Western Cape LIG Seminar

Session 1: Construction of Landfill Facilities

Prepared for

Institute of Waste Management of Southern Africa

LIG Landfill Interest Group

Disposal Treatment Utilisation Management

Specialist interest group within the
Institute of Waste Management of Southern Africa (IWMSA)
www.iwmsa.co.za/ligwc

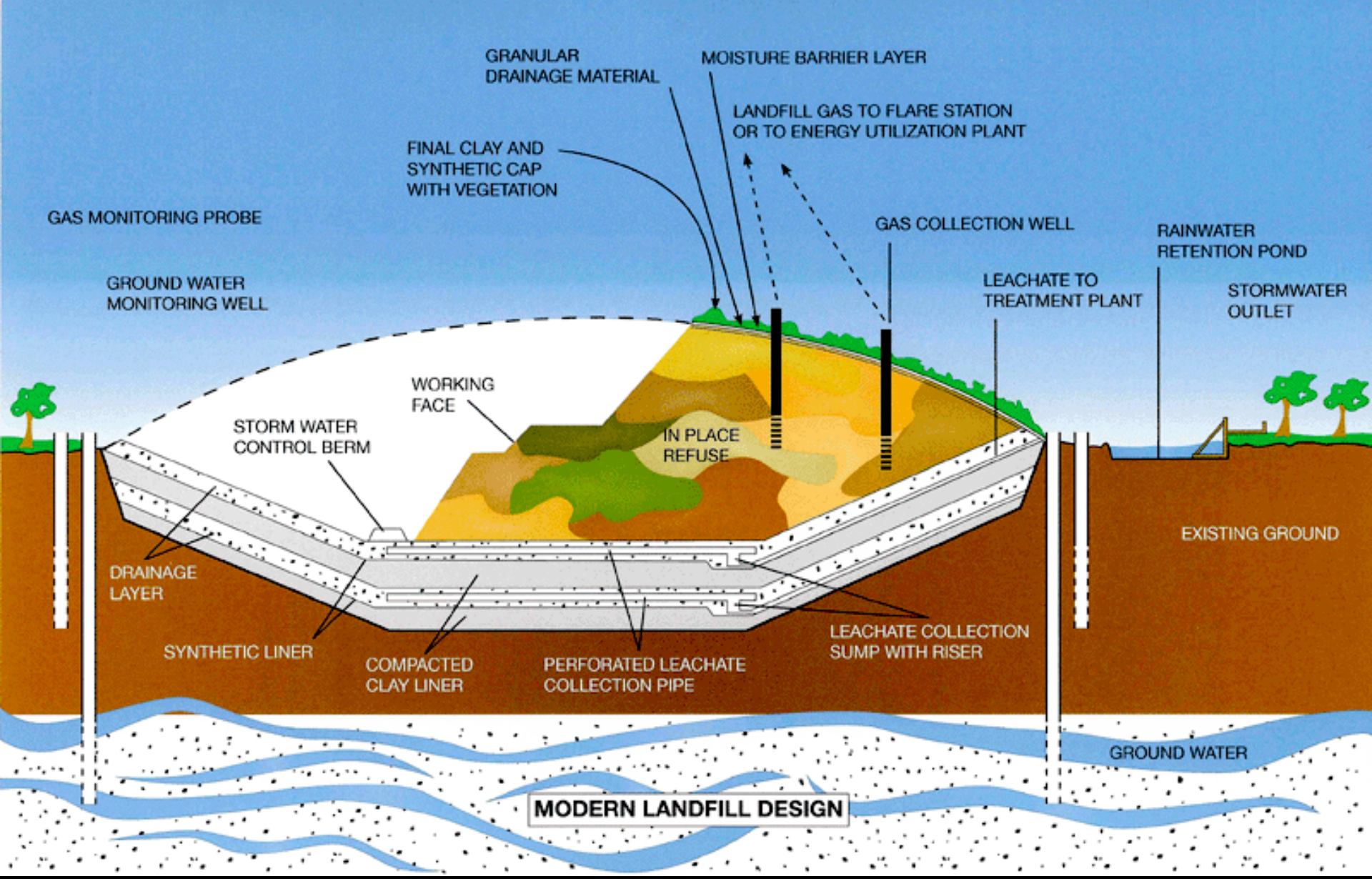
24 July 2014

KAYTECH ENGINEERED FABRICS

A Founder Member of

The *Geosynthetics Interest Group* of South Africa

gigsa



Landfills:
Complex Engineered Containments

Let's Just Look Back a Little..

27 February 2014

Western Cape Landfill Interest Group

Seminar on Landfill...

GUIDELINES TO THE DESIGN OF A LANDFILL FACILITY

LANDFILL INTEREST GROUP: SEMINAR SESSION 2: OVERVIEW OF LANDFILL FACILITY DESIGN AND ASSOCIATED INFRASTRUCTURE

27 February 2014

By: Wihan Visser Jan Palm Consulting Engineers
Thorsten Aab WSP Group Africa

Institute of Waste Management of Southern Africa

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Institute of Waste Management of Southern Africa

TENDERING PROCEDURES

Pieter Kriel, WorleyParsons

WorleyParsons
resources & energy

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Institute of Waste Management of Southern Africa

New Landfill Classifications

Richard Emery, Jeffares & Green
emeryr@jgi.co.za

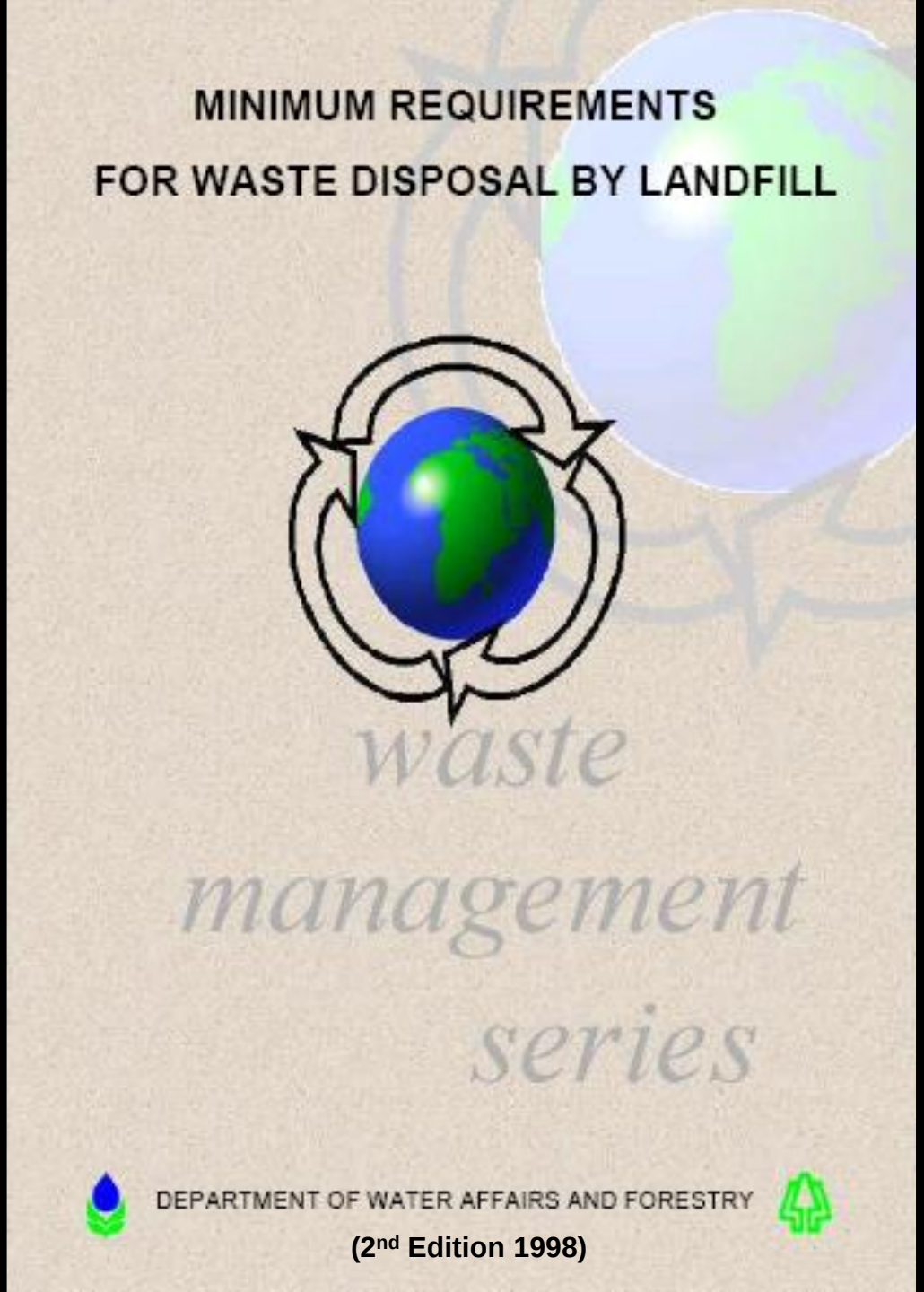
Jeffares & Green
ENGINEERING & ENVIRONMENTAL CONSULTING

Waste Disposal By Landfill

For Years The Principal South African Guidance Document →

(and Now Amended By

The National Norms and Standards for Waste Disposal by Landfill)



New RSA Landfill Classification System

("3rd Edition")

Section 8 in this Document – "National Norms and Standards for Disposal of Waste to Landfill"

