100 or similar approved, shall be placed around the trench to prevent the ingress of fines into the drainage media.

8.2.5 The pipework shall be 180mm outside diameter PE80 (minimum SDR 17.6) manufactured to DIN 8074. For perforated pipework, perforations shall be not less than 10,000mm^2 of holes per meter length of pipe. The perforations shall not reduce the pipe stiffness by more than 5%. Circular perforations shall not be greater than 12mm nor less than 8mm in diameter. Rectangular slots shall not be less than 5mm wide and 25mm long.

8.2.6 Pipework shall be installed in accordance with Sections 7.4.7 to 7.4.9 of this Specification.

8.2.7 Access to the pipework for recirculation of leachate and access for maintenance of the pipework, shall be provided at ground level as indicated on Drawing No. 6.

8.3 Landfill Gas Venting System

8.3.1 General

8.3.1.1 The landfill gas management will rely upon a passive venting and shall comprise a gas drainage layer over the top of the waste and deep wells retro fitted within the waste.

8.3.2 Gas Drainage Layer

8.3.2.1 The gas drainage layer comprises a 300mm thick layer of granular material overlying the final waste level providing a permeable layer from which landfill gas can be collected and vented through a system of pipework installed within the blanket and penetrating through the cap, as detailed on Drawing No. 7.

8.3.2.2 Prior to the installation of the gas drainage layer the surface of the final waste levels shall be graded and compacted to remove undulations and ensure a firm base to the capping system.

8.3.2.3 Immediately above the prepared waste surface a geotextile separator (non-woven Terram 1000 or similar approved) shall be installed to prevent the ingress of fines into the drainage layer during both installation and operation. The material shall be supplied and installed in accordance with Sections 7.2.10 to 7.2.12 of this Specification.

8.3.2.2 The gas drainage blanket shall be either a clean coarse grained sand or fine gravel. The blanket shall have a permeability of greater than 1 x 10^{-4} m/s. Gas drainage blanket material shall be sourced by Roadstone Dublin and stockpiled at a location agreed with the Contractor. Handling of the material in the stockpile will be done in such a manner as to minimise the potential for increasing the fines content.

8.3.2.3 The surface of the gas drainage layer to receive the GCL shall be smooth and free from debris, roots, angular or sharp rocks exceeding 19mm in diameter and any other deleterious materials that may cause damage to the system. Any such deleterious material shall be removed from the surface and any resulting depression repaired to the CQA Engineer's satisfaction.

8.3.2.4 The surface shall be rolled and compacted such that in any event it provides a firm unyielding foundation sufficient to permit the movement of vehicles and welding equipment over the surface without causing rutting or other deleterious effects. The surface shall have no sudden sharp or abrupt changes in grade in excess of 25mm.

8.3.2.6 A system of collection pipework shall be installed within the gas drainage layer which will allow the gas to vent through the cap, in accordance with the details presented on Drawing No. 7. Perforated pipe will run laterally within the gas drainage layer with plain pipe extending up through the cap.

8.3.2.7 The pipework shall be 180mm outside diameter PE80 (minimum SDR 17.6) manufactured to DIN 8074. For perforated pipework, perforations shall be not less than 10,000mm^2 of holes per meter length of pipe. The perforations shall not reduce the pipe stiffness by more than 5%. Circular perforations shall not be greater than 12mm nor less than 8mm in diameter. Rectangular slots shall not be less than 5mm wide and 25mm long.

8.3.2.8 Pipework shall be installed in accordance with Sections 7.4.7 to 7.4.9 of this Specification, inclusive

8.3.3 Gas Wells

8.3.3.1 A series of gas extraction wells are to be installed to allow the venting of gas from deep within the waste mass. The gas extraction wells shall be installed upon completion of waste placement and shall be installed in accordance with the details and at the locations indicated on Drawing No. 7.

8.3.3.2 Boreholes shall be sunk within the waste to a level 3m above the basal lining system. Prior to commencing the drilling of the boreholes, each location shall be set out and the ground level recorded. The target depth of each borehole shall then be calculated and recorded on a peg at the location of the each gas well.

8.3.3.3 The pipework shall be 180mm outside diameter PE80 (minimum SDR 17.6) manufactured to DIN 8074. Perforated shall extend from the base of the borehole to the level of the gas drainage layer and above this level a plain pipe surrounded by a bentonite seal shall penetrate the cap and restoration soils, as detailed on Drawing No. 7.

8.3.3.4 For perforated pipework, perforations shall be not less than 10,000mm^2 of holes per meter length of pipe. The perforations shall not reduce the pipe stiffness by more than 5%. Circular perforations shall not be greater than 12mm nor less than 8mm in diameter. Rectangular slots shall not be less than 5mm wide and 25mm long.

8.4 Geosynthetic Clay Liner

8.4.1 The Geosynthetic Clay Liner (GCL) shall be installed over the gas drainage layer as detailed on Drawing No. 6.

8.4.2 The GCL shall comprise a layer of bentonite distributed over a highly porous reinforcing layer, sandwiched between two layers of polypropylene fabric, jointed by either stitch bonding or needle punching. The material shall be supplied and installed in accordance with Section 5 of this Specification.

8.5 VFPE Geomembrane

8.5.1 The geomembrane shall consist of very flexible polyethylene (VFPE) unlaminated material. Geomembrane shall be 1mm thick double textured VFPE. The material should be produced from new resins and containing no fillers, plasticisers or additives of any kind with the exception of carbon black.

8.5.2 The geomembrane shall be placed directly over the GCL and shall be anchored in a trench around the perimeter of the landfill in accordance with the details presented on Drawing No 6.

8.5.3 The geomembrane material shall meet the minimum requirements set out in Table 3 of Appendix E. The geomembrane shall be free from cuts, holes, blisters, abrasions or other surface blemishes or defects. The Contractor shall include with his completed Tender a statement of which manufacturer of material he proposes to use and shall include a schedule of results of independent laboratory testing which show that the minimum requirements set out in Table 3 of Appendix E can be met by typical material of the type to be used.

8.5.4 All penetrations such as inspection chambers will be sealed so as to prevent any infiltration. Penetrations through the geomembrane will be sealed along using a "top hat" arrangement. The Contractor shall forward proposals for "top hats" for approval by the CQA Engineer. Detail work, defined as the work necessary to seal the liner/capping geomembrane to pipe penetrations, shall be as detailed on Drawing No. 6.

8.5.5 The geomembrane material shall meet the minimum requirements set out in Table 3 of Appendix E. The geomembrane shall be free from cuts, holes, blisters, abrasions or other surface blemishes or defects. The Contractor shall include with his completed Tender a statement as to the installer of the geomembrane, whether that be himself or a sub-contractor.

8.5.6 The material shall be delivered, handled and stored in accordance with Section 6.2 of this Specification

8.5.7 The Contractor shall supply certificates from the manufacturer detailing the quality control testing undertaken by the manufacturer for each batch of material delivered to site to demonstrate that the material meets the minimum requirements set out in Table 3 of Appendix E. The certificate shall contain the following information as a minimum.

Parameter	Test Specification
i. Thickness	ASTM D1593
ii. Carbon Black Content	ASTM D1603
iii. Carbon Black Dispersion	ASTM D5596
iv. Density	ASTM D1505A
v. Tensile properties Stress @ yield Stress @ break Elongation @ break	ASTM D638, Type IV, 2 ipm

8.5.7 Conformance testing shall be undertaken in accordance with frequencies and protocols set out in Section 6.4 of this Specification in order to demonstrate that the material meets the requirements set out in Table 3 of Appendix E.

8.5.9 Geomembrane shall be deployed and temporary surcharge provided in accordance with Sections 6.6 and 6.7 of this Specification respectively.

8.5.10 As part of the project Quality Assurance programme, the geomembrane thickness will be measured at random intervals by the CQA Engineer for each panel. The CQA Engineer will measure the lead, trial, left and right edges of each panel a minimum of 3 times, but typically 5 times. The thickness tolerances are given in Table 3 of Appendix E. Variation of geomembrane thickness outside these tolerances may be cause for rejection of the affected geomembrane. The rationale for thickness acceptance shall be:

- No single thickness measurement shall exceed the stated tolerances.
- The average of the CQA Engineer's measurements across a given roll width shall be greater than the specified thickness (1.00mm).

8.5.11 Seaming of the material shall be undertaken in accordance with Section 6.8 of this Specification.

8.5.12 Sampling and Testing of the geomembrane seams shall be undertake in accordance with the protocols and at the frequencies detailed in Section 6.9 of this Specification.

- Where air pressure testing is to be undertaken to non-destructively test fusion welds an initial pressure of between 21 and 24psi shall be used allowable drop over 5mins.
- Geomembrane seams will be required to meet the strength criteria set out in Table 4 of Appendix E.

8.5.13 All discontinuities in the welded geomembrane (whether caused by damage, or failure of geomembrane to conform with the Specification, or of sampling or testing or other factors), shall be repaired in accordance with Section 6.10 of this Specification.

8.5.14 Where the geomembrane is terminated in an anchor trench, then shoulders of the anchor trench shall be slightly rounded where the geomembrane enters the trench to minimise sharp bends in the key in trench. Anchor trench backfill shall be installed in lifts not exceeding 150mm and compacted with a wacker plate or other means approved by the CQA Engineer.

8.6 Geotextile Protector

8.6.1 General

8.6.1.1 Where the drainage layer overlying the geomembrane cap is to be formed using a fine gravel a protective geotextile layer shall be provided to prevent damage to the cap by the overlying materials. Note: the geotextile protector will not be required if the drainage layer is formed by a coarse sand.

8.6.2 Material Properties

8.6.2.1 The geotextile protector shall consist of a non woven geotextile and shall have the properties detailed in the table below:

Properties	Test Method	Required Minimum Value
Nominal Thickness @ 2kPa	ASTM D1777 DIN 53854 BS EN 964-1	3.5 mm
Puncture Resistance	DIN 54307 BS EN ISO 12236	2000 N

8.6.2.3 The geotextile protector manufacturer shall provide production test certificates for rolls delivered to site. Test methods employed shall be in accordance with the requirements of BS 6906. Certificates relevant to a batch of geotextile protector shall be furnished to the CQA Engineer prior to that batch of geotextile protector being incorporated in the works.

8.6.2.4 Geotextile materials shall be protected at all times against physical or chemical damage. They shall be kept in the wrappings provided by the manufacturer until required for use in the works. The rolls of geotextile protector shall be stored on level ground and stacked not more than five rolls high and no other materials shall be stacked on top. Geotextile material shall be delivered to site in packaging that will protect the rolls from degradation by ultra violet light.

8.6.2.5 The method of installation shall not impose stresses or strains likely to cause damage to the geotextile protector or the geomembrane. The method of installation shall ensure that the geotextile protector is in continuous contact with the surface on which it is placed without stretching or bridging over humps or hollows. Construction plant must not operate directly on the geotextile protector.

8.6.2.6 Laying of the geotextile protector is to be undertaken by staff experienced in this type of work. The Contractor shall submit a summary of his and of any intended subcontractor's experience of handling and laying this type of material for verification by the CQA Engineer of their suitability.

8.6.2.7 Joints shall be formed by either hot air welding or stitching. The material at the joints will overlap, by 300mm for hot air welding and by 150mm for stitching. The method of joining is to be approved by the CQA Engineer.

8.7 Drainage Layer

8.7.1 Immediately above the geotextile protector a 500mm thick granular drainage layer shall be installed, to allow the water percolating through the restoration soils to flow to the surface water ditches around the perimeter of the landfill.

8.7.2 The drainage layer shall be either a clean coarse grained sand or fine gravel. The blanket shall have a permeability of greater than 1×10^{-4} m/s. Drainage blanket material shall be sourced Roadstone Dublin and stockpiled at a location agreed with the Contractor. Handling of the material in the stockpile will be done in such a manner as to minimise the potential for increasing the fines content.

8.7.3 In order to protect the underlying geosynthetic materials from vehicles accessing the capped area, the Contractor shall ensure that haul roads across the cap are a minimum of 1m thick.

8.8 Restoration Soils

8.8.1 Upon completion of the drainage layer placement, a 1m thick layer of restoration soils shall be installed. The restoration soils shall comprise 0.85m of subsoil and 0.15m topsoil, in accordance with the details shown on Drawing No. 6.

8.8.2 The restoration soils shall be placed but not compacted. Access for dump trucks shall be restricted to ensure areas do not become compacted, should any areas, in the CQA Engineer's opinion become over trafficked then the soils in this area shall be ripped to a depth of 0.5m. Access over the 150mm thick topsoil layer should be avoided.

8.8.3 Topssoil and subsoil material shall be sourced within Roadstone Dublin's landhlding and stockpiled at a location agreed with the Employer's Site Manager.

8.8.4 Immediately above the geotextile protector the material forming the subsoil shall be free of particles in excess of 40mm, in order to provide protection to the geomembrane.

8.8.5 In order to protect the underlying geosynthetic materials from vehicles accessing the capped area, the Contractor shall ensure that temporary haul roads across the cap are a minimum of 1m thick.

8.9 Seals To Above Cap Installations

8.9.1 Within the area to be capped, a number of landfill gas and leachate management pipes will penetrate the VFPE cap. All of these installations require access upon completion of the capping and restoration works and therefore require sealing at the point where they penetrate the geomembrane liner.

8.9.2 The Contractor shall provide a suitable means to prevent accidental damage occurring to any of the above installations during the course of the works.

8.9.3 Around penetrations that pass vertically through the cap a "top hat" shall be constructed from VFPE, in accordance with the detail presented on Drawing No. 7. Immediately around the "top hat" a bentonite seal shall be placed to prevent the ingress of water.

8.9.4 Where pipes running up the side slopes penetrate the cap and it is not possible to install a "top hat", the penetration shall be sealed off using a minimum of 300mm thick bentonite seal alone.

8.9.5 The following methodology shall be adopted when installing bentonite seals to penetrations through the geomembrane cap:

- All bentonite used shall be in the granule form, pellets will not be permitted.
- A suitable form shall be used to maintain the anulus between the structure and the placed subsoil.
- Dry bentonite granuals shall be placed in 50mm layers in the annulus around the pipe.
- Water shall then be added such that the granules form a seal and water no longer drains away.
- Bentonite may then be added along with more water until the specified depth is achieved ensuring that at all times the water level is maintained above the bentonite granules.

APPENDIX A

WASTE LICENCE

APPENDIX B

SITE INVESTIGATION DATA : LANDFILL SITE

REFER TO APPENDIX 5D

APPENDIX C

CLAY LINER : CHARACTERISATION TEST REPORT

NATIONAL MATERIALS TESTING LABORATORY LTD

Report

LABORATORY TESTING OF GLACIAL TILL FOR CLAY LINER FOR PROPOSED LANDFILL CELL.

LABORATORY TESTS – PSD, ATTERBERG LIMITS, COMPACTION, SPECIFIC GRAVITY, UNDRAINED SHEAR STRENGTH AND CONSTANT HEAD PERMEABILITY IN TRIAXIAL CELL.

Carried out for: John Barnett and Associates

National Materials Testing Laboratory Ltd.

Triaxial Permeability Tests

Laboratory Testing of Glacial Till for Clay liner for Proposed Landfill Cell

1. INTRODUCTION

On the instructions of Derek Luby of (JBA), June 2003, laboratory testing of glacial till for clay liner for proposed landfill cell was carried out on samples retrieved from Hunstown. 5 nos. bulk samples were delivered to the laboratory and the following testing was specified.

- 5 nos. Natural moisture contents
- 5 nos. Atterberg limits
- 5 nos. Particle size distribution (Wet sieve including hydrometer)
- 5 nos. Particle density
- 5 nos. Undrained shear strength
- 5 nos. Dry density/moisture content relationship
- 5 nos. Constant head permeability in triaxial cell.

All tests were carried out to British Standard test procedure using preferred (definitive) method unless otherwise stated. The procedure for constant head triaxial permeability testing is described below.

1. GENERAL

This method discusses the procedures required to carry out constant head triaxial permeability test in a triaxial cell. The method required is the "Triaxial permeability test with two back pressure systems" as described by Head (1986), pp 1017- 1020.

2. SPECIMEN SIZE

The specimens were from bulk disturbed samples. The client will specify the remoulding specifics. The dimensions of test specimens were approximately105mm diameter and 1115mm long.

3. SAMPLE PREPARATION

Specimens were remoulded to bulk densities as specified by the client. All preparation work and testing was carried out in a temperature-controlled environment.

Mounting

The remoulded sample was placed in a split ring mould and trimmed to size. The sample weight, length and diameter are measured. When the sample was ready it was wrapped in cling film while the base pedestal of triaxial cell is prepared. De-aired water was flushed through the base pedestal and the backpressure system.

One of the de-aired porous stones will be placed on a film of water on the base pedestal. No filter drains will be used. The sample was unwrapped and put in place. The other porous stone is placed on top of the sample. The membrane was stretched, and placed over the soil sample and released ensuring that no air is trapped between the sample and the membrane. Two O-rings were used to seal the bottom of the membrane and a further two rings to seal the top of the specimen. Care was needed to ensure all air is expelled from the system.

The cell is then filled with de-aired water.