Is Where We'll Concentrate

Government Gazette
Staatskoerant

REPUBLIC OF SOUTH AFRICA
REPUBLIEK VAN SUID-AFRIKA

Regulation Gazette No. 10008 *Regulasiekoerant*

Vol. 578 Pretoria, 23 August Augustus 2013 No. 36784

CONTENTS • INHOUD

No.		Page No.	Gazette No.
	GOVERNMENT NOTICES		
Environmental Affairs, Department of			
Government Notices			
R. 634	National Environmental Management: Waste Act (59/2008): Waste Classification and Management Regulations	3	36784
R. 635	do.: National norms and standards for the assessment of waste for landfill disposal	22	36784
R. 636	do.: National norms and standards for disposal of waste to landfill	34	36784

Now Only Four

Classes of Landfill:

“A” (Formerly H:H and H:h) – “Type 1” Waste
(‘Hazardous Waste’)

“B” (Formerly G:L:B^{+}) – “Type 2” Waste
(Municipal Garbage)

“C” (Formerly G:L:B^{+}) – “Type 3” Waste
(Post-Consumer Packaging, Tyres)

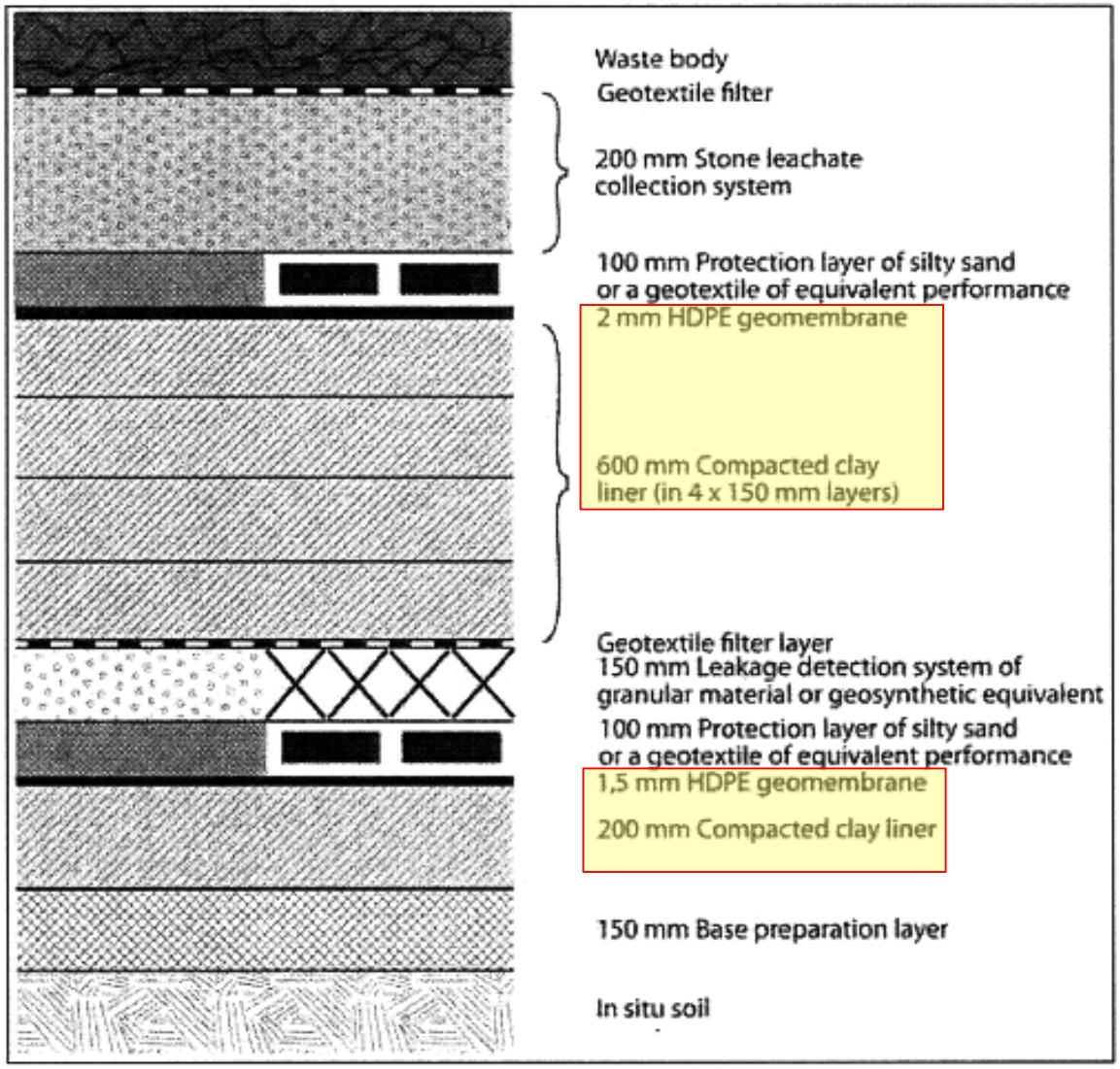
“D” (Formerly G:S:B^{-}) – “Type 4” Waste
(Inert Waste e.g. Builders Rubble)

(a) Class A Landfill: **(Hazardous Waste)**

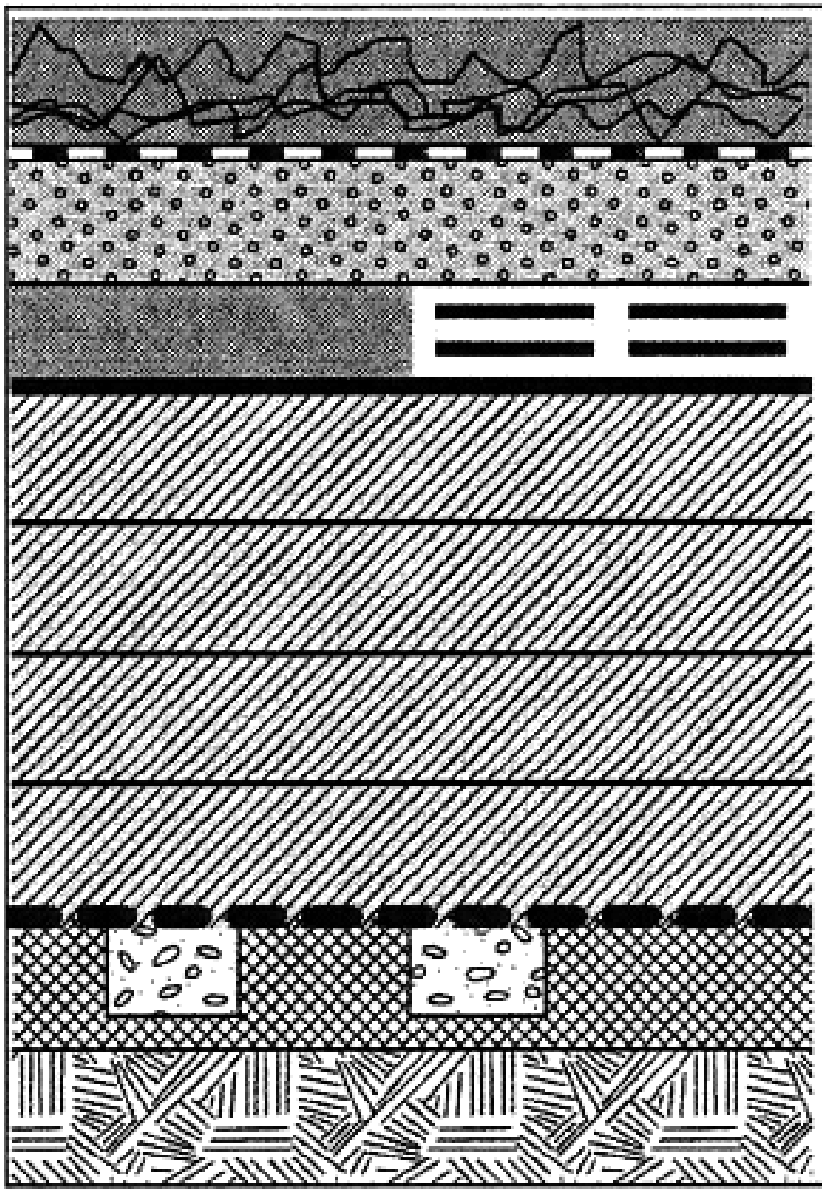
Primary Composite Liner

Max Outflow 0.03 m/y (1×10^{-7} cm/s)

Secondary Composite Liner



(b) Class B Landfill: (Municipal Waste)



Waste body

Geotextile
150 mm Stone leachate collection system

100 mm Protection layer of silty sand or a Geotextile of equivalent performance

1,5 mm HDPE Geomembrane

Primary Composite Liner

600 mm Compacted clay liner (in 4 x 150 mm layers)

Max Outflow 0.3 m/y

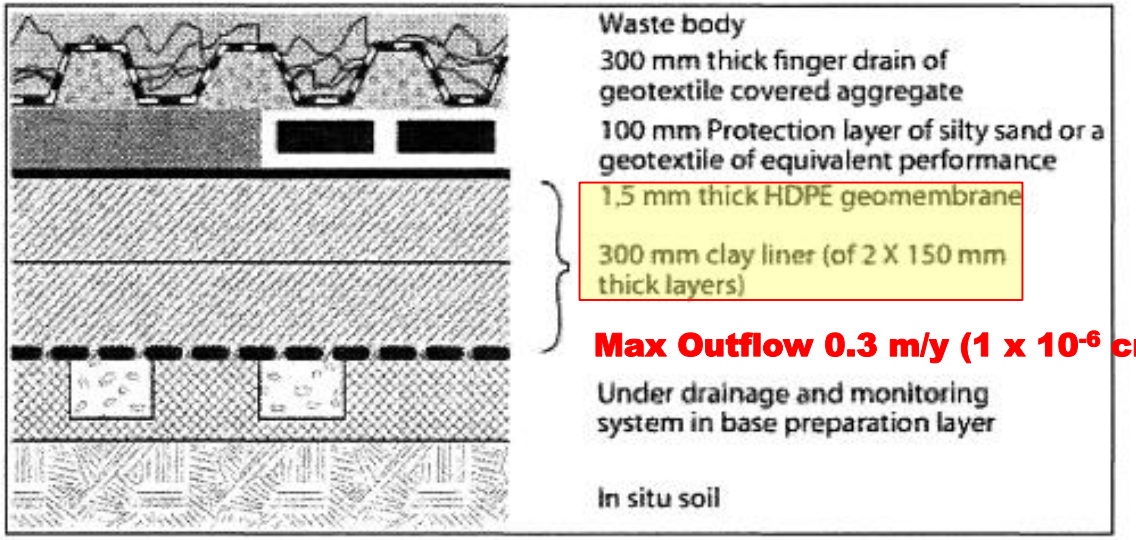
(1 x 10^{-6} cm/s)

Under drainage and monitoring system and 150 mm Base preparation layer

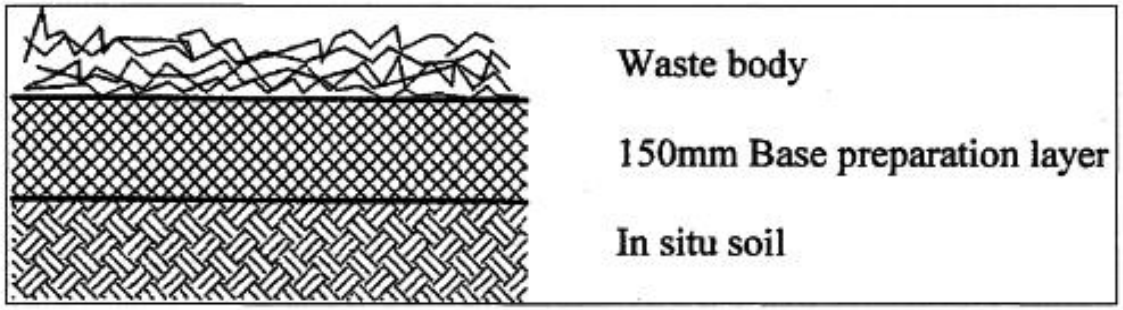
In situ soil

(c) Class C Landfill: **(Post-Consumer Packaging Tyres)**

Primary Composite Liner



(d) Class D Landfill: **(Inert Waste – Builders Rubble)**



O layer: A desiccation protection layer consisting of 150 mm of soil, gravel, rubble or other similar material that completely covers the B layer for **G:M:B**$^-$ and **G:L:B**$^-$ landfills and protects it from desiccation and cracking until it is covered by waste. Under certain circumstances, the thickness of the O layer may need to be increased.

A layer: A leachate collection layer comprising a 150 mm thick layer of single-sized gravel or crushed stone having a size of between 38 mm and 50 mm, and a system of perforated pipe drains located within the stone layer.

B layer: A 150 mm thick compacted clay liner layer. This must be compacted to a minimum density of 95% Standard Proctor* maximum dry density at a water content of Proctor optimum to optimum +2%. Permeabilities must be such that the outflow rates stated in Section 8.4.3 are not exceeded. Interfaces between B layers must be lightly scarified to assist in bonding the layers together.

The surface of every clay liner layer must be graded towards the leachate collection drain or sumps (see section 8.4.4) at a minimum gradient of 2% for general waste disposal sites and 5% for hazardous waste disposal sites. At the discretion of the Competent Authority, up to 4 x B layers may be replaced by a GCL of at least equivalent performance, (in terms of permeability, toughness and chemical resistance) supported on a 100 mm thick silt/sand layer.

C layer: This is a layer of high modulus geotextile laid on top of any D layer to protect it from contamination by fine material from above.

D layer: A leakage detection and collection layer. This is always below a C layer and above a B layer in **B**$^+$ and hazardous waste landfills. In lagoons it is underlain by an E layer which protects the second FML or geomembrane. It has a minimum thickness of 150 mm and will consist of single-sized gravel or crushed stone having a size of between 38 mm and 50 mm. At the discretion of the Department (formal communication should take place through the Competent Authority), this layer may be replaced a geosynthetic drainage of at least equivalent drainage performance.

E layer: This is a cushion of 100 mm of fine to medium sand or similar suitable material which is placed immediately above any F layer to protect it from mechanical damage.

F layer: A geomembrane or flexible membrane liner (FML) which must be laid in direct contact with the upper surface of a compacted clay B layer. A geomembrane is a Minimum Requirement for all hazardous waste landfills and lagoons. In the case of an **H:h** landfill, it is a 1,5 mm thick geomembrane underlain by four B layers. In the case of an **H:H** landfill, it is a 2,0 mm thick geomembrane underlain by four B layers. In the case of a hazardous waste lagoon, there are two geomembranes. The first is 2,0 mm thick underlain by four B layers and the second is 1,0 mm thick underlain by two B layers[34].

The geomembrane thickness specified shall be minimum nominal thickness, as measured in accordance with the SANS 1526:2003.

G layer: This is a base preparation layer consisting of a compacted layer of reworked in-situ soil with a minimum thickness of 150 mm and constructed to the same compaction standards as a B layer. Where the permeability of a G layer can be proven to be of the same standard as a B layer, it may replace the lowest B layer.

The surface of every G layer must be graded towards a leachate collection drain or sump in the case of **B**$^+$ landfill or to a central channel on the down gradient side of a **B**$^-$ landfill, from which sporadic leachate can be collected if it occurs. The central channel must contain a prism of A layer material with a perforated pipe drain so as to act as an efficient leachate collector or finger drain. The minimum gradient must be 2% for **G** sites and 5% for **H** sites.

These "Layer" Descriptions

(From "2nd Edition "Appendix 8.2: Design of the Lining and Capping Systems")

Are Still Valid and Must be Consulted in Current Designs,

Some Important New Requirements

The following containment barrier requirements must be included in an application for approval of a landfill site or cell –

(a) Design reports and drawings shall be certified by a registered, professional civil engineer prior to submission to the competent authority;

(b) Service life considerations shall be quantified taking into account temperature effects on containment barriers;

(c) Total solute seepage (inorganic and organic) shall be calculated in determining acceptable leakage rates and action leakage rates;

(d) Alternative elements of proven equivalent performance may be considered, such as the replacement of-

(i) granular filters or drains with geosynthetic filters or drains;

(ii) protective soil layers with geotextiles;

(iii) clay components with geomembranes or geosynthetic clay liners;

Some Important New Requirements (Cont.)

The following containment barrier requirements must be included in an application for approval of a landfill site or cell –

(e) All drainage layers shall contain drainage pipes of adequate size, spacing and strength to ensure atmospheric pressure within the drainage application for the service life of the landfill;

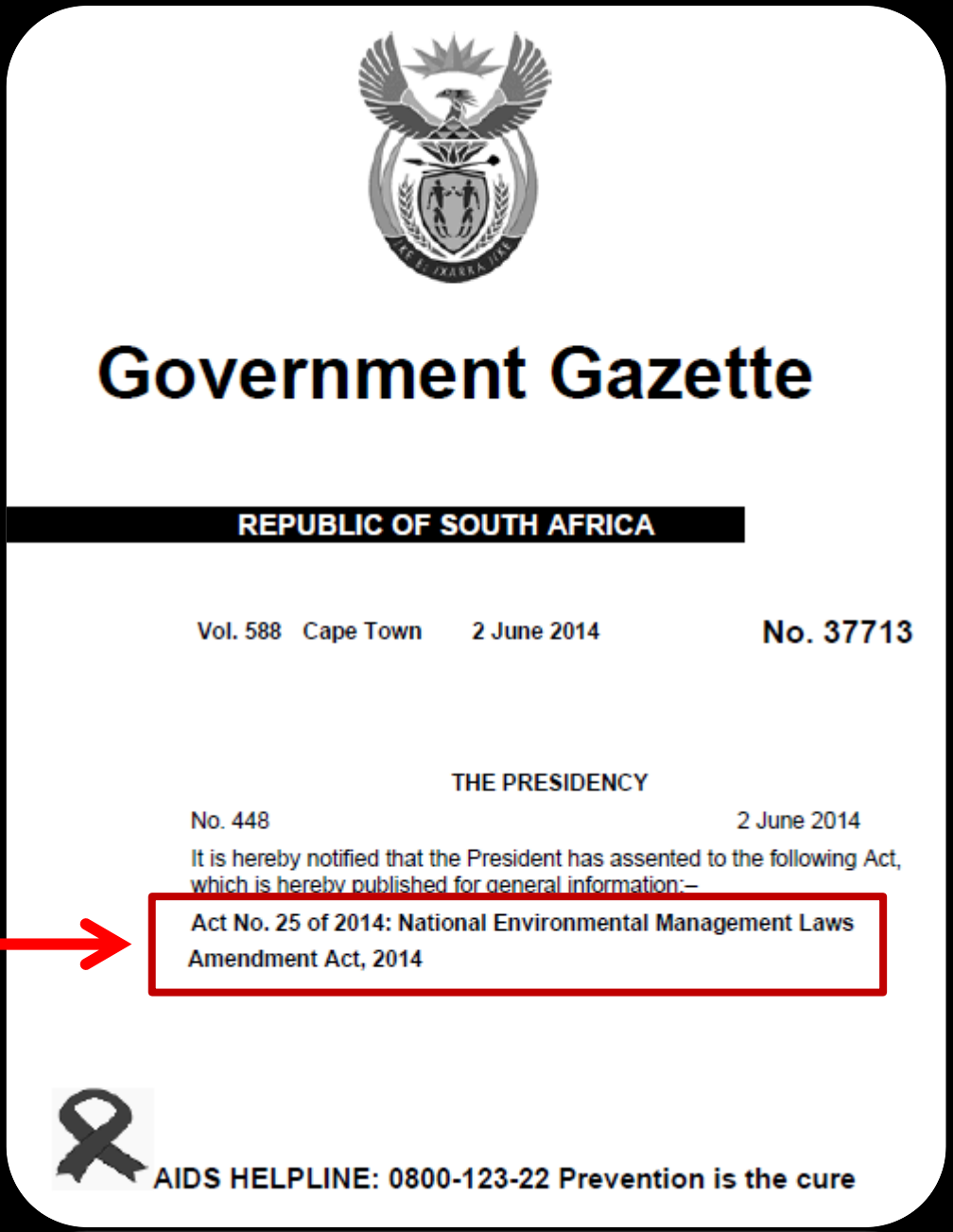
(f) Alternative design layouts for slopes exceeding 1:4 (vertical: horizontal) may be considered provided equivalent performance is demonstrated;