4. SATURATION STAGE.

An increase in cell pressure, of 50 kPa was first applied. The pore pressure parameter, B was then determined. If B is > or = to 0.95 the specimen was considered to be sufficiently saturated and the cell pressure was raised in fairly rapid steps to that required for the consolidation stage. If B < 0.95 then a back pressure was applied to reinstate the initial effective stress and the system was allowed to equalise. A further increment of cell pressure was then applied and B is measured. This cycle of cell pressure and backpressure continued until a satisfactory value of B was achieved. This stepwise application was carried out slowly in such a manner that the axial strain does dot exceeds 0.1%.

5. CONSOLIDATION STAGE

Consolidation was applied isotropically in one stage and the consolidation stress was maintained for a minimum period of 24 hours and until the volume change is less than 0.0001% per minute and greater than 95% pore pressure dissipation was complete. Following the consolidation the permeability stage was carried out.

The client specified the mean effective stresses and hydraulic gradients.

6. PERMEABILITY STAGE

Following the consolidation stage the permeability stage was carried out, by raising the pressure at one end of the specimen relative to the other, until the flow was initiated. The flow of water in and out was measured until linear graph of flow in and out is achieved.

7. REPORTING

As a minimum the following plots are reported.

Saturation stage.

- B Value v Cell pressure

Consolidation stage

- Volume v time

Permeability Stage

- Flow in / Flow out v time

ACCURACY OF EQUIPMENT

- Pore pressure Transducer ±1.0 kPa
- Volume change ± 0.1 ml

Classification testing was carried out in accordance with BS: 1377: 1990

The results of testing are on the following pages.

REFERENCES

Head, K.H. (1986). Manual of soil laboratory testing, Volume 3, Effective stress Tests".

BS 1377 1990 Part 6

National Materials Testing Laboratory Ltd.

SUMMARY OF TEST RESULTS

					Index Properties				Chemical Tests		Organic	
Trial pit	Depth	Moisture	<425um	LL	PI	Pi	PSD	Particle	pH	Sulphate	Content	Remarks
No.	m	%	%	%	%	%		density		SO3 g/l	%	
TP1		12.3	34	30	16	14	*	2.71				
TP2		12.7	50	24	14	10	*	2.72				
TP3		13.0	38	31	17	14	*	2.70				
TP4		11.6	52	26	13	13	*	2.69				
TP5		13.3	58	26	14	12	*	2.71				

NMTL Notes : 1. Specimen recompacted at natural moisture with 2.5kg rammer.
2. All BS tests carried out using preferred (definitive) method unless otherwise stated.

Job ref No. NMTL050
Location Huntstown

Table 1

National Materials Testing Laboratory Ltd.

SUMMARY OF TEST RESULTS

				Index Properties					Undrained Triaxial Tests			
Sample	Depth	Moisture	<425um	Liquid Limit	Plastic Limit	Plasticity Index	Bulk Density	Cell Pressure	Compressive	Strain at	Cu	Mode of
No.	m	%	%	%	%	%	Mg/m3	kPa	Stress kPa	Failure %	kPa	Failure
TP1		11.8					2.19	100	94	19.16	47	Plastic
TP2		11.6					2.20	100	96	19.81	48	Plastic
TP3		12.5					2.15	100	66	19.60	33	Plastic
TP4		10.9					2.17	100	165	19.99	83	Plastic
TP5		12.8					2.17	100	70	19.99	35	Plastic

NMTL Notes : 1. Specimen recompacted at natural moisture with 2.5kg rammer.
2. All BS tests carried out using preferred (definitive) method unless otherwise stated.

Job ref No. NMTL050 Table

Location Huntstown 1

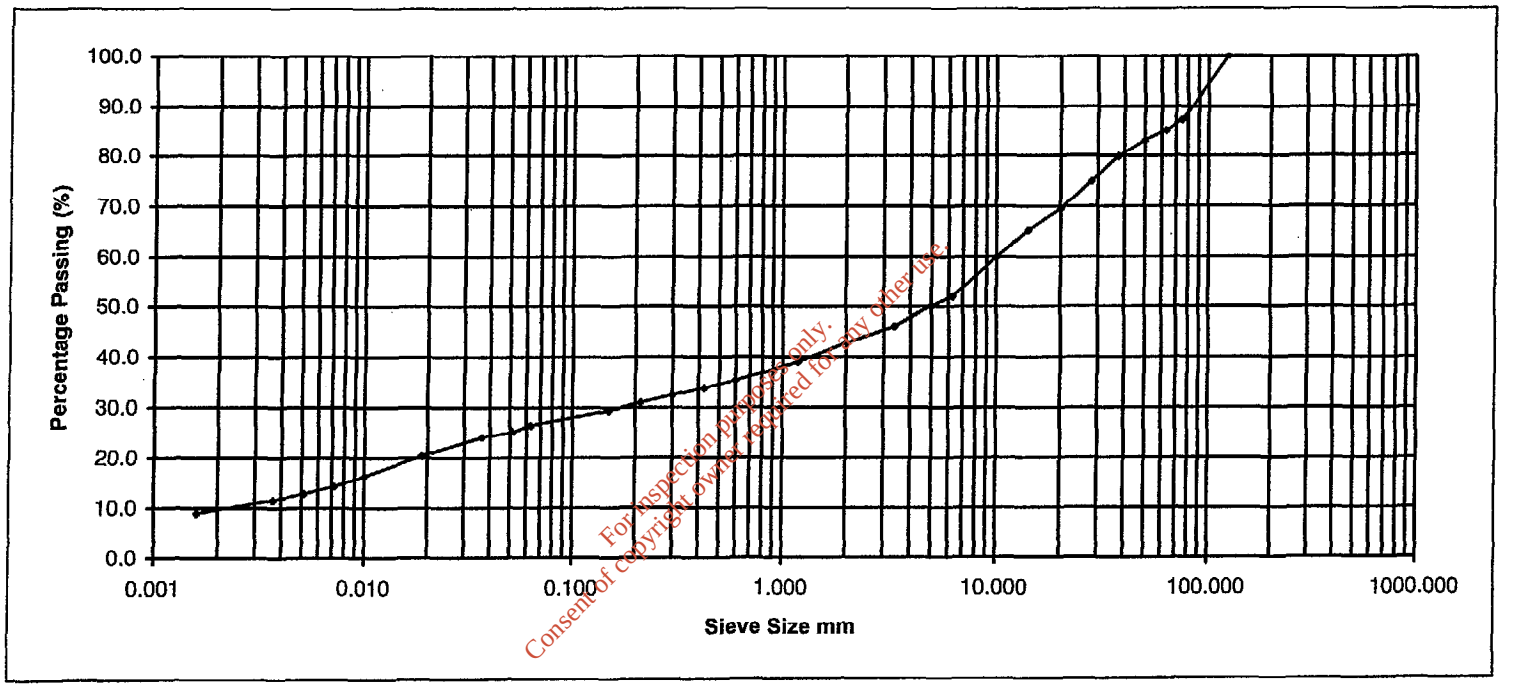
National Materials Testing Laboratory Ltd

Sieve Size mm	% Passing
125.000	100.0
75.000	87.2
63.000	85.1
50.000	83.1
37.500	79.8
28.000	74.9
20.000	69.5
14.000	65.3
10.000	59.9
6.300	51.9
5.000	50.1
3.350	46.1
2.000	42.8
1.180	39.0
0.600	35.3
0.425	33.8
0.300	32.3
0.212	31.0
0.150	29.4
0.063	26.5
0.051	25.2
0.036	24.1
0.019	20.4
0.010	16.2
0.007	14.2
0.005	12.7
0.004	11.5
0.002	8.9

NM TL Ltd

Determination of Particle Size Distribution

BS 1377 : 1990 : Part 2 : Clauses 9.2 & 9.5



Percentage Particle Size

Clay	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	Cobbles	Boulder
		Silt			Sand			Gravel			
8.9		17.6			16.3			42.3		14.9	0.0

Sample Description *Grey brown slightly sandy gravelly CLAY.*

Project Huntstown

Project No.	NMTL050
Borehole No.	TP1
Sample No.	N/A
Depth	N/A

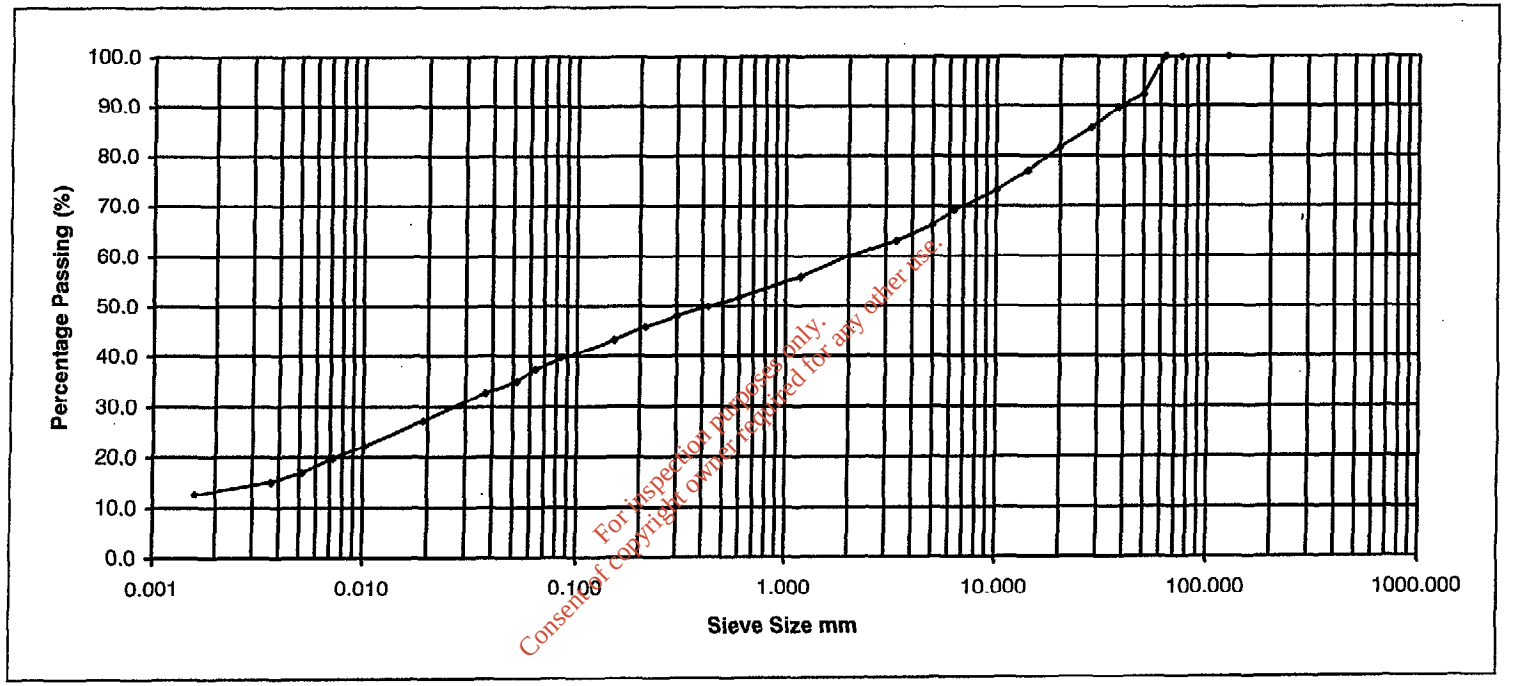
National Materials Testing Laboratory Ltd

Determination of Particle Size Distribution

BS 1377 : 1990 : Part 2 : Clauses 9.2 & 9.5

Sieve Size mm	% Passing
125.000	100.0
75.000	100.0
63.000	100.0
50.000	92.2
37.500	89.6
28.000	85.5
20.000	81.7
14.000	76.9
10.000	73.1
6.300	69.0
5.000	66.1
3.350	63.0
2.000	60.0
1.180	55.8
0.600	51.8
0.425	49.9
0.300	48.0
0.212	45.9
0.150	43.3
0.063	37.5
0.052	35.0
0.037	32.8
0.019	27.2
0.010	22.3
0.007	19.8
0.005	16.9
0.004	15.2
0.002	12.7

NM TL Ltd



Percentage Particle Size

Clay	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	Cobbles	Boulder
		Silt			Sand			Gravel			
12.7		24.7			22.5			40.0		0.0	0.0

Sample Description: Brown slightly sandy gravelly CLAY.

Project: Huntstown

Project No.: NMTL050

Borehole No.: TP2

Sample No.: N/A

Depth: N/A

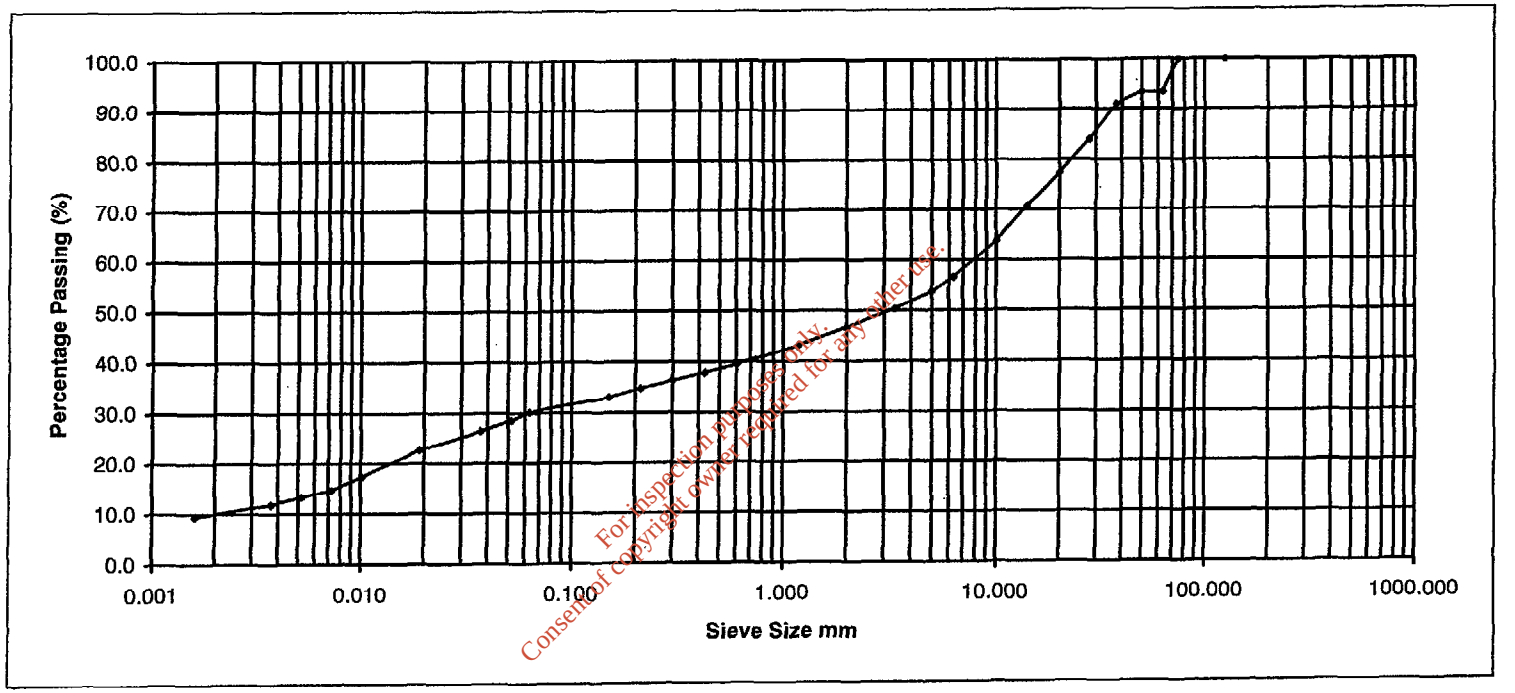
National Materials Testing Laboratory Ltd

Determination of Particle Size Distribution

BS 1377 : 1990 : Part 2 : Clauses 9.2 & 9.5

Sieve Size mm	% Passing
125.000	100.0
75.000	100.0
63.000	93.4
50.000	93.4
37.500	91.0
28.000	84.0
20.000	77.3
14.000	70.7
10.000	63.7
6.300	56.5
5.000	53.7
3.350	50.2
2.000	46.7
1.180	43.1
0.600	39.5
0.425	37.9
0.300	36.3
0.212	34.8
0.150	33.0
0.063	30.2
0.052	28.4
0.037	26.5
0.019	22.6
0.010	17.3
0.007	14.6
0.005	13.2
0.004	11.8
0.002	9.4

NM TL Ltd



Percentage Particle Size

Clay	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	Cobbles	Boulder
		Silt			Sand			Gravel			
9.4		20.8			16.5			46.7		6.6	0.0

Sample Description: Grey brown slightly sandy gravelly CLAY.