(g) Construction Quality Assurance during construction;

(h) Geosynthetic materials shall comply with relevant South African National Standard specifications, or any prescribed management practice or standards which ensure equivalent performance; and

(i) Consideration of the compatibility of liner material with the waste stream, in particular noting the compatibility of natural and modified clay soils exposed to waste containing salts.

Amendments On 2 June 2014



Government Gazette

REPUBLIC OF SOUTH AFRICA

Vol. 588 Cape Town 2 June 2014 No. 37713

THE PRESIDENCY

No. 448 2 June 2014

It is hereby notified that the President has assented to the following Act, which is hereby published for general information:–

Act No. 25 of 2014: National Environmental Management Laws Amendment Act, 2014

AIDS HELPLINE: 0800-123-22 Prevention is the cure

(English text signed by the President)
(Assented to 30 May 2014)

Mining Residues Now Included

ACT

To amend the—

- National Environmental Management Act, 1998, so as to amend certain definitions and to define certain words and expressions; to provide for the review of environmental management instruments; to provide for minimum information requirements to be included under environmental management instruments; to provide for the Minister responsible for mineral resources to be the competent authority for environmental matters in so far as they relate to prospecting, exploration, mining or production of mineral and petroleum resources; to empower the Minister to take an environmental decision in so far as it relates to prospecting, exploration, mining or production instead of the Minister responsible for mineral resources under certain circumstances; to clarify the provisions relating to integrated environmental authorisations; to strengthen the financial provisions in the Act; to provide for consultation with State Departments; to provide for the management of residue stockpiles and residue deposits; to empower the Director-General of the Department responsible for mineral resources to issue section 28 directives in so far as they relate to

Amendment of section 24 of Act 107 of 1998, as substituted by section 2 of Act 8 of 2004, section 2 of Act 62 of 2008 and section 5 of Act 30 of 2013

2. Section 24 of the National Environmental Management Act, 1998, is hereby amended—

(a) by the substitution in subsection (5)*(b)* for subparagraph (vi) of the following subparagraph:

"(vi) the management and control of residue stockpiles and deposits **[on a prospecting, mining, exploration or production area]**;"; and

(b) by the substitution in subsection (5) for paragraph *(b*A*)* of the following paragraph:

"*(b*A*)* laying down the procedure to be followed for the preparation, evaluation, **[and]** adoption and review of prescribed environmental management instruments, including—

(i) environmental management frameworks;
(ii) strategic environmental assessments;
(iii) environmental impact assessments;
(iv) environmental management programmes;
(v) environmental risk assessments;
(vi) environmental feasibility assessments;
(vii) norms or standards;
(viii) ~~spatial development tools, [or]~~
(viiiA) minimum information requirements; or
(ix) any other relevant environmental management instrument that may be developed in time;".

Phola Coal Processing Plant

Ogies, Mpumalanga

EnviroFix X 800 206 000 m²


Phola Coal Processing Plant
Ogies, Mpumalanga
EnviroFix X 800
206 000 m²

Legislation

Waste in South Africa is currently governed by means of a number of pieces of legislation, including:

- **The South African Constitution (Act 108 of 1996)**
- **Hazardous Substances Act (Act 5 of 1973)**
- **Health Act (Act 63 of 1977)**
- **Environment Conservation Act (Act 73 of 1989)**
- **Occupational Health and Safety Act (Act 85 of 1993)**
- **National Water Act (Act 36 of 1998)**
- **The National Environmental Management Act (Act 107 of 1998)**
- **Municipal Structures Act (Act 117 of 1998)**
- **Municipal Systems Act (Act 32 of 2000)**
- **Mineral and Petroleum Resources Development Act (Act 28 of 2002)**
- **Air Quality Act (Act 39 of 2004)**
- **National Environmental Management: Waste Act, 2008 (Act 59 of 2008)**
- **Waste Classification and Management Regulations, 2013**

The President of the Republic of South Africa signed The National Environmental Management: Waste Bill into an Act of Parliament in March 2009, The Act took effect from 01 July 2009. It is the intention of this Act to address the current fragmentation in waste legislation in South Africa.

Heavy Penalties for Non-Compliance

Offences and Penalties

13. (1) A person is guilty of an offence if that person—

(a) fails to comply with Regulations 4(2), (3), (4), (5), (6), 5, 6, 7(1), 8(1), 10(1), 10(3), 11(1), (2), (4), (5), (6), (7), (8) or 12; or

(b) provides incorrect or misleading information in any record or document required or submitted in terms of these Regulations.

(2) A person convicted of an offence under subregulation (1)(a) is liable to a fine not exceeding R10 million or to imprisonment for a period not exceeding 10 years, or to both such fine or such imprisonment.

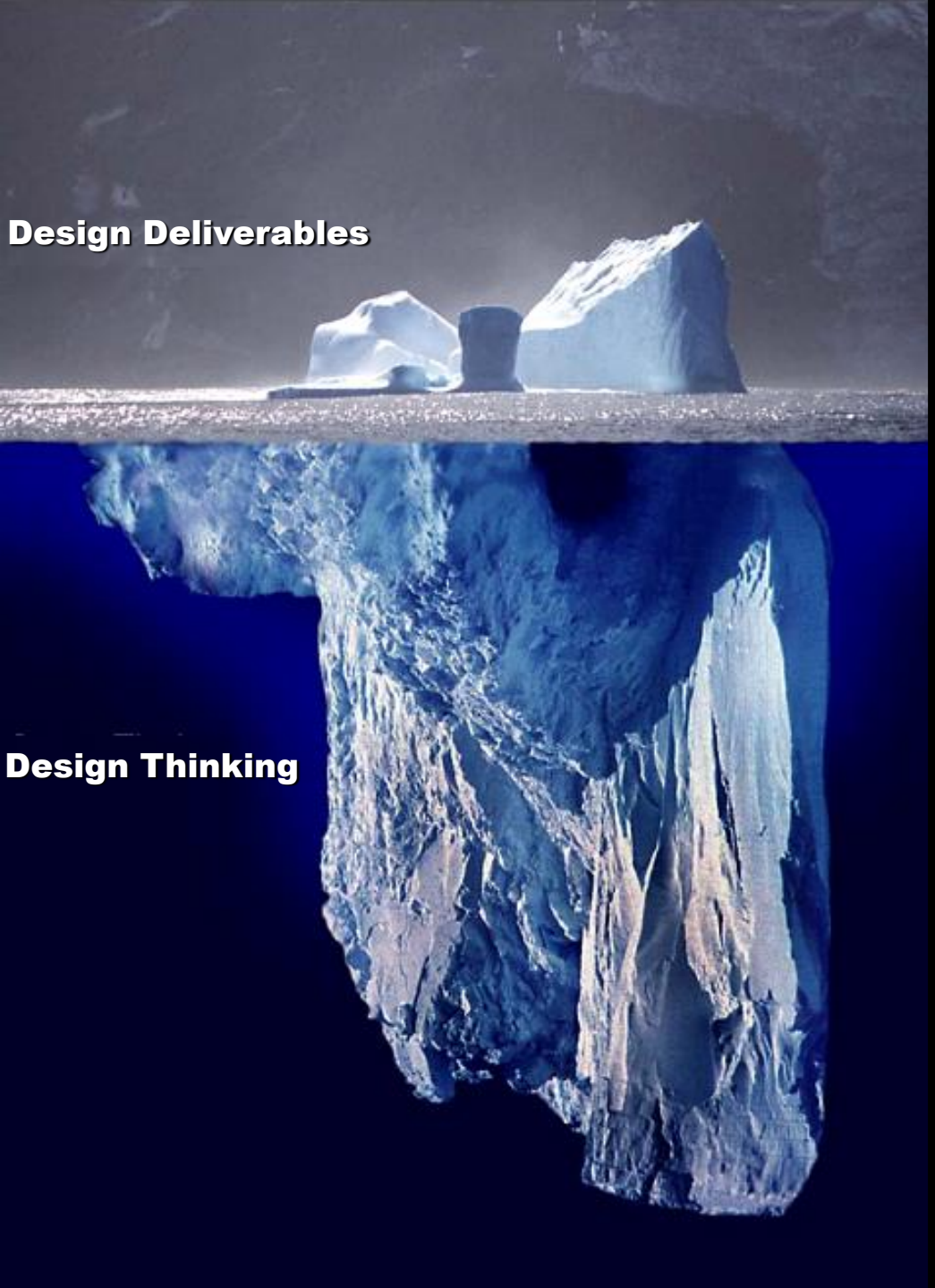
(3) A person convicted of an offence under subregulation (1)(b) is liable to a fine of R20 000 or to imprisonment for a period not exceeding 1 year or to both a fine and such imprisonment.

Short Title and Commencement

14. These Regulations are called the Waste Classification and Management Regulations, 2013.

If You Get it Wrong...

Jislaaik !!!



Careful Thought Required

Resources

All SA Government Waste Management Regulations Can Be Found Here:

http://sawic.environment.gov.za/?menu=13

Any enquiries may be directed to Dr. Shauna Costely, email scostely@environment.gov.za, Tel: 012 310 3330

or Mr. Rendani Ndou, email: RNdou@environment.gov.za

So…

Richard and Wihan Asked me if I Would Like to Contribute to Todays LIG Seminar

Time	Activity
14:30 – 15:00	Registration
15:00 – 15.45	Session 1 : Construction of Landfill Facilities – Peter Davies (Kaytech) • Mineral layer installation and QA • Geosynthetics installation and QA • Practical considerations in the construction of such Facilities

And, Wihan Gave Me Some Guidelines…

Thanks Peter

Some points of interest. As mentioned last week, you can use what you like, one can obviously go on and on and on! Let me know if there's anything else you need.

General:

Consideration should be given to climate / seasons. Construction preferably in the non-rain period of the year. Constructing landfill liners during the rainy season creates costly delays.

Best practice to construct lining systems from high point to low point to prevent flooding of the lining system at the low point and prevent run-off underneath the liner.

Clay layers:

Do sufficient tests prior to construction to establish at which moisture content and compaction the clay must be to obtain the required permeability. Knowing the correct moisture content and compaction makes quality control on site a lot easier.

Clay layers to be covered with HDPE (or overlying layer) as soon as possible to prevent desiccation cracking.

Prevent long slopes steeper than 1:3 due to compaction plant limitations on steeper slopes.

Sheepsfoot roller should be used for all layers except for the smoothening of the final clay layer.

The cleats on the sheepsfoot roller should be longer than the clay layer thickness to ensure proper mixing and kneading of the clay layers.

Uncompacted layer thicknesses should not be more than 250mm thick.

Final surface to be very smooth and free of any loose stones, sticks, ruts etc. It's a good idea to have a separate payment item just for the smoothening of the final clay layer with a strict specification of what is required. Smooth surface is required for intimate contact with the overlying geomembrane.

On site permeability tests to be done over at least 48 hours due to initial higher infiltration in the drier top area of the clay as well as the infiltration through loose disturbed material along the sides of the steel infiltrometer that has been knocked into the clay layer.

Cover the infiltromer carefully with plastic to prevent animals drinking from the water as well as prevent evaporation and water ingress through rain.

If on-site clay is not of good enough quality to meet the permeability and PI requirements it can be enhanced by mixing it with natural sodium bentonite powder, typically 2 – 6% by mass. Quality control to ensure even and consistent mixing is very important though.

In cases where no clay is available the clay could be replaced by a geosynthetic clay liner (GCL). Swelling tests with on-site leachate should be done prior to using a GCL to confirm compatibility and performance.

GCL's are easy to install and can save on airspace / excavation costs if the GCL is found to be suitable. For a Class A landfill the total clay layer thickness is 800mm while it can be replaced by two layers of GCL with a thickness of approximately 8mm each. Thus adding approximately 790mm of additional airspace or alternatively reducing the excavations with 790mm over the footprint.

CQA of the GCL installation is very important to ensure the required overlaps are being done correctly.

It is important that only as much GCL that can be covered per day should be installed. It is important to have the approximately 300mm confining layer on top of the GCL in place before the GCL hydrates.

Important to take extra care with the storage of GCL's, stacked above ground with free surface drainage around and underneath the rolls.

HDPE Geomembranes:

The 100mm sand protection layer on top of the HDPE specified in the new Regs are impractical to place and increases the risk of liner damage during placing. 200mm compacted clean sand proofs to be better.

Place sand protection layer early in the morning due to HDPE's high thermal expansion. When the sun comes out the HDPE forms waves and wrinkles which makes placing of the sand difficult. This must be specified as such in the tender specifications to be enforceable on site without running the risk of additional costs as a result.

Wrinkles must be avoided at all times since it increases the flow rate in case of a leak.

White geomembranes can be considered in hotter climates due to their reduced surface temperature compared to black HDPE.

Sand protection layer to be end-tipped and only traffic allowed on the sand itself and not on liner at all.

No liner installation can be done in rainy conditions or in high wind. Sufficient sand bags to be available prior to liner deployment.

Permanent CQA a must during HDPE installations. All destructive and non-destructive tests to be done or at least witnessed by the CQA consultant.

The CQA consultant must understand the HDPE specifications and must be experienced in the field to understand which tests are required and how it is performed and be aware of the frequencies.

Testing of each day's trial welds is important before any welding takes place. Trial welds should be done 1st thing in the morning and again after lunch time or if there was any interruption in power supply to the welding machines.

Be practical with regards to where destructive production welds are taken. Take sample in the anchor trenches or where patches are required in any case if possible. Try to avoid to cut a production weld sample from a perfect weld in the middle of the landfill. It does not make sense to replace a perfect wedge weld with a patch that is extrusion welded.

During wedge welds make sure that the entire length of weld is tested. This is done by opening the "air tube" on the far end of the weld and see if the needle on the pressure gauge drops. If not the weld is blocked somewhere in-between. The CQA consultant must know how to address this.

Copper wire to be installed in all extrusion welds for spark testing.

All seam areas to be clean and dry to ensure proper contact.

All HDPE sheets should constantly be visually examined for any holes or defects and repaired if found. All patches to have round edges.

No horizontal welds / joints should be allowed on the 1:3 slopes. The joint / weld should be on the floor approximately 1m from the toe of the 1:3 slope.

Extra care should be taken at liner penetrations (if any). This is the most likely area for a leak and would also almost always be under a constant hydraulic head. The design detail of the liner penetration must make provision for proper seal of the pipe to the liner without any permanent stresses on any of the welds around the penetration.

Leachate drainage layer:

Preferably stone with an even grading, typically 38mm or 53mm. Avoid gap-graded stone and finer material due to easy clogging.

Stone to be end-tipped until the area is big enough to drive on. No vehicle traffic directly on liner.

Stone to be inspected specifically for fines; fines to be avoided in the stone layer due to the clogging issue.

Tyre shreds can be considered as a drainage material but the layer's thickness will have to be increased due to the tyre shreds' high compressibility. Stone should still be used in critical areas like around the leachate drainage pipes and at the leachate extraction point / area.

A filter geotextile on top of stone leachate drainage layer is good practice. This reduces the clogging of the critical leachate drainage layer (stone), the geotextile would also clog over time but this is not too critical as leachate would always find a path through the geotextile eventually, but at least the stone layer will be free draining and as a result reduces the hydraulic head on the liner.

Geonets can be considered in the place of the stone leachate drainage layer, but care should be taken in terms of stability due to the weak friction interface between the geonet and the underlying geomembrane. It is also not recommended to be used as the primary leachate drainage medium due to its higher likelihood of clogging compared to a stone layer for instance.

Geocomposite sheets (cuspated) can also be considered but the possible buckling / deformation of the cusps under higher loads can significantly reduce flow capacities.

Clay / waste / bentonite penetration into geosynthetic drainage mediums also significantly reduces their flow capacities.

Leachate drainage pipes:

Pipes to have sufficient ring stiffness to be able to withstand the future overlying waste body. When comparing different types of pipes for leachate drainage it is important to test for deflection without the surrounding stone layer since it would be very difficult to place / pack the stone on site the same as in the lab and one might not get the same load distribution on site than tested in the lab.

Leachate drainage pipes should not be wrapped with geotextile to prevent clogging of the critical drainage medium.

Circular perforations proofed less prone to clogging than narrow slots. Typically 10 – 15mm dia.

Geotextiles:

Non-woven geotextiles are normally used in landfill construction.

Overlaps should be heat tacked or sewn together.

Overlaps are typically 100mm and overlaps / joints should preferably not be allowed on side slopes (horizontal joints), unless designed for the purpose.

A thicker grade of geotextile can be used as HDPE protection instead of sand. A minimum grade of 1000g/m2 can be used, but preferably at least 1500g/m2.

Geotextiles should be covered as soon as possible due to UV degredation.

Regards

Wihan Visser Pr. Tech. Eng.

So,

I Thought...

Nee Wat – Life is Too Short !


go on
without me

But I Had a Plan, and Here I Am...