Project: Huntstown

Project No.: NMTL050
Borehole No.: TP3
Sample No.: N/A
Depth: N/A

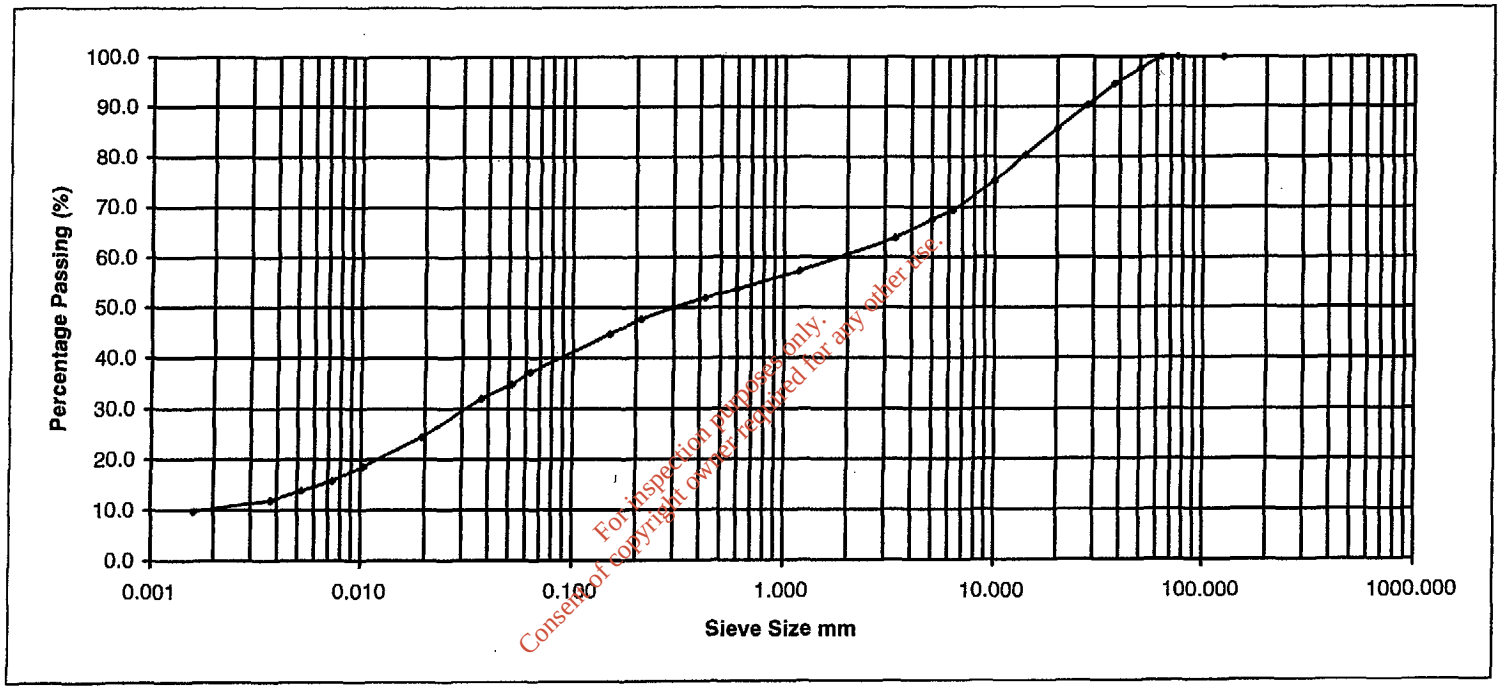
National Materials Testing Laboratory Ltd

Sieve Size mm	% Passing
125.000	100.0
75.000	100.0
63.000	100.0
50.000	97.6
37.500	94.5
28.000	90.3
20.000	85.6
14.000	80.4
10.000	75.2
6.300	69.3
5.000	67.4
3.350	63.8
2.000	60.6
1.180	57.2
0.600	53.6
0.425	51.8
0.300	49.9
0.212	47.6
0.150	44.7
0.063	37.2
0.052	34.8
0.037	32.0
0.019	24.4
0.010	18.6
0.007	15.8
0.005	13.8
0.004	11.9
0.002	9.7

NM TL Ltd

Determination of Particle Size Distribution

BS 1377 : 1990 : Part 2 : Clauses 9.2 & 9.5



Percentage Particle Size

Clay	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	Cobbles	Boulder
		Silt			Sand			Gravel			
9.7		27.5			23.4			39.4		0.0	0.0

Sample Description	Grey slightly sandy gravelly CLAY.	Project No.	NMTL050
		Borehole No.	TP4
Project	Huntstown	Sample No.	N/A
		Depth	N/A

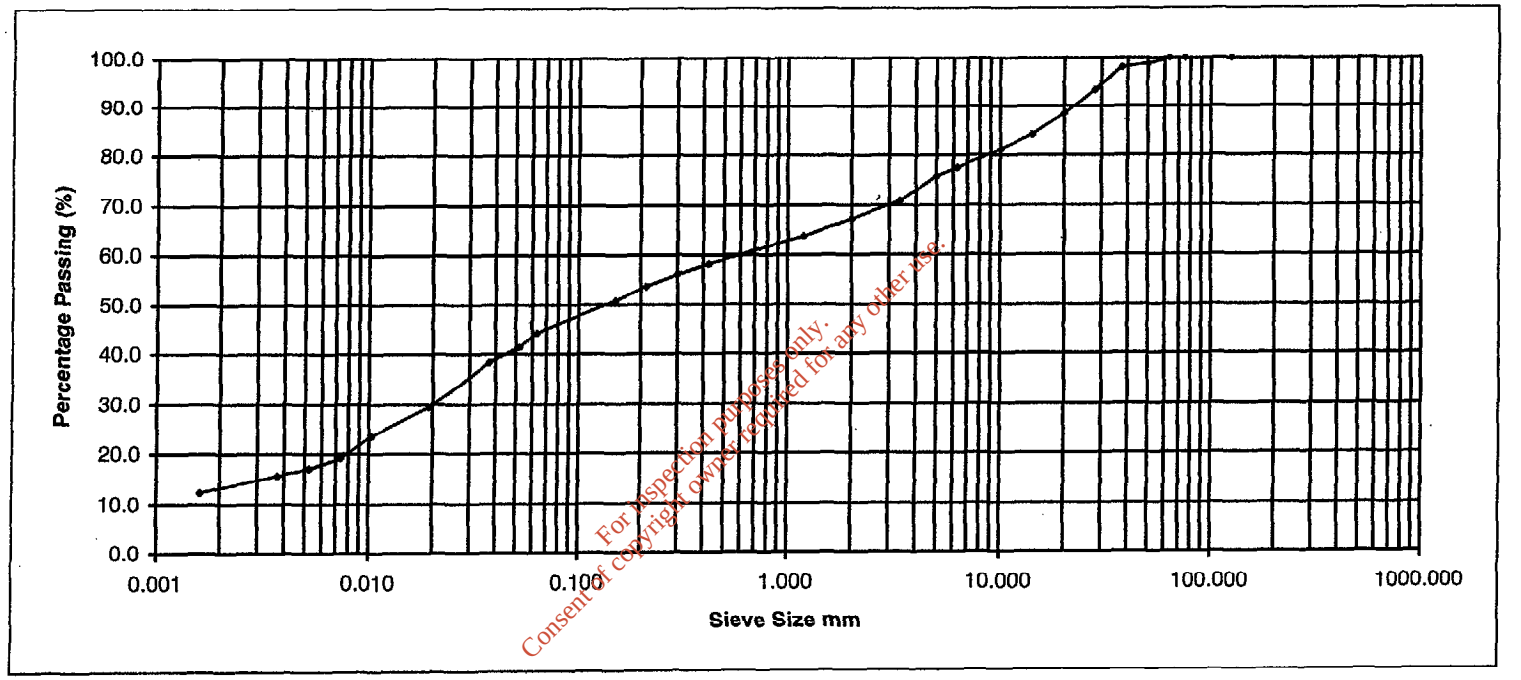
National Materials Testing Laboratory Ltd

Determination of Particle Size Distribution

BS 1377 : 1990 : Part 2 : Clauses 9.2 & 9.5

Sieve Size mm	% Passing
125.000	100.0
75.000	100.0
63.000	100.0
50.000	98.7
37.500	98.0
28.000	93.4
20.000	88.4
14.000	84.2
10.000	81.0
6.300	77.4
5.000	75.7
3.350	70.9
2.000	67.2
1.180	63.7
0.600	59.9
0.425	58.1
0.300	56.1
0.212	53.8
0.150	50.8
0.063	44.2
0.052	41.3
0.037	38.4
0.019	29.5
0.010	23.4
0.007	19.2
0.005	17.1
0.004	15.8
0.002	12.4

NM TL Ltd



Percentage Particle Size

Clay	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	Cobbles	Boulder
		Silt			Sand			Gravel			
12.4		31.8			23.0			32.8		0.0	0.0

Sample Description *Grey slightly sandy slightly gravelly CLAY.*

Project Huntstown

Project No. NMTL050
Borehole No. TP5
Sample No. N/A
Depth N/A

Determination of dry density / moisture content relationship

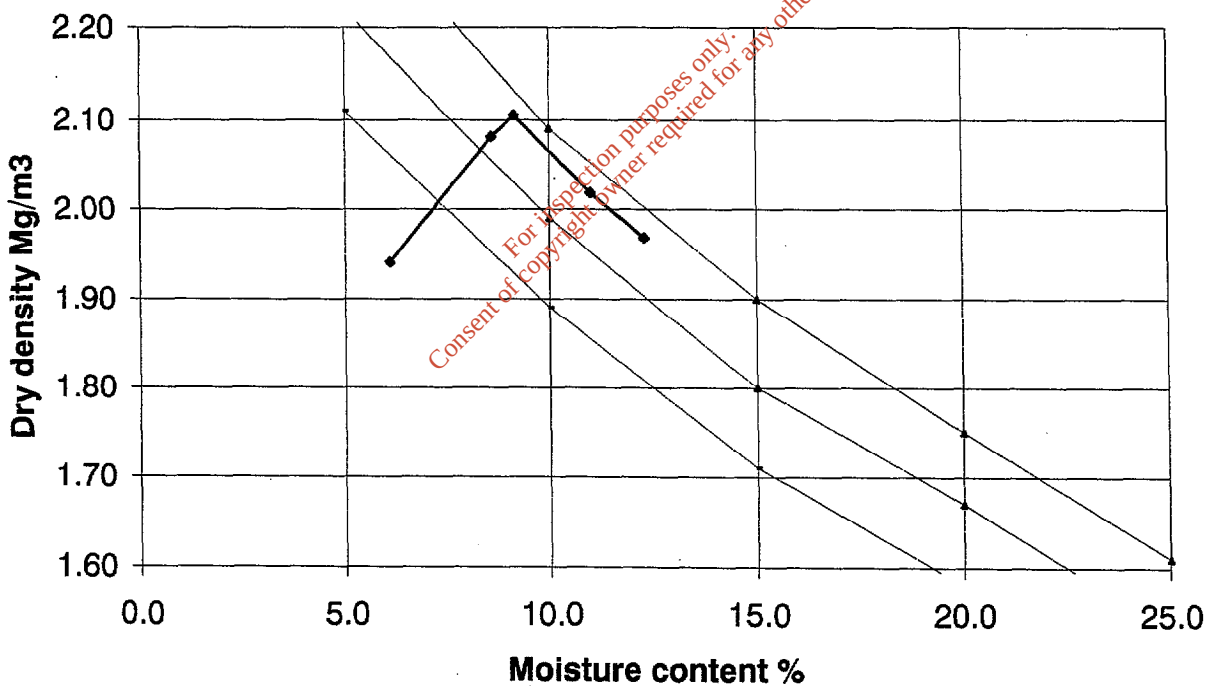
BS 1377: Part 4: 1990 : Clause 3.4

Location Huntstown

Soil description. Brown slightly sandy gravelly CLAY.

Test No.		1	2	3	4	5
Bulk Density	Mg/m3	2.06	2.26	2.30	2.24	2.21
Moisture Content	%	6.1	8.6	9.2	11.0	12.3
Dry Density	Mg/m3	1.94	2.08	2.11	2.02	1.97

Compaction Test



Maximum Dry Density	2.11	Mg/m3	% passing 37.5 mm sieve	80
Optimum Moisture content	9.2	%	% passing 20 mm sieve	70
Particle Density	2.70	Assumed		

Job No.	NMTL050
TP No.	TP1
Sample No.	N/A
Depth	N/A
Fig No.	

NMTL Ltd

Determination of dry density / moisture content relationship

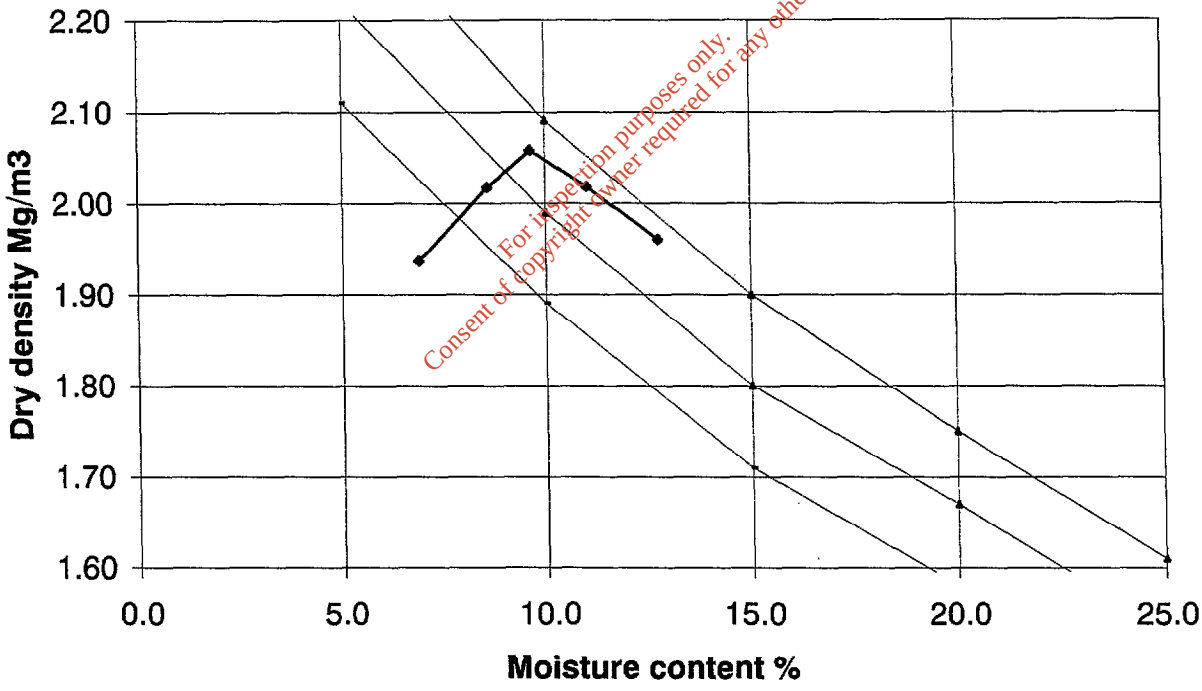
BS 1377: Part 4: 1990 : Clause 3.4

Location Huntstown

Soil description. Brown slightly sandy gravelly CLAY.

Test No.		1	2	3	4	5
Bulk Density	Mg/m3	2.07	2.19	2.26	2.24	2.21
Moisture Content	%	6.9	8.6	9.6	11.0	12.7
Dry Density	Mg/m3	1.94	2.02	2.06	2.02	1.96

Compaction Test



Maximum Dry Density	2.06	Mg/m3	% passing 37.5 mm sieve	90
Optimum Moisture content	9.6	%	% passing 20 mm sieve	82
Particle Density	2.70	Assumed		

Job No.	NMTL050
TP No.	TP2
Sample No.	N/A
Depth	N/A
Fig No.	

NMTL Ltd

Determination of dry density / moisture content relationship

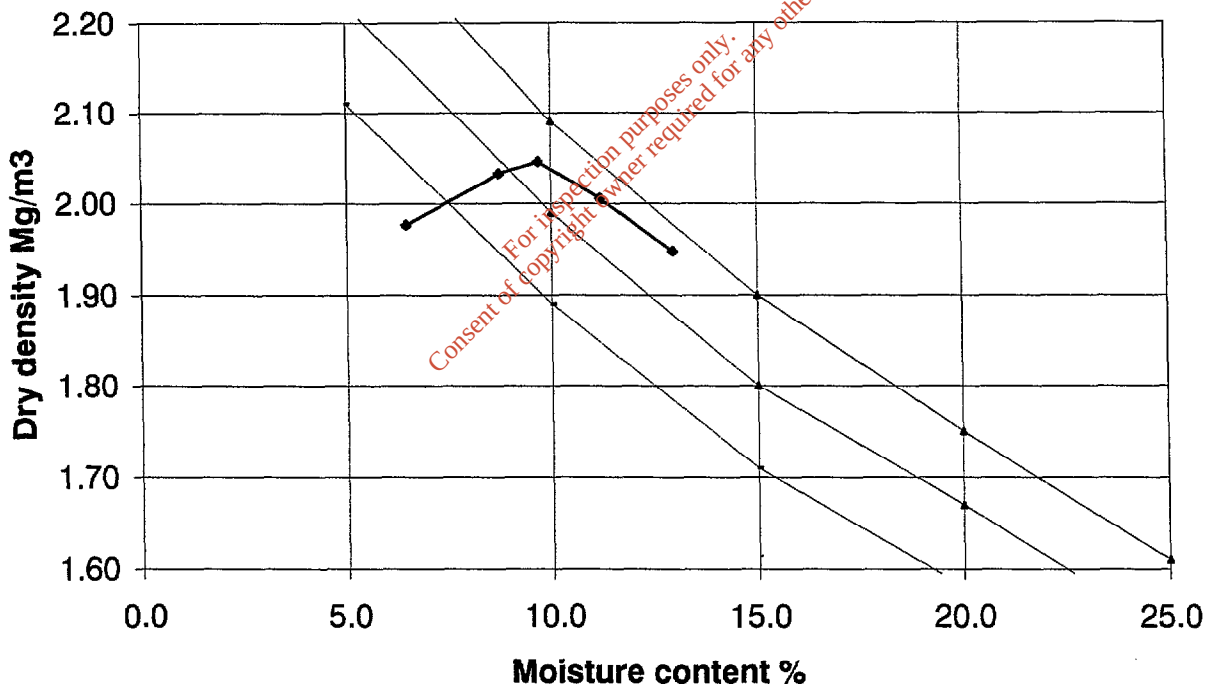
BS 1377: Part 4: 1990 : Clause 3.4

Location Huntstown

Soil description. Grey brown slightly gravelly CLAY.