Session 1
Construction of Landfill Facilities

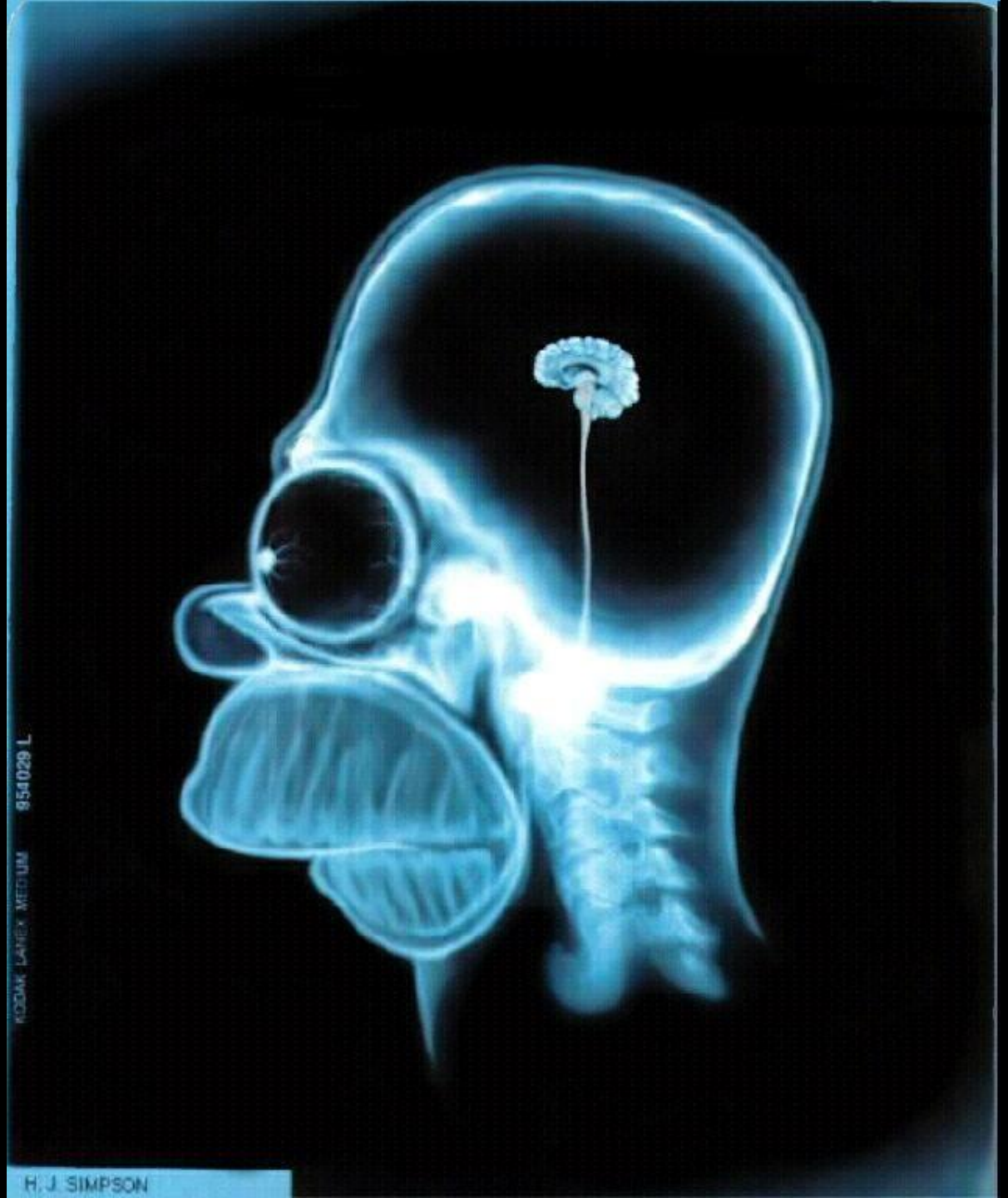
- Mineral layer installation and QA
- Geosynthetics installation and QA
- Practical considerations

CQA

1st Principle:

Eyes in the Right Place At All Times!

Because the Cheapest Contractor...



Might Not Believe in This:

"Integrity is always doing the right thing – even if no one is watching"

C.S. Lewis

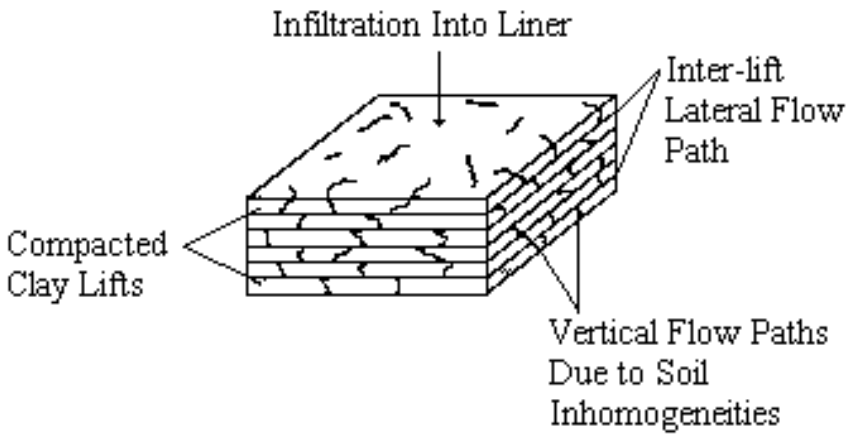
So Your Contract Documentation Must be Watertight

Typical Landfill Lining Materials

Compacted Clay Liner (CCL)

Desiccation Cracking

A Major Concern With Compacted Clay Liners . . .



Environment Agency

enhancing... improving... cleaning... restoring..
changing... tackling... protecting... reducing...
create a better place... influencing... inspiring...
advising... managing... adapting...

LFE4 - Earthworks in landfill engineering

Design, construction and quality assurance of earthworks in landfill engineering

(To Be Issued In Electronic Form to All Registered Delegates to this Seminar)

CONTENTS

Bentonite-Modified Insitu Soils

Bentonite-Modified Insitu Soils-Rotavator

Bentonite-Modified Insitu Soils (Pugmill)

Bentonite-Modified Insitu Soils (Paver)

Environment Agency

enhancing... improving... cleaning... restoring...
changing... tackling... protecting... reducing...
create a better place... influencing... inspiring...
advising... managing... adapting...

LFE10 - Using bentonite enriched soils in landfill engineering

But, If You Are Going to Do IT, Here is an Excellent Guideline

(To Be Issued In Electronic Form to All Registered Delegates to this Seminar)

Contents


Geomembrane Liner (GM)

Geomembrane Production:

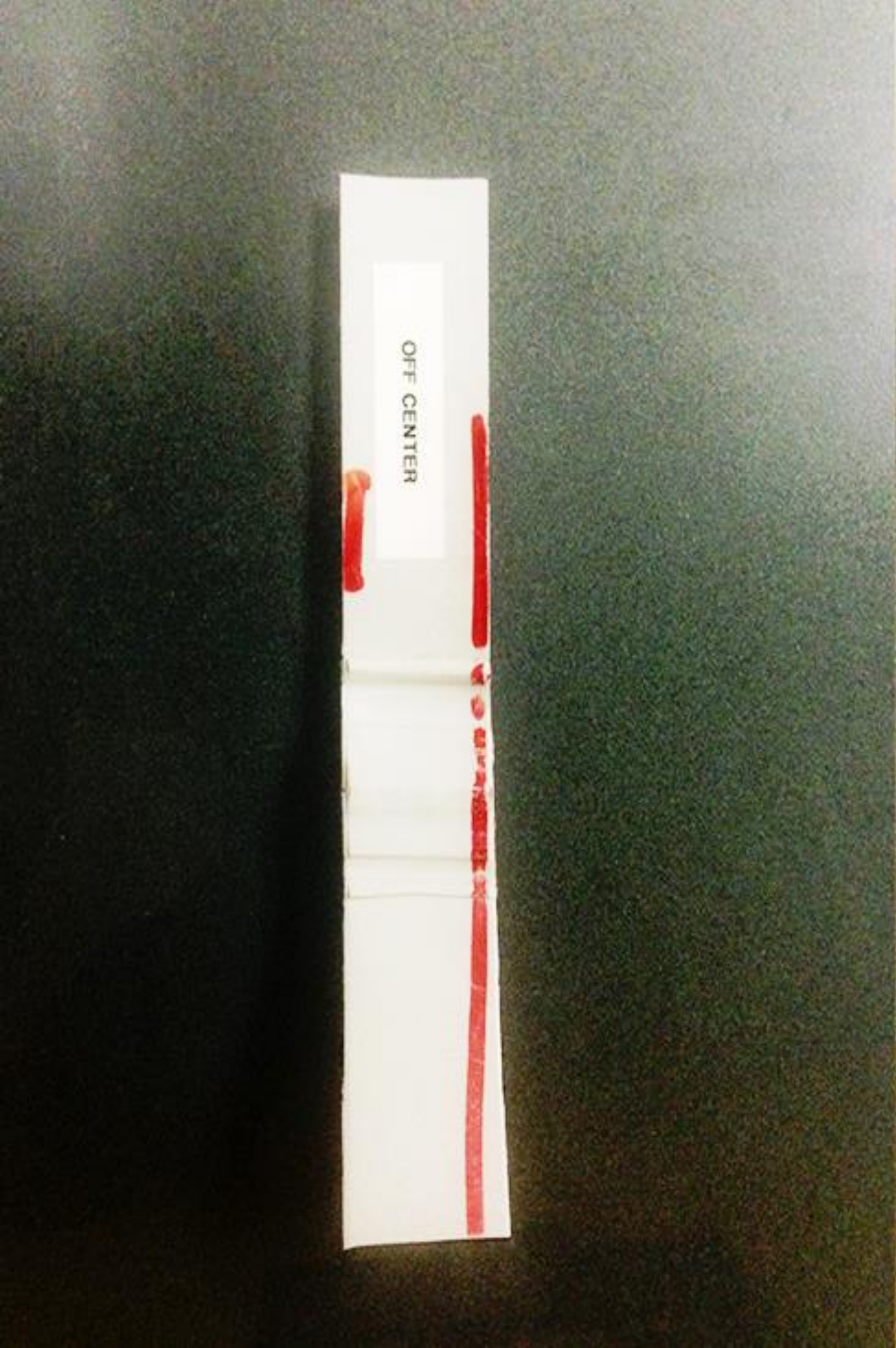
Tight Facory Q.C

Geomembrane Installation:

Complex Welding & Testing Equipment


STOP
Do not pull on the slide once the sample is fastened!
WARTUNG
MAINTENANCE


DEMTECH


OFF CENTER


Environment Agency

enhancing... improving... cleaning... restoring..
changing... tackling... protecting... reducing...
create a better place... influencing... inspiring..
advising... managing... adapting...