Test No.		1	2	3	4	5
Bulk Density	Mg/m3	2.10	2.21	2.24	2.23	2.20
Moisture Content	%	6.5	8.7	9.7	11.2	13.0
Dry Density	Mg/m3	1.98	2.03	2.05	2.01	1.95

Compaction Test



Maximum Dry Density	2.05	Mg/m3	% passing 37.5 mm sieve	91
Optimum Moisture content	9.7	%	% passing 20 mm sieve	77
Particle Density	2.70	Assumed		

Job No.	NMTL050
TP No.	TP3
Sample No.	N/A
Depth	N/A
Fig No.	

NMTL Ltd

Determination of dry density / moisture content relationship

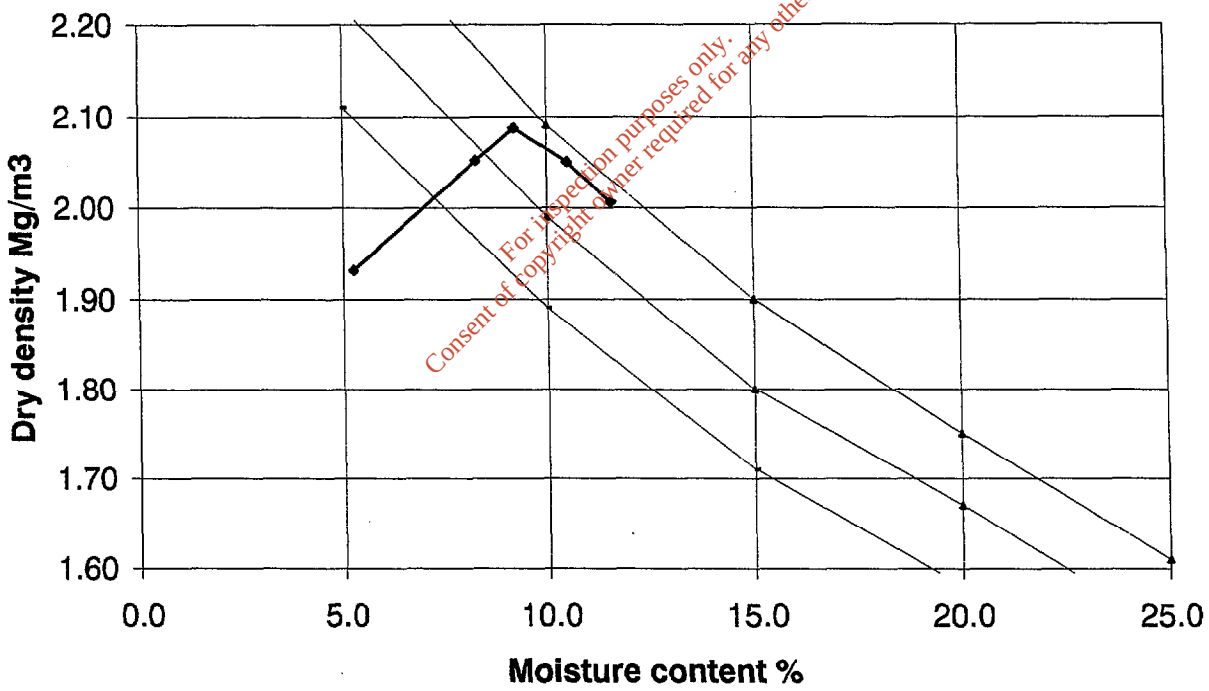
BS 1377: Part 4: 1990 : Clause 3.4

Location Huntstown

Soil description. Grey slightly sandy gravelly CLAY.

Test No.		1	2	3	4	5
Bulk Density	Mg/m3	2.03	2.22	2.28	2.27	2.24
Moisture Content	%	5.2	8.3	9.2	10.5	11.6
Dry Density	Mg/m3	1.93	2.05	2.09	2.05	2.01

Compaction Test



Maximum Dry Density	2.08	Mg/m3	% passing 37.5 mm sieve	95
Optimum Moisture content	9.8	%	% passing 20 mm sieve	86
Particle Density	2.70	Assumed		

Job No.	NMTL050
TP No.	TP4
Sample No.	N/A
Depth	N/A
Fig No.	

NMTL Ltd

Determination of dry density / moisture content relationship

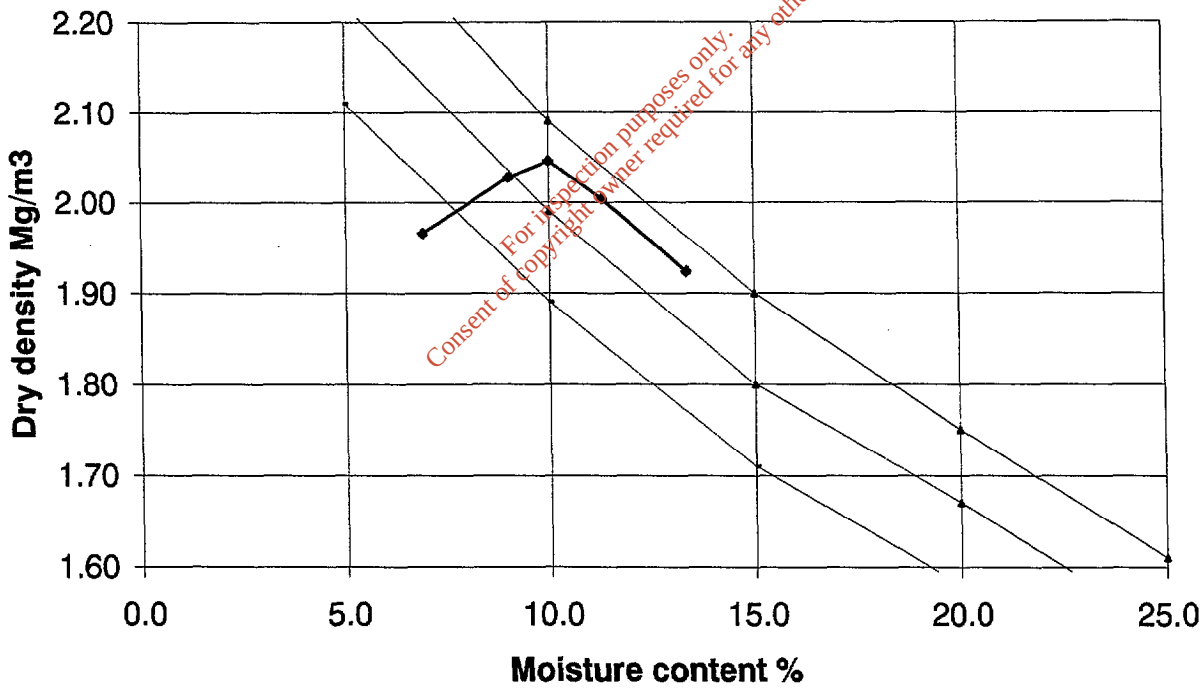
BS 1377: Part 4: 1990 : Clause 3.4

Location Huntstown

Soil description. Grey slightly sandy slightly gravelly CLAY.

Test No.		1	2	3	4	5
Bulk Density	Mg/m3	2.10	2.21	2.25	2.23	2.18
Moisture Content	%	6.9	9.0	10.0	11.3	13.3
Dry Density	Mg/m3	1.97	2.03	2.05	2.00	1.92

Compaction Test



Maximum Dry Density	2.05	Mg/m3	% passing 37.5 mm sieve		98
Optimum Moisture content	10.0	%	% passing 20 mm sieve		88
Particle Density	2.70	Assumed		Job No.	NMTL050
				TP No.	TP5
				Sample No.	N/A
				Depth	N/A

NMTL Ltd

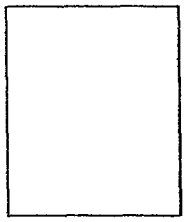
Fig No.

Permeability Tests

Triaxial Cell Constant Head

Sample details

Sketch showing specimen location in original Sample



Depth	0.00m
Description:	Soft grey brown slightly sandy gravelly CLAY.
	Specimen 1
Type	
Height H_0 (mm)	115.5
Diameter D_0 (mm)	105
Weight W_0 (gr)	2190.76
Bulk Density ρ (Mg/m3)	2.19
Particle Density ρ_s	0
	(measured)

Initial Conditions

Inlet Volume Channel	MGO775	Moisture Content w%0	12
Outlet Volume Channel	12793	Dry Density ρ_d (Mg/m3)	1.95
Pore Pressure Channel	VJT2501A	Voids Ratio e_0	0.39
Test Frame	HEADLOSS_001	Deg of Saturation S_0%	85.69
		Flow Direction	DOWN
		Sample Preparation	
Stage	1		
Cell Pressure σ_3 (kPa)	375.00		
Back Pressure u_b (kPa)	300.00		
Drain Pressure u_d (kPa)	315.00		
Effective Stress σ_v (kPa)	67.50		
Temperature oC	20.		

Permeability Results

Moisture Content w_f%	11	Voids Ratio e_f	0.38
Dry Density ρ_d (Mg/m3)	1.97	Deg of Saturation S_f%	81.70
Stage	1		
Hydraulic Gradient (kPa)	15.00		
Mean Flow Rate q (mL/min)	0.002		
Head Loss p_c (kPa)	0.00		
Permeability k_v (m/s)	2.88 e-10		

Notes Remoulded at dry density of 1.95 Mg/m3 at 12 % moisture content.

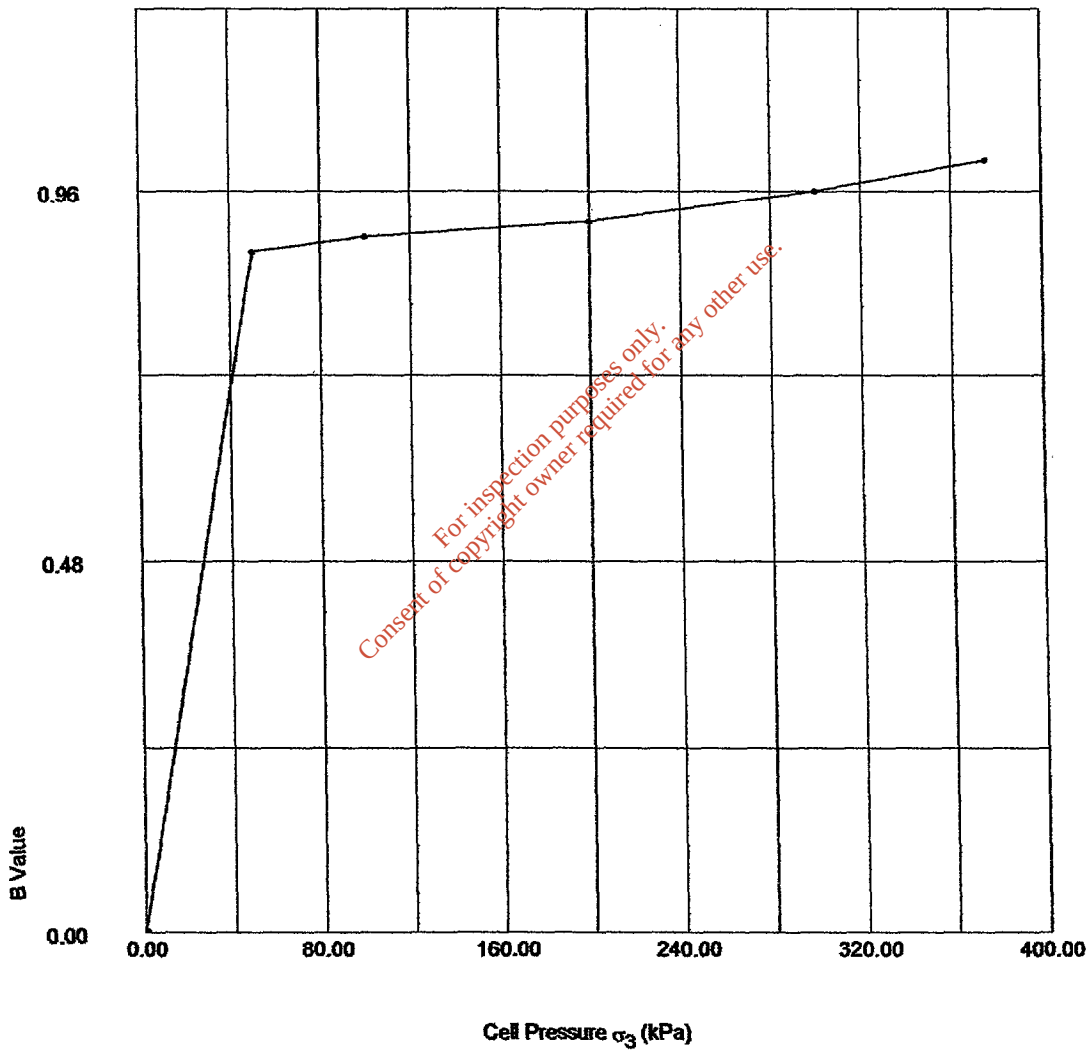
NMTL Ltd

Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/TP1
		Date of Test:	7/1/2003
Site Reference:	Huntstown	Sample:	TP1
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP1
Operator:	*Checked:*		*Approved:*

Permeability Tests

Triaxial Cell Constant Head

Saturation Stage Data	
Test Method:	Cell P. only
Final Cell Pressure σ_{3f} (kPa)	375.00
Final Pore Pressure u_f (kPa)	355.00
Final B Value	1.00



NMTL Ltd

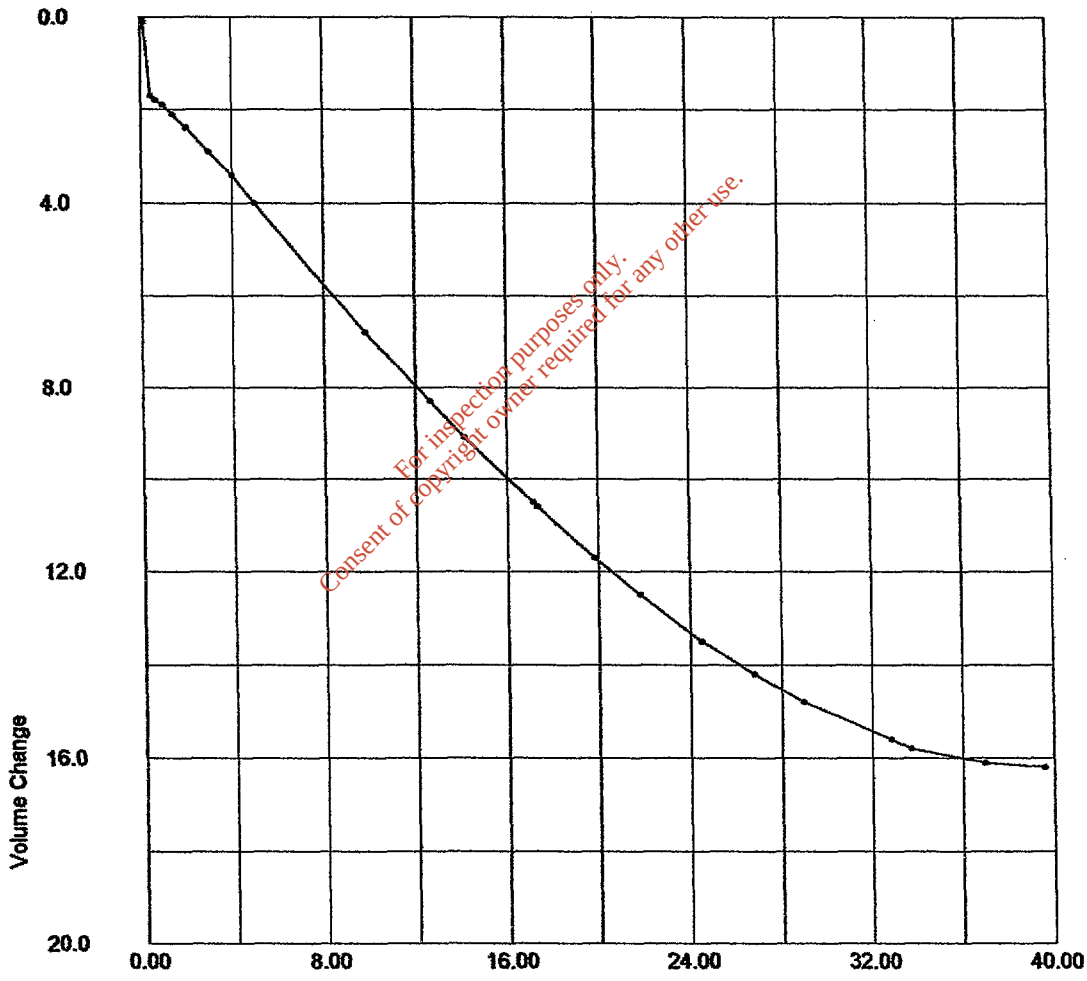
Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/TP1
		Date of Test:	7/1/2003
Site Reference:	Huntstown	Sample:	TP1
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP1
Operator:	*Checked:*		*Approved:*

Permeability Tests

Triaxial Cell Constant Head

Consolidation Test Data

Cell Pressure σ_3 (kPa)	375.0
Back Pressure u_b (kPa)	300.0
Effective Pressure u_v (kPa)	75.0
Test Temperature oC	20.
Final Height H_f (mm)	114.876
Voids Ratio e_f	0.337
t_{50} (min)	590.32
Coef. of Consolidation c_v (m2/year)	4.50
Coef. of Vol. Compressibility m_v (m2/MN)	0.22

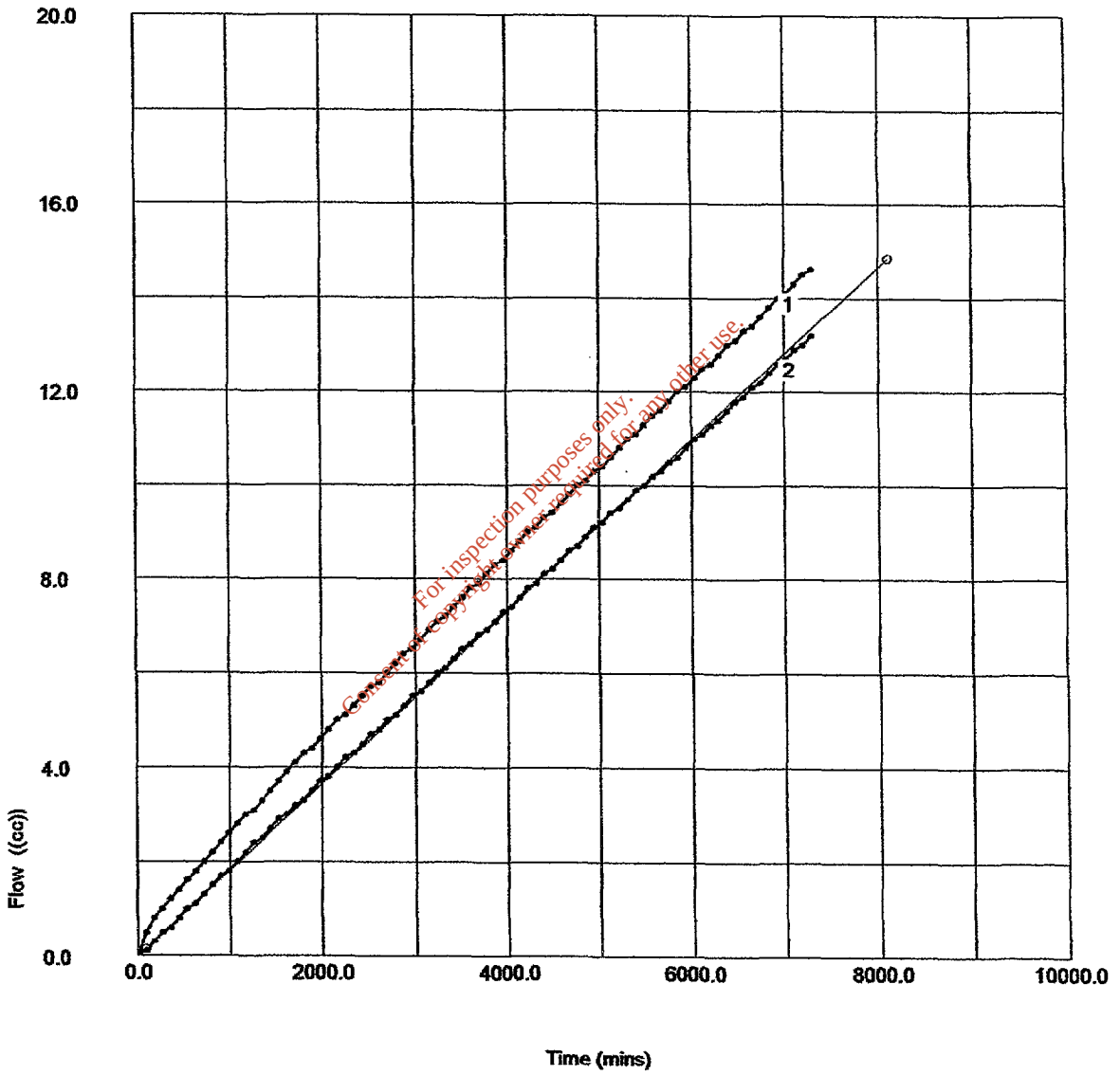


NMTL Ltd

Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/TP1
		Date of Test:	7/1/2003
Site Reference:	Huntstown	Sample:	TP1
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP1
Operator:	*Checked:*	*Approved:*	

Permeability Tests

Triaxial Cell Constant Head



NMTL Ltd

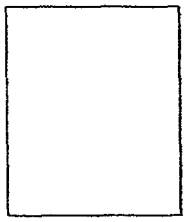
Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/TP1
		Date of Test:	7/1/2003
Site Reference:	Huntstown	Sample:	TP1
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP1
Operator:	*Checked:*		*Approved:*

Permeability Tests

Triaxial Cell Constant Head

Sample details

Sketch showing specimen location in original Sample



Depth	0.00m
Description:	Soft brown slightly sandy gravelly CLAY.
	Specimen 1
Type	
Height H_0 (mm)	115.5
Diameter D_0 (mm)	105
Weight W_0 (gr)	2186.01
Bulk Density ρ (Mg/m3)	2.19
Particle Density ρ_s	0
	(measured)

Initial Conditions

Inlet Volume Channel	MGO775	Moisture Content w%0	12
Outlet Volume Channel	MG0777	Dry Density ρ_d (Mg/m3)	1.96
Pore Pressure Channel	VJT02503A	Voids Ratio e_0	0.39
Test Frame	HEADLOSS_001	Deg of Saturation S_0%	81.68
		Flow Direction	DOWN
		Sample Preparation	
Stage	1		
Cell Pressure σ_3 (kPa)	390.00		
Back Pressure u_b (kPa)	300.00		
Drain Pressure u_d (kPa)	316.50		
Effective Stress σ_v (kPa)	81.75		
Temperature oC	20.		

Permeability Results

Moisture Content w_f%	12	Voids Ratio e_f	0.39
Dry Density ρ_d (Mg/m3)	1.95	Deg of Saturation S_f%	82.52
Stage	1		
Hydraulic Gradient (kPa)	16.50		
Mean Flow Rate q (mL/min)	0.001		
Head Loss p_c (kPa)	0.00		
Permeability k_v (m/s)	1.31 e-10		

Notes Remoulded at dry density of 1.95 Mg/m3 at 12% moisture content.

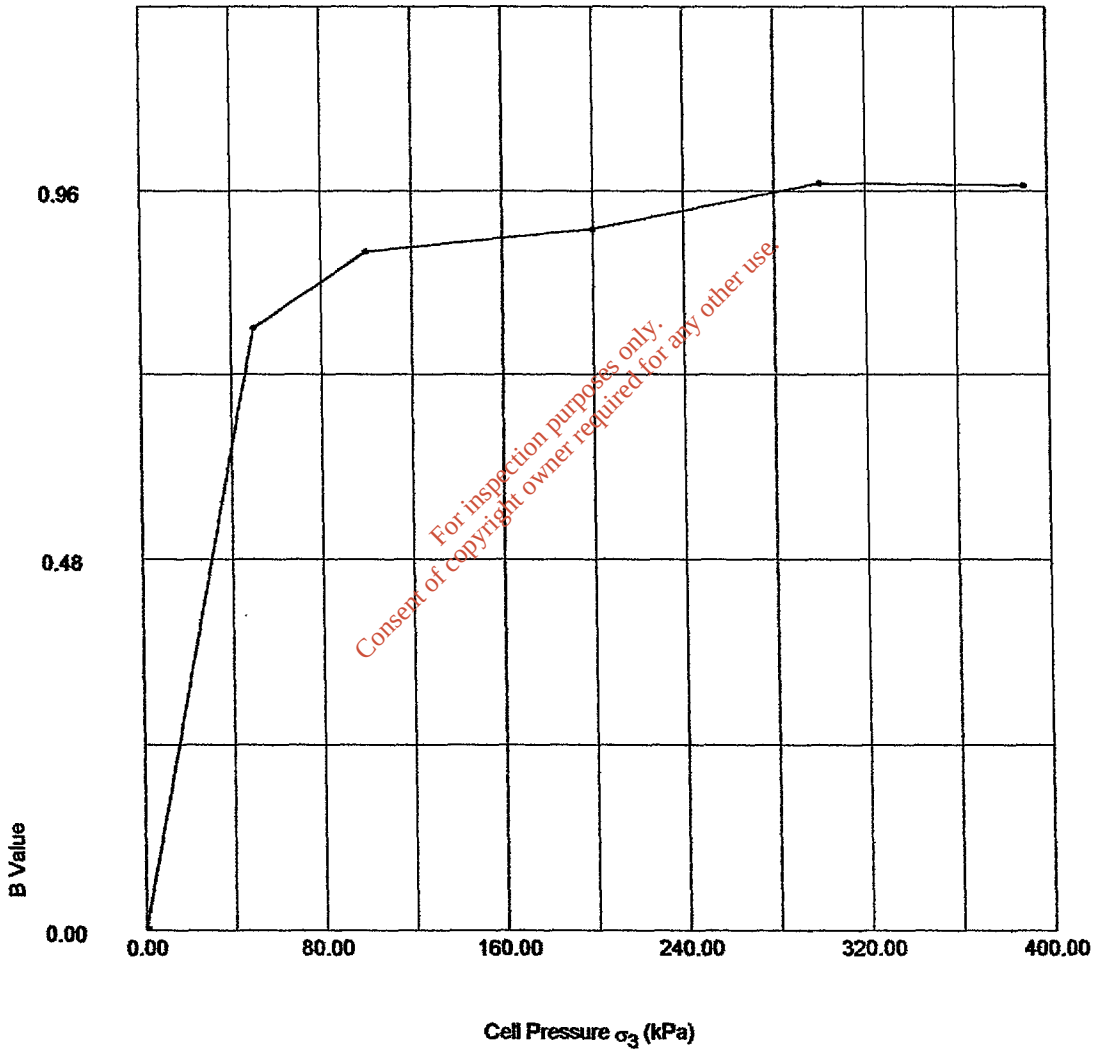
NMTL Ltd

Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/TP2
		Date of Test:	7/1/2003
Site Reference:	Huntstown	Sample:	TP2
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP2
Operator:	*Checked:*	*Approved:*	

Permeability Tests

Triaxial Cell Constant Head

Saturation Stage Data	
Test Method:	Cell P. only
Final Cell Pressure σ_{3f} (kPa)	390.00
Final Pore Pressure u_f (kPa)	362.00
Final B Value	0.97



NMTL Ltd

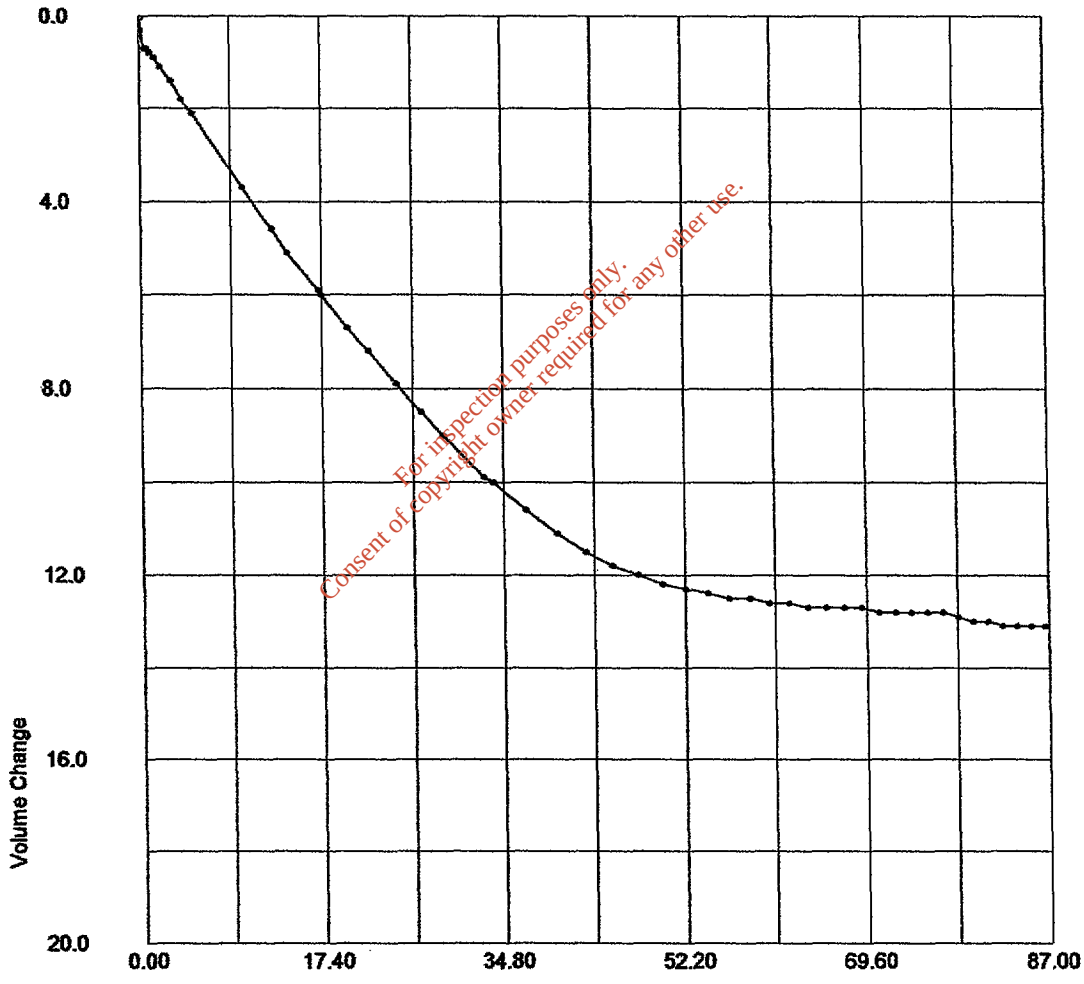
Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/TP2
		Date of Test:	7/1/2003
Site Reference:	Huntstown	Sample:	TP2
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP2
Operator:	*Checked:*	*Approved:*	

Permeability Tests

Triaxial Cell Constant Head

Consolidation Test Data

Cell Pressure σ_3 (kPa)	390.0
Back Pressure u_b (kPa)	300.0
Effective Pressure u_v (kPa)	90.0
Test Temperature oC	20.
Final Height H_f (mm)	114.996
Voids Ratio e_f	0.372
t_{50} (min)	905.67
Coef. of Consolidation c_v (m2/year)	2.93
Coef. of Vol. Compressibility m_v (m2/MN)	0.15