LFE5 - Using geomembranes in landfill engineering

(To Be Issued In Electronic Form to All Registered Delegates to this Seminar)

Appendix B – manufacturing quality control for geomembranes

These tables are reproduced from GRI standards GM13 and GM17. These standards are included for information and guidance.

High density polyethylene (HDPE) geomembrane – smooth

Properties	Test method	Test value							Testing frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness – mils (min, avg.) • Lowest individual of 10 values	D5199	Nom. (mil) - 10%	Nom. (mil) - 10%	Nom. (mil) - 10%	Nom. (mil) - 10%	Nom. (mil) - 10%	Nom. (mil) - 10%	Nom. (mil) - 10%	Per roll
Density (min.)	D1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	90,000 kg
Tensile properties (1) (min, avg) • Yield strength • Break strength • Yield elongation • break elongation	D 6693 Type IV	 11 kN/m 20 kN/m 12% 700%	 15 kN/m 27 kN/m 12% 700%	 18 kN/m 33 kN/m 12% 700%	 22 kN/m 40 kN/m 12% 700%	 29 kN/m 53 kN/m 12% 700%	 37 kN/m 67 kN/m 12% 700%	 44 kN/m 80 kN/m 12% 700%	9,000 kg
Tear Resistance (min.ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min.ave.)	D 4833	240 N	320 N	400 N	480 N	640 N	800 N	960 N	20,000 kg
Stress Crack Resistance (2)	D 5397 (App.)	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	Per GRI GM -10
Carbon Black Content - %	D 1603 (3)	2.0 – 3.0%	2.0 – 3.0%	2.0 – 3.0%	2.0 – 3.0%	2.0 – 3.0%	2.0 – 3.0%	2.0 – 3.0%	9,000 kg
Carbon Black Dispersion	D5596	Note (4)	Note (4)	Note (4)	Note (4)	Note (4)	Note (4)	Note (4)	20, 000 kg
Oxidative Induction Time (OIT) (min, avg.) (5) (a) Standard OIT - or – (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	90,000 kg
Oven Aging at 85°C (5), (6) (a) Standard OIT (min, avg.) - % retained after 90 days - or – (b) High pressure OIT (min, avg.) - % retained after 90 days	D 5721 D 3895 D 5885	 55 % 80 %	 55 % 80 %	 5 % 80 %	 55 % 80 %	 55 % 80 %	 55 % 80 %	 55 % 80 %	Per each formulation
UV Resistance (7) (a) Standard OIT (min, avg.) - or – (b) High pressure OIT (min, avg.) - % retained after 1600hrs (9)	 D 3895 D 5885	 N. R. (8) 50 %	 N. R. (8) 50 %	 N. R. (8) 50 %	 N. R. (8) 50 %	 N. R. (8) 50 %	 N. R. (8) 50 %	 N. R. (8) 50 %	Per each formulation

(1) Machine Direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50mm
(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
(3) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.
(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in category 1 or 2 and in Category 3
(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(6) It is also recommended to the evaluate samples at 30 and 60 days to compare with the 90 day response
(7) The condition of the test should be 20hr. UV cycle at 75°C followed by 4hr. Condensation at 60°C.
(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidant sin the exposed samples.
(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

High density polyethylene (HDPE) geomembrane – textured

Properties	Test method	Test value							Testing frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness – mils (min.ave.) • Lowest individual for 8 out of 10 values • Lowest individual for any of the 10 values	D 5994	nom. (-5%) - 10% - 15%	nom. (-5%) - 10% - 15%	nom. (-5%) - 10% - 15%	nom. (-5%) - 10% - 15%	nom. (-5%) - 10% - 15%	nom. (-5%) - 10% - 15%	nom. (-5%) - 10% - 15%	Per roll
Asperity Height mils (min, avg.) (1)	GM 12	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	0.25 mm	90,000 kg
Density (min.ave.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	Every 2nd roll (2)
Tensile Properties (min, avg.) (3) • Yield strength • Break strength • Yield elongation • Break elongation	D 6693 Type IV	 11 kN/m 8 kN/m 12% 100%	 15 kN/m 10 kN/m 12% 100%	 18 kN/m 13 kN/m 12% 100%	 22 kN/m 16 kN/m 12% 100%	 29 kN/m 21 kN/m 12% 100%	 37kN/m 26 kN/m 12% 100%	 44 kN/m 32 kN/m 12% 100%	9,000 kg
Tear Resistance (min.ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min.ave.)	D 4833	200 N	267 N	333 N	400 N	534 N	667 N	800 N	20,000 kg
Stress Crack Resistance (4)	D 5397 (App.)	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	300 hr.	Per GRI GM 10
Carbon Black Content (range)	D 1603 (5)	2.0 – 3.0%	2.0 – 3.0%	2.0 – 3.0%	2.0 – 3.0%	2.0 – 3.0%	2.0 – 3.0%	2.0 – 3.0%	9,000 kg
Carbon Black Dispersion	D5596	Note (6)	Note (4)	Note (4)	Note (4)	Note (4)	Note (4)	Note (4)	20, 000 kg
Oxidative Induction Time (OIT) (min, avg.) (7) (a) Standard OIT - or – (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	90,000 kg
Oven Aging at 85°C (7), (8) (a) Standard OIT (min, avg) - % retained after 90 days - or – (b) High Pressure OIT (min, avg) - % retained after 90 days	D 5721 D 3895 D 5885	 55 % 80 %	 55 % 80 %	 5 % 80 %	 55 % 80 %	 55 % 80 %	 55 % 80 %	 55 % 80 %	Per each formulation
UV Resistance (9) (a) Standard OIT (min, avg) - or – (b) High pressure OIT (min, avg) - % retained after 1600hrs (11)	GM11 D 3895 D 5885	 N. R. (10) 50 %	 N. R. (8) 50 %	 N. R. (8) 50 %	 N. R. (8) 50 %	 N. R. (8) 50 %	 N. R. (8) 50 %	 N. R. (8) 50 %	Per each formulation

(1) Of 10 readings; 8 out of 10 must be ≥ 0.18 mm, and lowest individual reading must be ≥ 0.13mm

(2) Alternate the measurement side for double sided textured sheet

(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 33mm
Break elongation is calculated using a gage length of 50mm

(4) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets the same formulation as being used for the textured sheet materials. The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value Via MQC testing.

(5) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established)

(6) Carbon black dispersion (only near spherical agglomerates) 10 different views:
9 in categories 1 or 2 and 1 in category 3

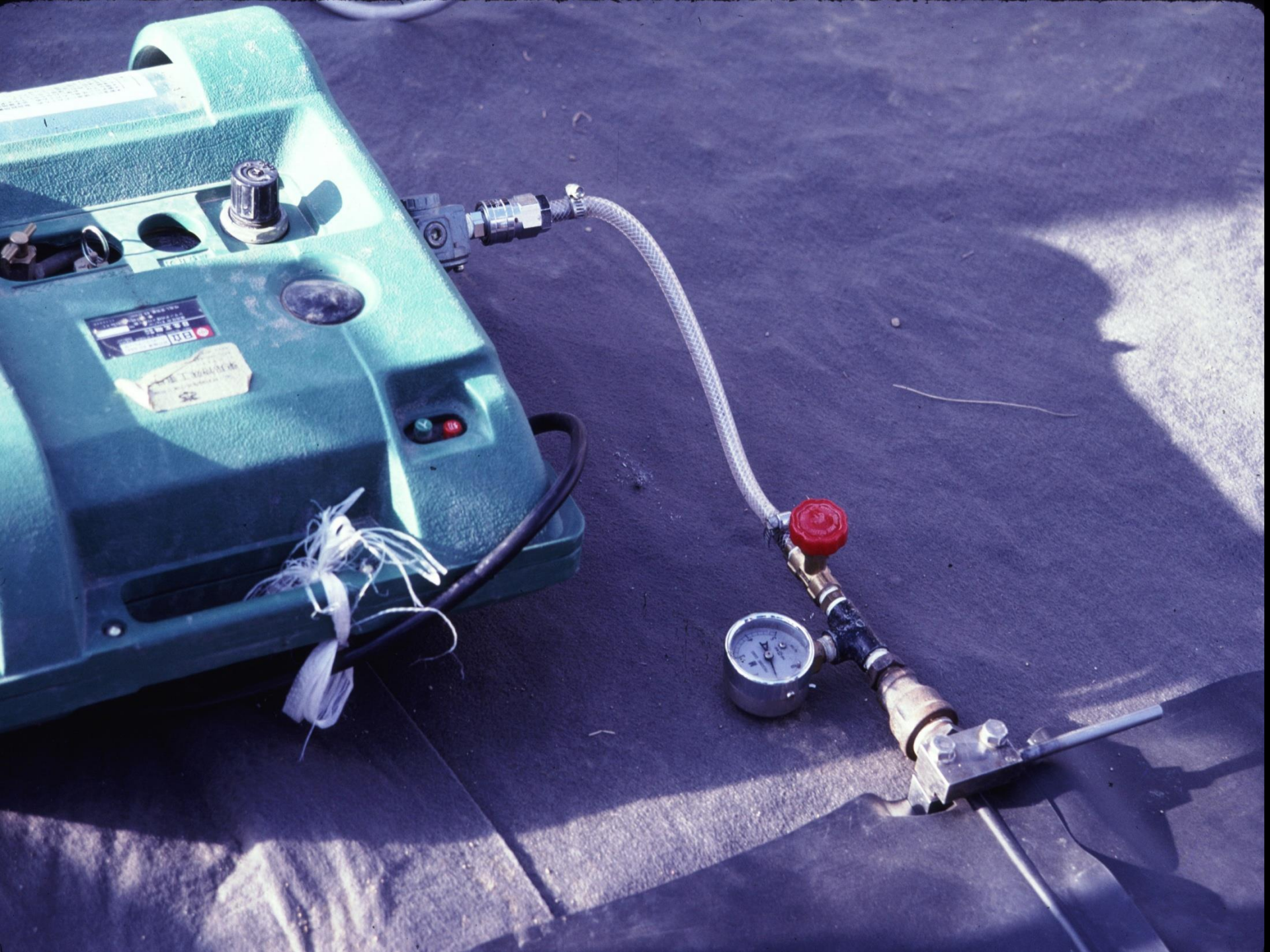
(7) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(8) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(9) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C