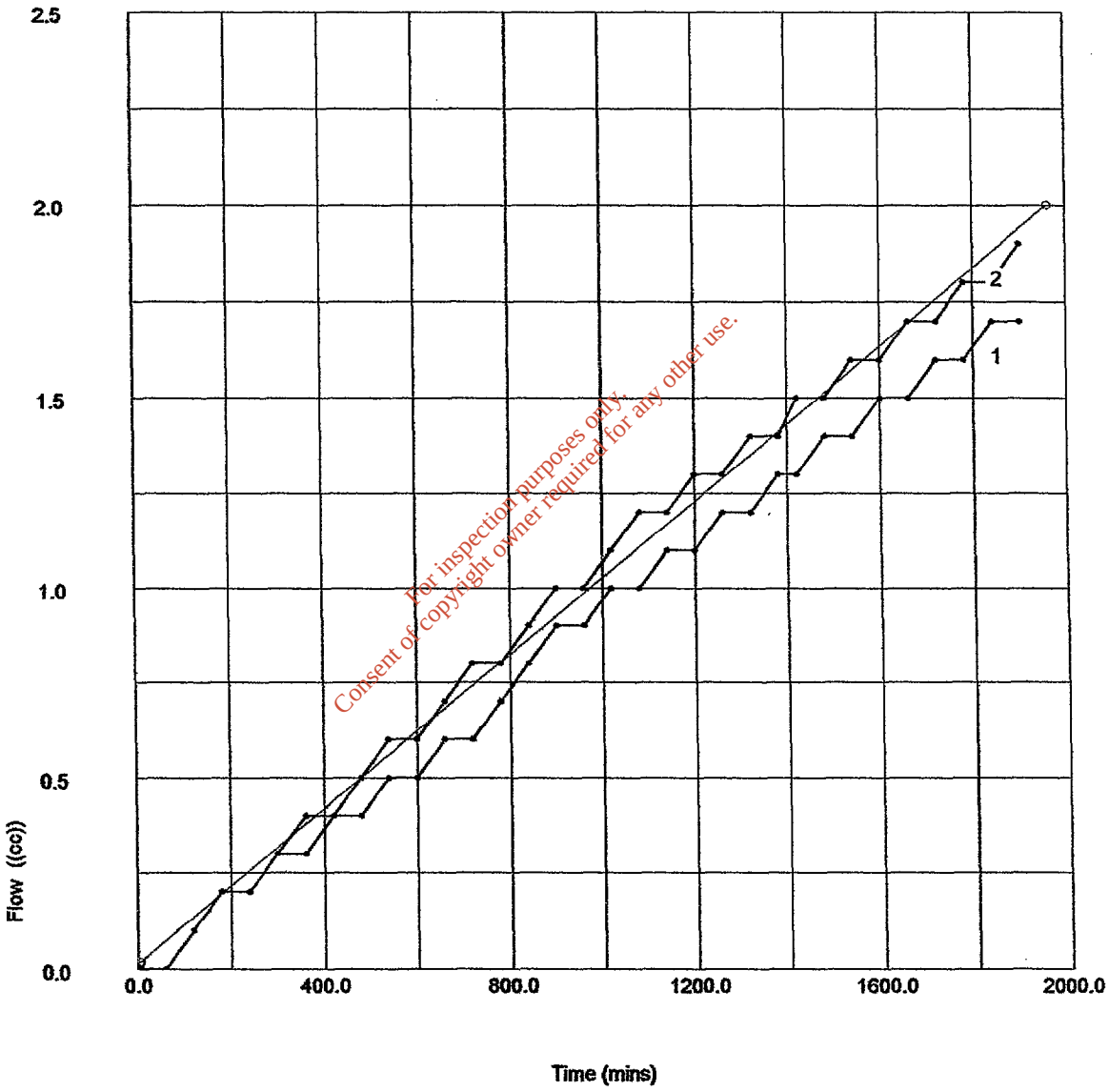


NMTL Ltd

Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name Date of Test:	Huntstown/TP2 7/1/2003
Site Reference: Jobfile:	Huntstown C:\WINCLISP\NMTL050.JOB	Sample: Borehole:	TP2 TP2
Operator:	*Checked:*	*Approved:*	

Permeability Tests

Triaxial Cell Constant Head



NMTL Ltd

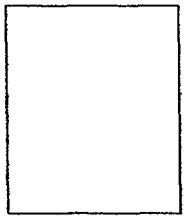
	Test Method : BS1377 : Part 6 : 1990 (Clause 6)	Test name	Huntstown/TP2
		Date of Test:	7/1/2003
	Site Reference: Huntstown	Sample:	TP2
	Jobfile: C:\WINCLISP\NMTL050.JOB	Borehole:	TP2
	Operator:	*Checked:*	*Approved:*

Permeability Tests

Triaxial Cell Constant Head

Sample details

Sketch showing specimen location in original Sample



Depth	0.00m
Description:	Soft grey brown slightly sandy gravelly CLAY.
	Specimen 1
Type	
Height H_0 (mm)	115.153
Diameter D_0 (mm)	105
Weight W_0 (gr)	2112.087
Bulk Density ρ (Mg/m3)	2.12
Particle Density ρ_s	0
	(measured)

Initial Conditions

Inlet Volume Channel	MGO775	Moisture Content w%0	12
Outlet Volume Channel	12793	Dry Density ρ_d (Mg/m3)	1.89
Pore Pressure Channel	VJT2501A	Voids Ratio e_0	0.43
Test Frame	HEADLOSS_001	Deg of Saturation S_0%	77.14
		Flow Direction	DOWN
		Sample Preparation	
Stage	1		
Cell Pressure σ_3 (kPa)	390.00		
Back Pressure u_b (kPa)	300.00		
Drain Pressure u_d (kPa)	317.00		
Effective Stress σ_v (kPa)	81.50		
Temperature oC	20.		

Permeability Results

Moisture Content w_f%	11	Voids Ratio e_f	0.42
Dry Density ρ_d (Mg/m3)	1.90	Deg of Saturation S_f%	72.42
Stage	1		
Hydraulic Gradient (kPa)	17.00		
Mean Flow Rate q (mL/min)	0.002		
Head Loss p_c (kPa)	0.00		
Permeability k_v (m/s)	2.53 e-10		

Notes Remoulded at dry density of 1.90 Mg/m3 at 12% moisture content.

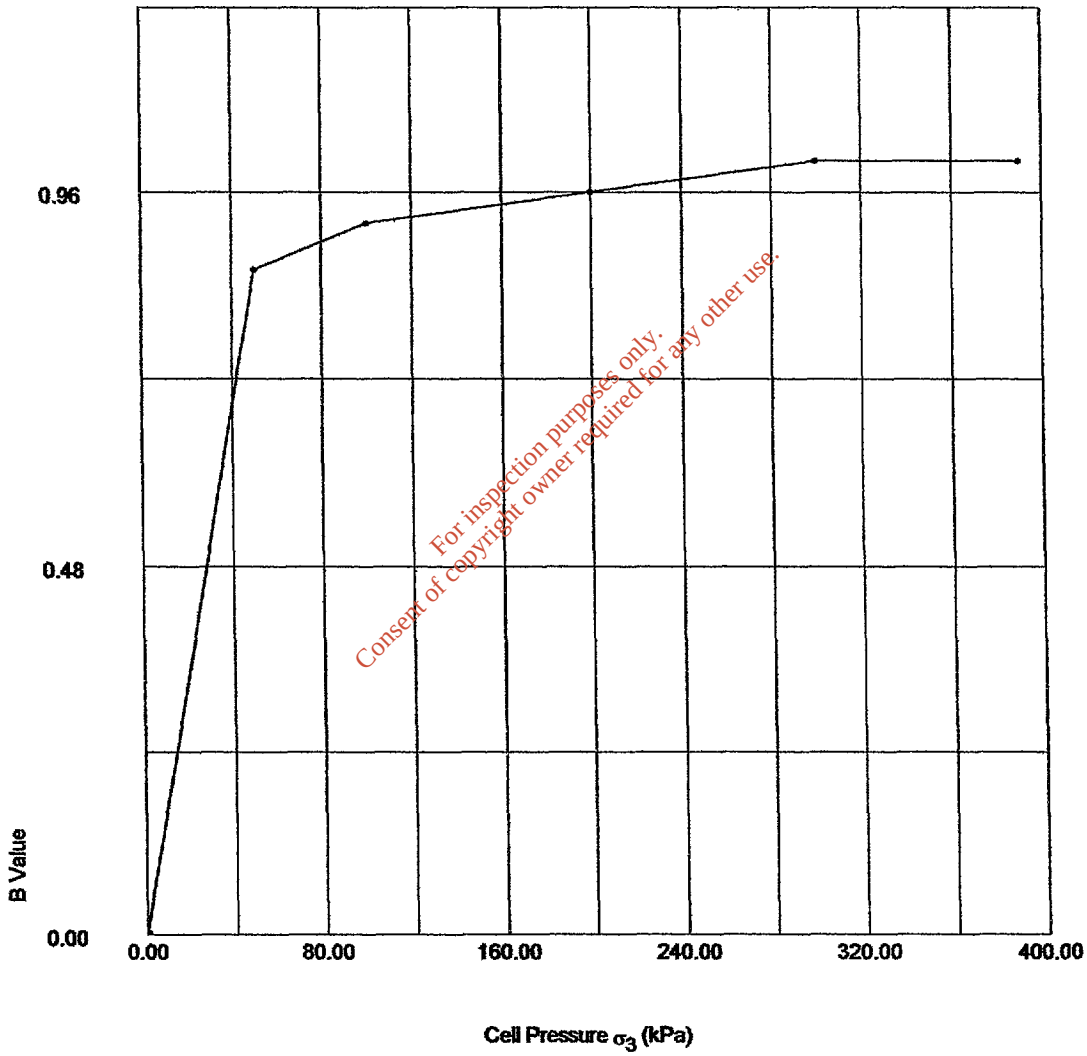
NMTL Ltd

Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/TP3
		Date of Test:	7/7/2003
Site Reference:	Huntstown	Sample:	TP3
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP3
Operator:	*Checked:*		*Approved:*

Permeability Tests

Triaxial Cell Constant Head

Saturation Stage Data	
Test Method:	Cell P. only
Final Cell Pressure σ_{3f} (kPa)	390.00
Final Pore Pressure u_f (kPa)	379.00
Final B Value	1.00



NMTL Ltd

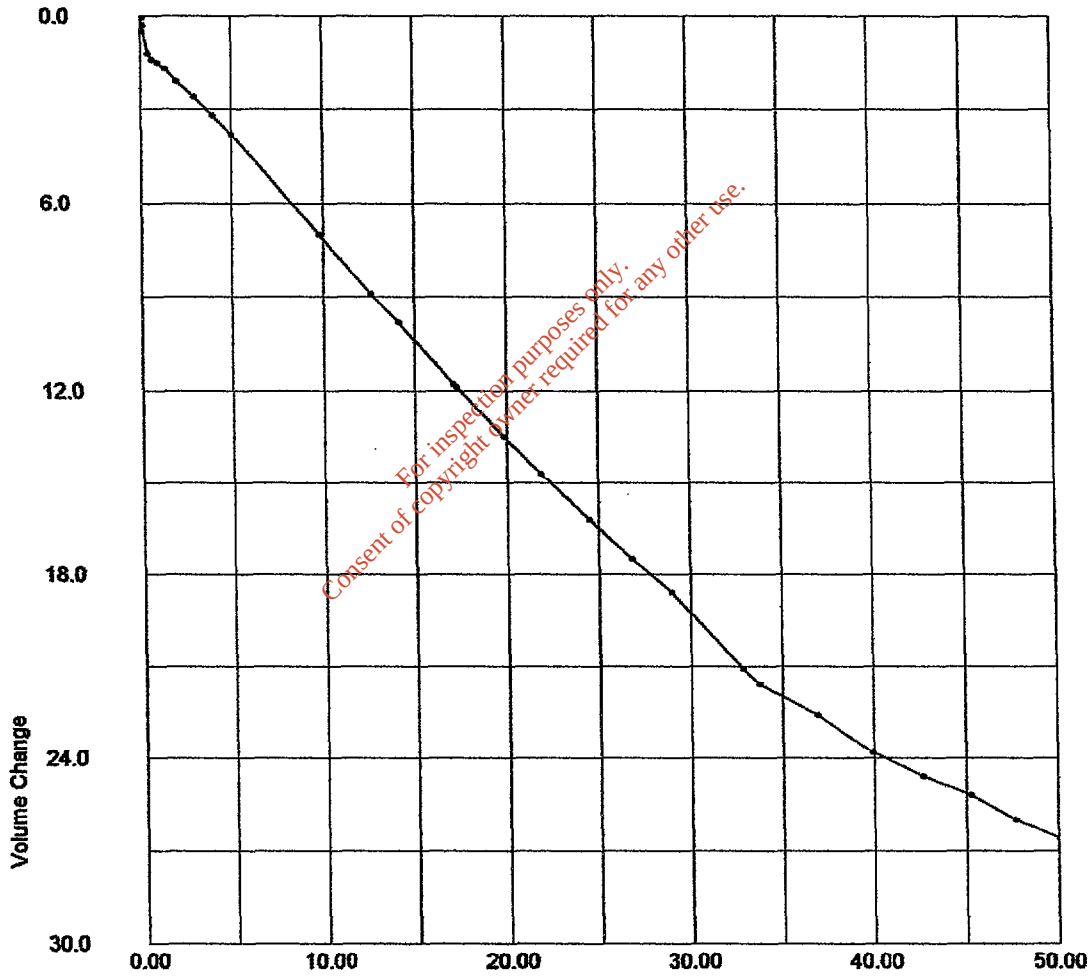
Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/TP3
		Date of Test:	7/7/2003
Site Reference:	Huntstown	Sample:	TP3
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP3
Operator:	*Checked:*	*Approved:*	

Permeability Tests

Triaxial Cell Constant Head

Consolidation Test Data

Cell Pressure σ_3 (kPa)	390.0
Back Pressure u_b (kPa)	300.0
Effective Pressure u_v (kPa)	90.0
Test Temperature oC	20.
Final Height H_f (mm)	114.129
Voids Ratio e_f	0.394
t_{50} (min)	863.61
Coef. of Consolidation c_v (m2/year)	3.04
Coef. of Vol. Compressibility m_v (m2/MN)	0.30

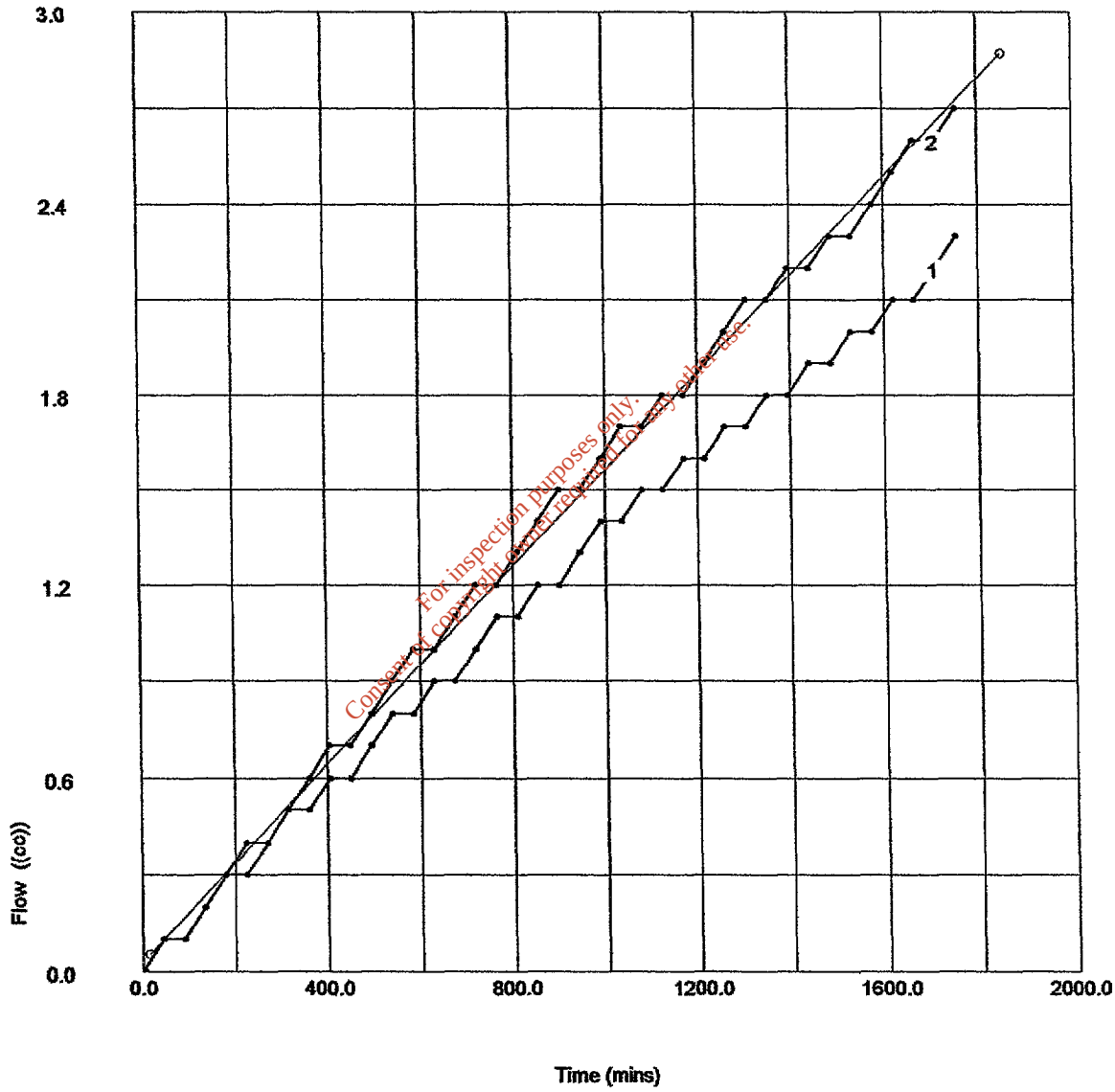


NMTL Ltd

Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/TP3
		Date of Test:	7/7/2003
Site Reference:	Huntstown	Sample:	TP3
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP3
Operator:	*Checked:*	*Approved:*	

Permeability Tests

Triaxial Cell Constant Head



NMTL Ltd

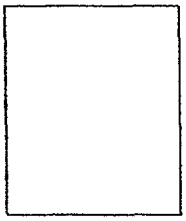
Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/TP3
		Date of Test:	7/7/2003
Site Reference:	Huntstown	Sample:	TP3
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP3
Operator:	*Checked:*	*Approved:*	

Permeability Tests

Triaxial Cell Constant Head

Sample details

Sketch showing specimen location in original Sample



Depth	0.00m
Description:	Soft to firm grey slightly sandy gravelly CLAY.
	Specimen 1
Type	
Height H_0 (mm)	115.5
Diameter D_0 (mm)	105
Weight W_0 (gr)	2186.08
Bulk Density ρ (Mg/m3)	2.19
Particle Density ρ_s	0
	(measured)

Initial Conditions

Inlet Volume Channel	MGO775	Moisture Content w%0	12
Outlet Volume Channel	MG0777	Dry Density ρ_d (Mg/m3)	1.95
Pore Pressure Channel	VJT02503A	Voids Ratio e_0	0.38
Test Frame	HEADLOSS_001	Deg of Saturation S_0%	85.59
		Flow Direction	DOWN
		Sample Preparation	
Stage	1		
Cell Pressure σ_3 (kPa)	405.00		
Back Pressure u_b (kPa)	300.00		
Drain Pressure u_d (kPa)	314.00		
Effective Stress σ_v (kPa)	98.00		
Temperature oC	20.		

Permeability Results

Moisture Content w_f%	12	Voids Ratio e_f	0.37
Dry Density ρ_d (Mg/m3)	1.96	Deg of Saturation S_f%	83.87
Stage	1		
Hydraulic Gradient (kPa)	14.00		
Mean Flow Rate q (mL/min)	9.89 e-04		
Head Loss p_c (kPa)	0.00		
Permeability k_v (m/s)	1.53 e-10		

Notes Remoulded at dry density of 1.95 Mg/m3 and at 12% moisture content.

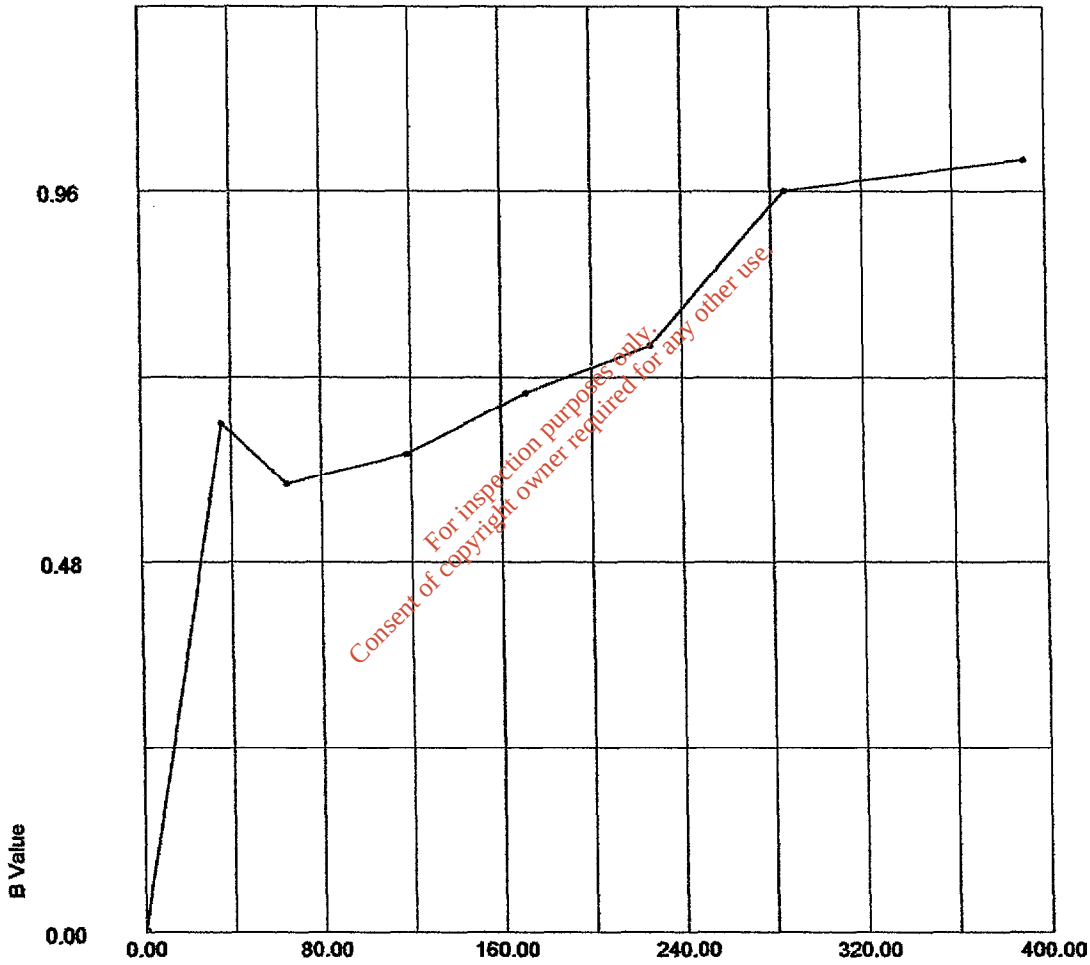
NMTL Ltd

Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/T4
		Date of Test:	7/8/2003
Site Reference:	Huntstown	Sample:	TP4
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP4
Operator:	*Checked:*		*Approved:*

Permeability Tests

Triaxial Cell Constant Head

Saturation Stage Data	
Test Method:	Cell P. And Pore P.
Final Cell Pressure σ_{3f} (kPa)	405.00
Final Pore Pressure u_f (kPa)	391.00
Final B Value	1.00



NMTL Ltd

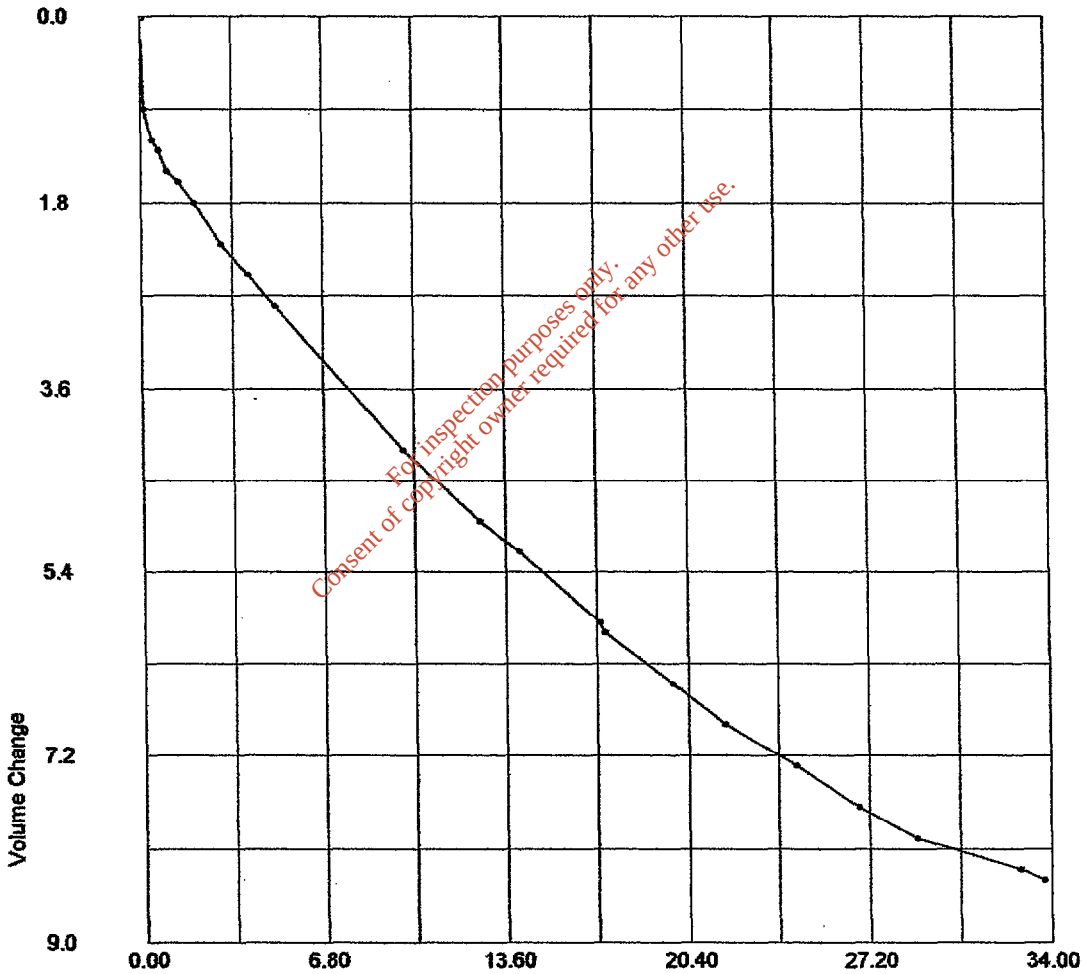
Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/T4
		Date of Test:	7/8/2003
Site Reference:	Huntstown	Sample:	TP4
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP4
Operator:	Checked:		Approved:

Permeability Tests

Triaxial Cell Constant Head

Consolidation Test Data

Cell Pressure σ_3 (kPa)	405.0
Back Pressure u_b (kPa)	300.0
Effective Pressure u_v (kPa)	105.0
Test Temperature oC	20.
Final Height H_f (mm)	115.177
Voids Ratio e_f	0.368
t_{50} (min)	202.47
Coef. of Consolidation c_v (m2/year)	13.14
Coef. of Vol. Compressibility m_v (m2/MN)	0.08

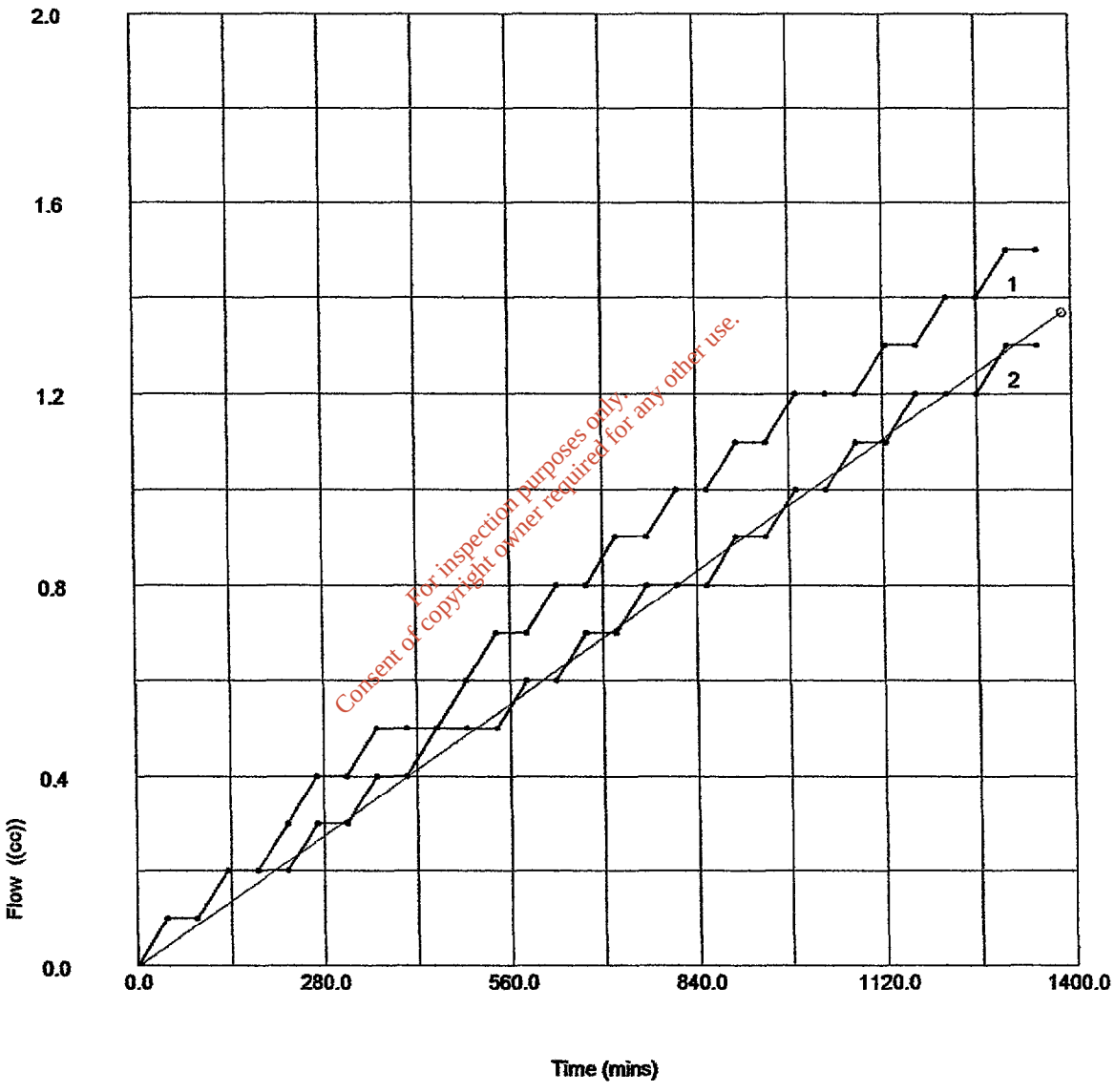


NMTL Ltd

Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/T4
		Date of Test:	7/8/2003
Site Reference:	Huntstown	Sample:	TP4
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP4
Operator:	*Checked:*	*Approved:*	

Permeability Tests

Triaxial Cell Constant Head



NMTL Ltd

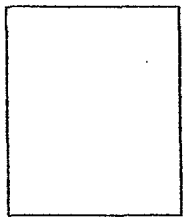
Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/T4
		Date of Test:	7/8/2003
Site Reference:	Huntstown	Sample:	TP4
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP4
Operator:	*Checked:*		*Approved:*

Permeability Tests

Triaxial Cell Constant Head

Sample details

Sketch showing specimen location in original Sample



Depth	0.00m
Description:	Soft grey slightly sandy slightly gravelly CLAY.
	Specimen 1
Type	
Height H_0 (mm)	115.5
Diameter D_0 (mm)	105
Weight W_0 (gr)	2189
Bulk Density ρ (Mg/m3)	2.19
Particle Density ρ_s	0 (measured)

Initial Conditions

Inlet Volume Channel	MGO775	Moisture Content w%0	12
Outlet Volume Channel	12793	Dry Density ρ_d (Mg/m3)	1.95
Pore Pressure Channel	VJT2501A	Voids Ratio e_0	0.39
Test Frame	HEADLOSS_001	Deg of Saturation S_0%	84.09
		Flow Direction	DOWN
		Sample Preparation	
Stage	1		
Cell Pressure σ_3 (kPa)	420.00		
Back Pressure u_b (kPa)	300.00		
Drain Pressure u_d (kPa)	315.00		
Effective Stress σ_v (kPa)	112.50		
Temperature oC	20.		

Permeability Results

Moisture Content w_f%	12	Voids Ratio e_f	0.39
Dry Density ρ_d (Mg/m3)	1.95	Deg of Saturation S_f%	84.31
Stage	1		
Hydraulic Gradient (kPa)	15.00		
Mean Flow Rate q (mL/min)	9.17 e-04		
Head Loss p_c (kPa)	0.00		
Permeability k_v (m/s)	1.32 e-10		

Notes Remoulded at dry density of 1.95 Mg/m3 at 12% moisture content.

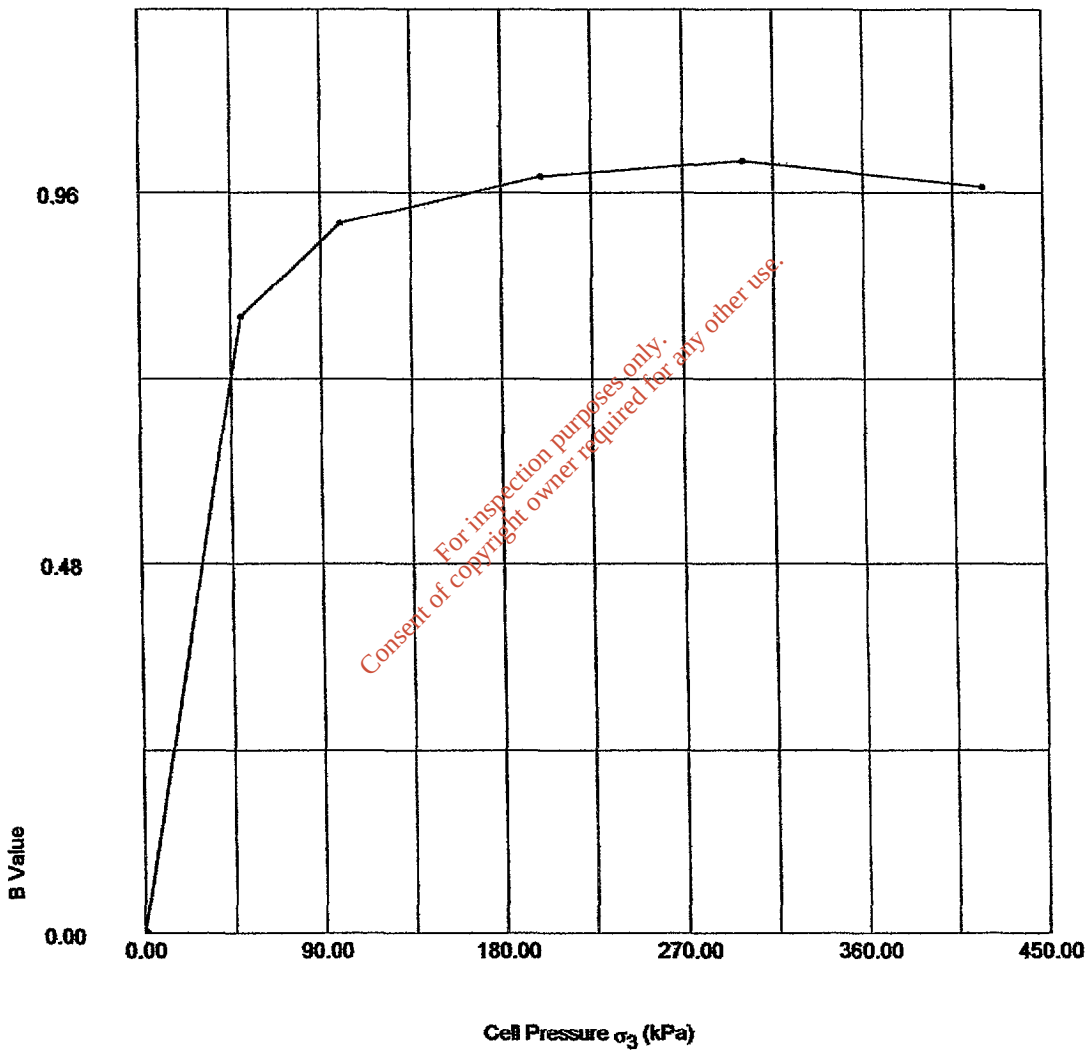
NMTL Ltd

Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/T5
		Date of Test:	7/10/2003
Site Reference:	Huntstown	Sample:	TP5
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP5
Operator:	*Checked:*		*Approved:*

Permeability Tests

Triaxial Cell Constant Head

Saturation Stage Data	
Test Method:	Cell P. only
Final Cell Pressure σ_{3f} (kPa)	420.00
Final Pore Pressure u_f (kPa)	404.00
Final B Value	0.97



NMTL Ltd

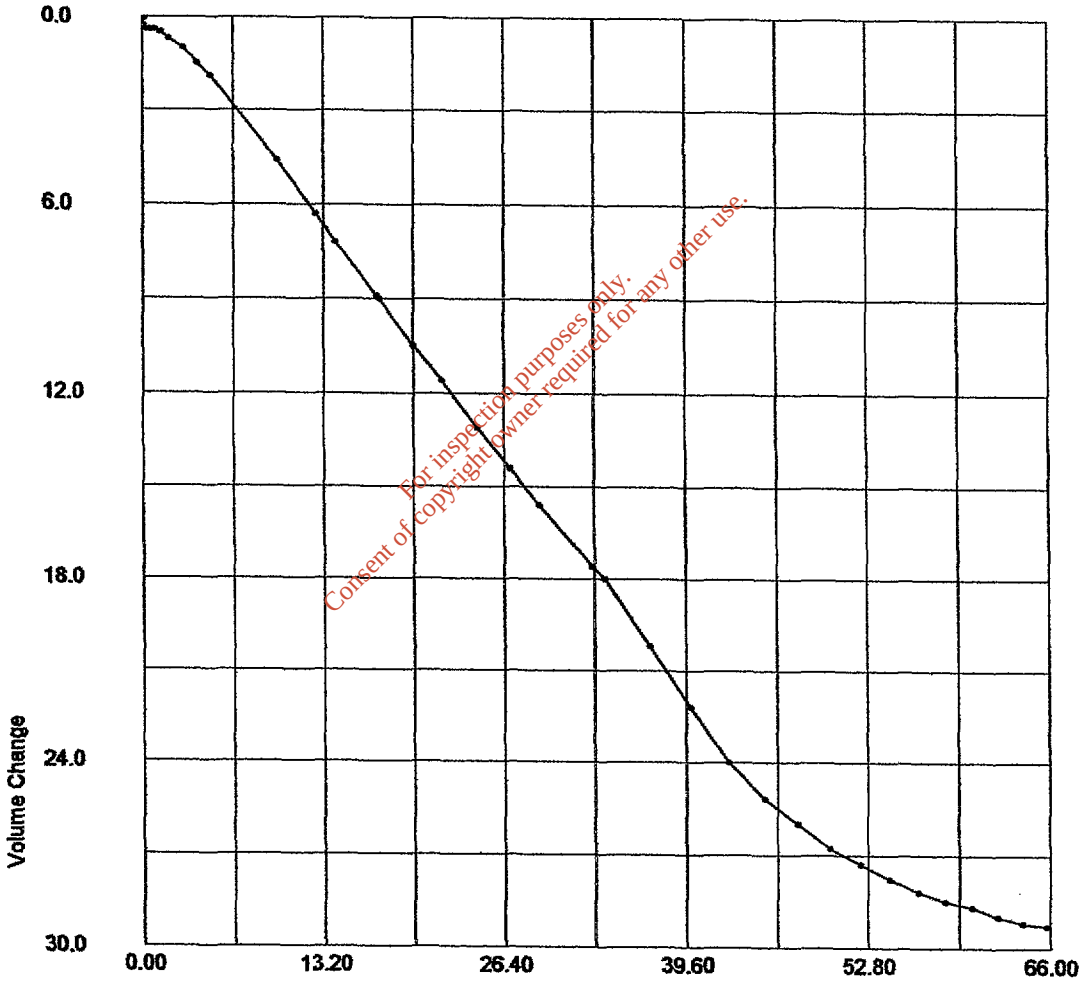
Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/T5
		Date of Test:	7/10/2003
Site Reference:	Huntstown	Sample:	TP5
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP5
Operator:	*Checked:*		*Approved:*

Permeability Tests

Triaxial Cell Constant Head

Consolidation Test Data

Cell Pressure σ_3 (kPa)	420.0
Back Pressure u_b (kPa)	300.0
Effective Pressure u_v (kPa)	120.0
Test Temperature oC	20.
Final Height H_f (mm)	114.372
Voids Ratio e_f	0.37
t_{50} (min)	1492.24
Coef. of Consolidation c_v (m2/year)	1.77
Coef. of Vol. Compressibility m_v (m2/MN)	0.24

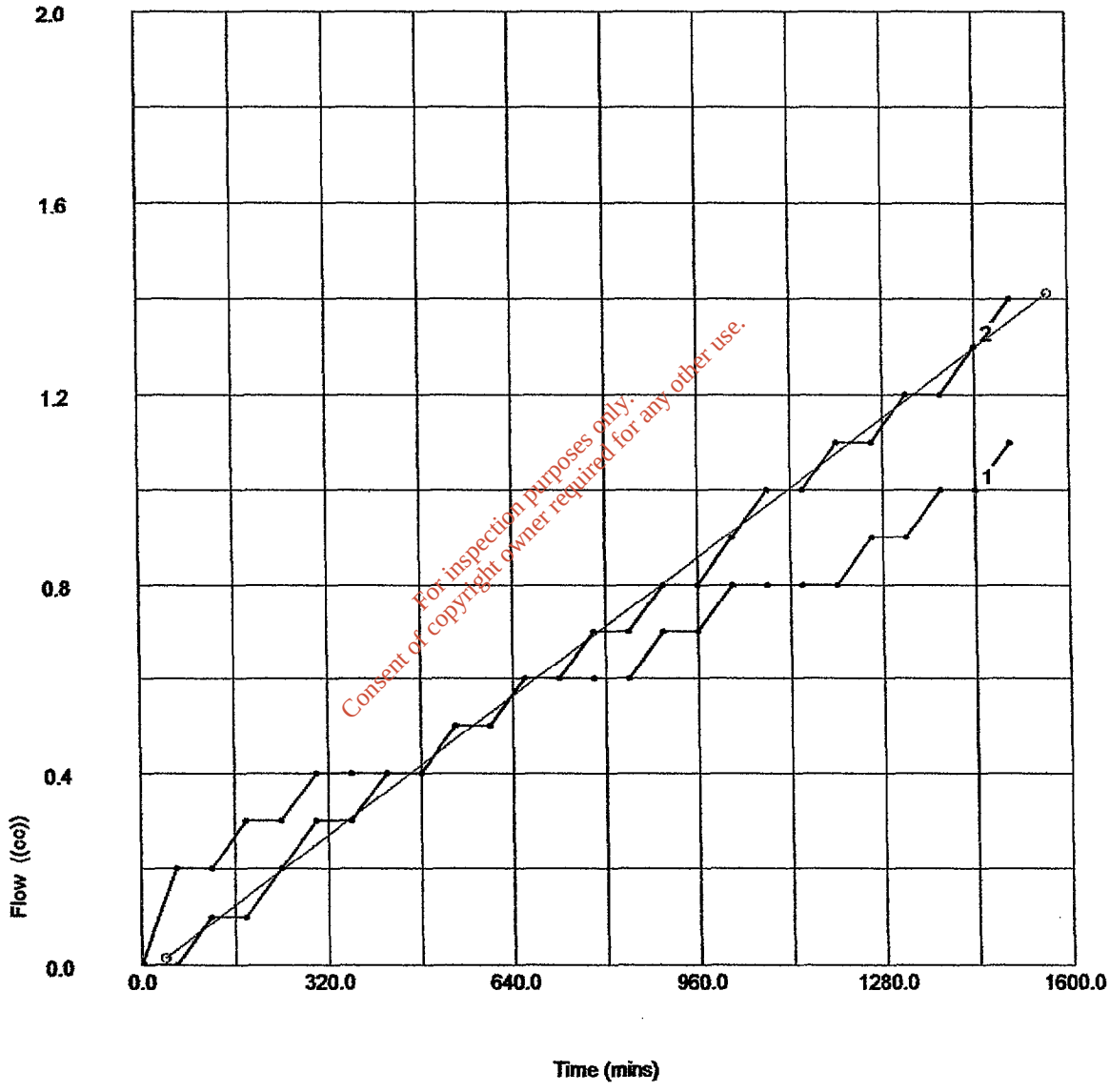


NMTL Ltd

Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/T5
		Date of Test:	7/10/2003
Site Reference:	Huntstown	Sample:	TP5
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP5
Operator:	*Checked:*	*Approved:*	

Permeability Tests

Triaxial Cell Constant Head



NMTL Ltd

Test Method : BS1377 : Part 6 : 1990 (Clause 6)		Test name	Huntstown/T5
		Date of Test:	7/10/2003
Site Reference:	Huntstown	Sample:	TP5
Jobfile:	C:\WINCLISP\NMTL050.JOB	Borehole:	TP5
Operator:	*Checked:*		*Approved:*

APPENDIX D

GEOSYNTHETIC CLAY LINER REQUIREMENTS

TABLE 1: GEOSYNTHETIC CLAY LINER SPECIFICATION AND QUALITY CONTROL TESTING FREQUENCIES (SODIUM BENTONITE)

Test Description	Test Method	Frequency of Conformance Tests	Required Value
Bentonite			
Montmorilinite Content	VDG P69/XRD	1 per 5000 m^2	≥75%
Swell Index/Free swell of clay	ASTM D 5890	1 per 2500 m^2	≥25ml
Water Absorption	ASTM E946		≥650%
Geotextiles			
Mass per unit area of woven geotextile	ASTM D5261		≥105g/m^2
Mass per unit area of needle punched geotextile	ASTM D5261		≥200g/m^2
GCL			
Mass per unit area of bentonite @ 12% moisture content	ASTM D5993		≥4595g/m^2
CBR / Puncture Resistance of finished GCL	ASTM 4833		≥1800Nm
Mass per unit area of finished GCL **	ASTM D5933	1 per 500m^2	≥4900g/m^2
Moisture Content of clay from finished GCL	ASTM D4643	1per 2,500m^2	<50% as delivered to site
Strip Tensile strength	ASTM D4632		≥6kN/m^2
Peel Strength	ASTM D413	1 per 500m^2	≥60N/10cm
Perme ability	ASTM D5084	1 per 5,000m^2	<5x10^{-11}m/s

** bentonite component of GCL based on 12% moisture content.

APPENDIX E

HDPE AND VFPE GEOMEMBRANE REQUIREMENTS

TABLE 1 : GEOMEMBRANE MATERIAL REQUIREMENTS
2.0mm HDPE

	Parameter	Test Method	Specification HDPE 2.0mm
1.	Thickness	ASTM D1593	2.0 +/- 10% mm (See Section 6.8 of Specification)
2.	Carbon Black Content	ASTM D1603	>2.0% by mass
3.	Carbon Black Dispersion	ASTM D5596	Minimum 8 of 10 in categories 1 or 2. All of 10 categories 1,2 or 3
4.	Density	ASTM D1505A	940 +/- 1% kg/m^3
5.	Tensile Properties	ASTM D638, Type IV, 2 ipm	
	(Tensile testing to be performed in longitudinal and transverse directions)		
	Stress at yield		>29kN/m
	Stress at break		>21kN/m
	Elongation at yield		>12%
	Elongation at break		>100%
6.	Melt Flow Index	ASTM D1238E	<2g/10min
7.	Puncture Resistance	ASTM D4833	530N
8.	Stress Crack Resistance	ASTM D5397(c)	>200hours

TABLE 2 : FIELD SEAM – DESTRUCTIVE TEST CRITERIA FOR 2mm HDPE GEOMEMBRANE

1. FUSION WELDS

Test	Method	Requirement
Shear Tests	ASTM D4437 (As modified by NSF 54-1993)	1. Fill Tear Bond 2. Shear Strength> 28.0N/mm 3. Shear Elongation at failure (i) Smooth >100% x L (ii) Textured >50% x L
Peel Test	ASTM D4437 (As modified by NSF 54-1993)	1. Fill Tear Bond 2. Peel Strength >21.0 N/mm 3. Peel Separation <10% of seam width

Notes:

1. Peel Test on double fusion weld to be carried our on both welds.

2. FILLET EXTRUSION WELDS

Test	Method*	Requirement**
Shear Tests	ASTM D4437 (As modified by NSF 54-1993)	1. Fill Tear Bond 2. Shear Strength> 28.0N/mm 3. Shear Elongation at failure (i) Smooth >100% x L (ii) Textured >50% x L
Peel Test	ASTM D4437 (As modified by NSF 54-1993)	1. Fill Tear Bond 2. Peel Strength >18.2 N/mm 3. Peel Separation <10% of seam width

TABLE 3: GEOMEMBRANE MATERIAL REQUIREMENTS
1.0mm VFPE

Parameter		Test Method	Specification Textured VFPE 1.0mm
1.	Thickness	ASTM D1593	1.0 +/- 10% mm (See Section 6.8 of Specification)
2.	Carbon Black Content	ASTM D1603	>2.0% by mass
3.	Carbon Black Dispersion	ASTM D3015	A1, A2, or B1
4	Density	ASTM D1505A	920 +/- 1% kg/m^3
5.	Tensile Properties	ASTM D638, Type IV, 2 ipm	

(Tensile testing to be performed in longitudinal and transverse directions)

Stress at break	>11kN/m
Elongation at break	>250%

6.	Melt Flow Index	ASTM D1238E	<2g/10min
7.	Puncture Resistance	ASTM D4833	195N
8.	Tear Resistance	ASTM D1004	>100N

TABLE 4 : FIELD SEAM – DESTRUCTIVE TEST CRITERIA FOR 1mm TEXTURED VFPE GEOMEMBRANE

1. FUSION WELDS

Test	Method*	Requirement**
Shear Tests	ASTM D4437 (As modified by NSF 54-1993)	1. Fill Tear Bond 2. Shear Strength> 9.8N/mm 3. Shear Elongation at failure (i) Smooth >100% x L (ii) Textured >50% x L
Peel Test	ASTM D4437 (As modified by NSF 54-1993)	1. Fill Tear Bond 2. Peel Strength >8.4 N/mm 3. Peel Separation <10% of seam width

Notes:

1. Peel Test on double fusion weld to be carried our on both welds.

2. FILLET EXTRUSION WELDS

Test	Method*	Requirement**
Shear Tests	ASTM D4437 (As modified by NSF 54-1993)	1. Fill Tear Bond 2. Shear Strength> 9.8N/mm 3. Shear Elongation at failure (i) Smooth >100% x L (ii) Textured >50% x L
Peel Test	ASTM D4437 (As modified by NSF 54-1993)	1. Fill Tear Bond 2. Peel Strength >8.4 N/mm 3. Peel Separation <10% of seam width

APPENDIX F

HDPE AND VFPE GEOMEMBRANE DESTRUCTIVE SAMPLE FAILURE CODES

APPENDIX G

HDPE AND VFPE GEOMEMBRANE DESTRUCTIVE SAMPLE DETAIL

APPENDIX H

TYPICAL CYLINDER TEST ARRANGEMENT