(10) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(11) UV resistance is based on percent retained value regardless of the original HP-OIT value



Environment Agency

enhancing... improving... cleaning... restoring...
changing... tackling... protecting... reducing...
create a better place... influencing... inspiring...
advising... managing... adapting...

Using Geosynthetic Clay Liners in Landfill Engineering (version 3)

(To Be Issued In Electronic Form to All Registered Delegates to this Seminar)

Contents


Geosynthetic Clay Liner (GCL)

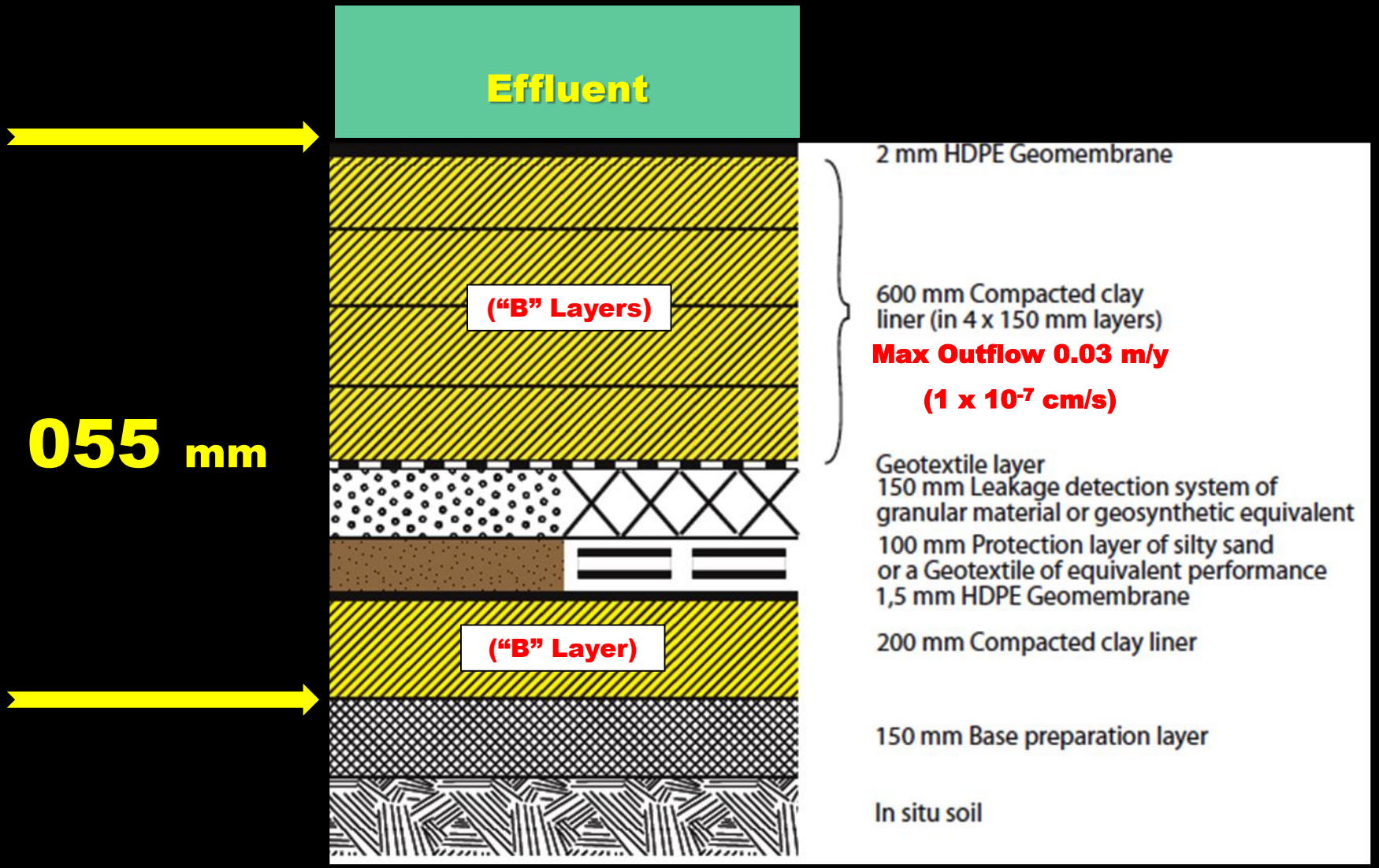

GCL Production:
Tight Facory Q.C
2011/09/27 14:02

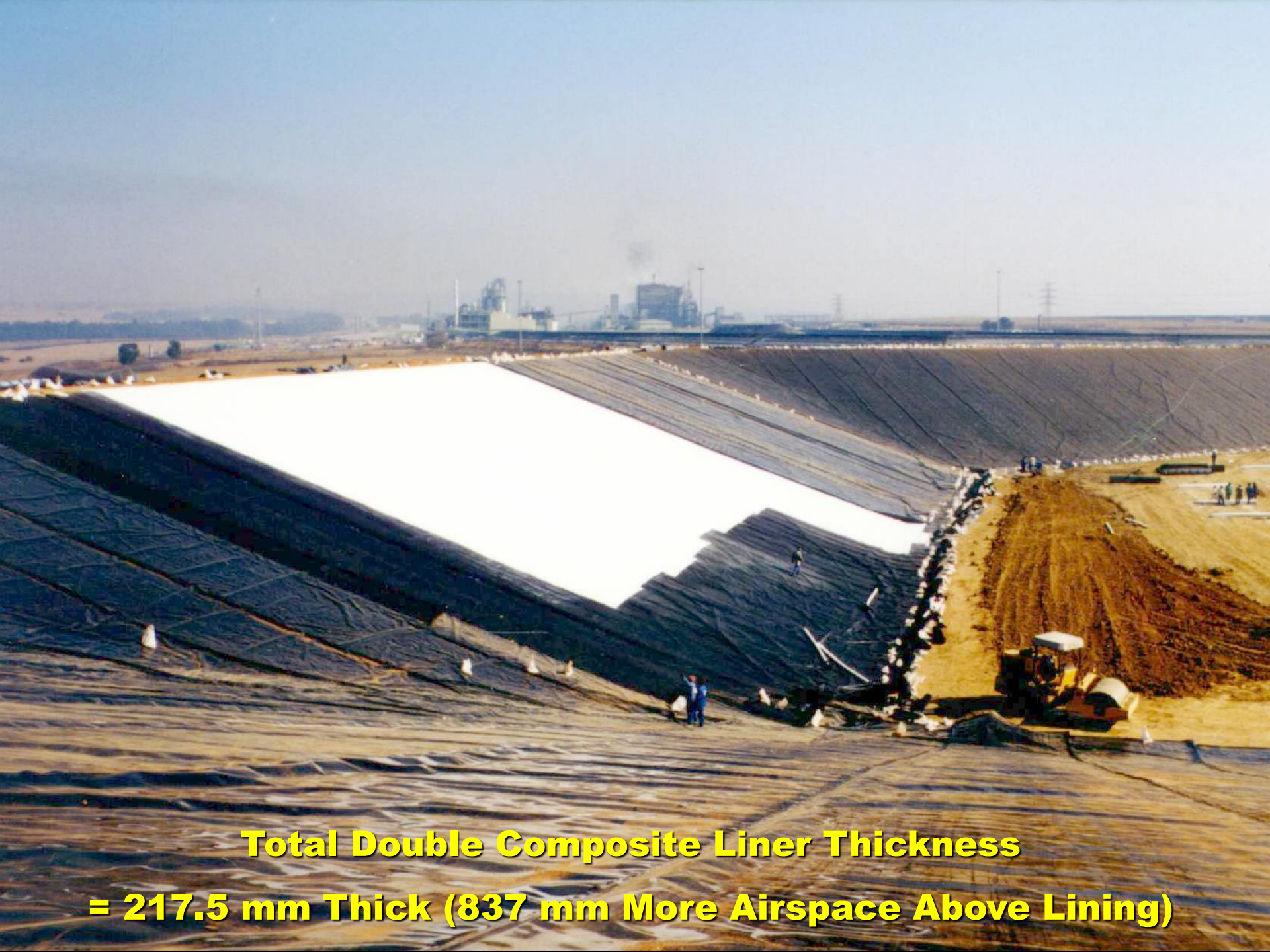
1st GCL Laid in South Africa by an Earthworks Contractor (1999)


Combinations of All Three: GMB, GCL, CCL

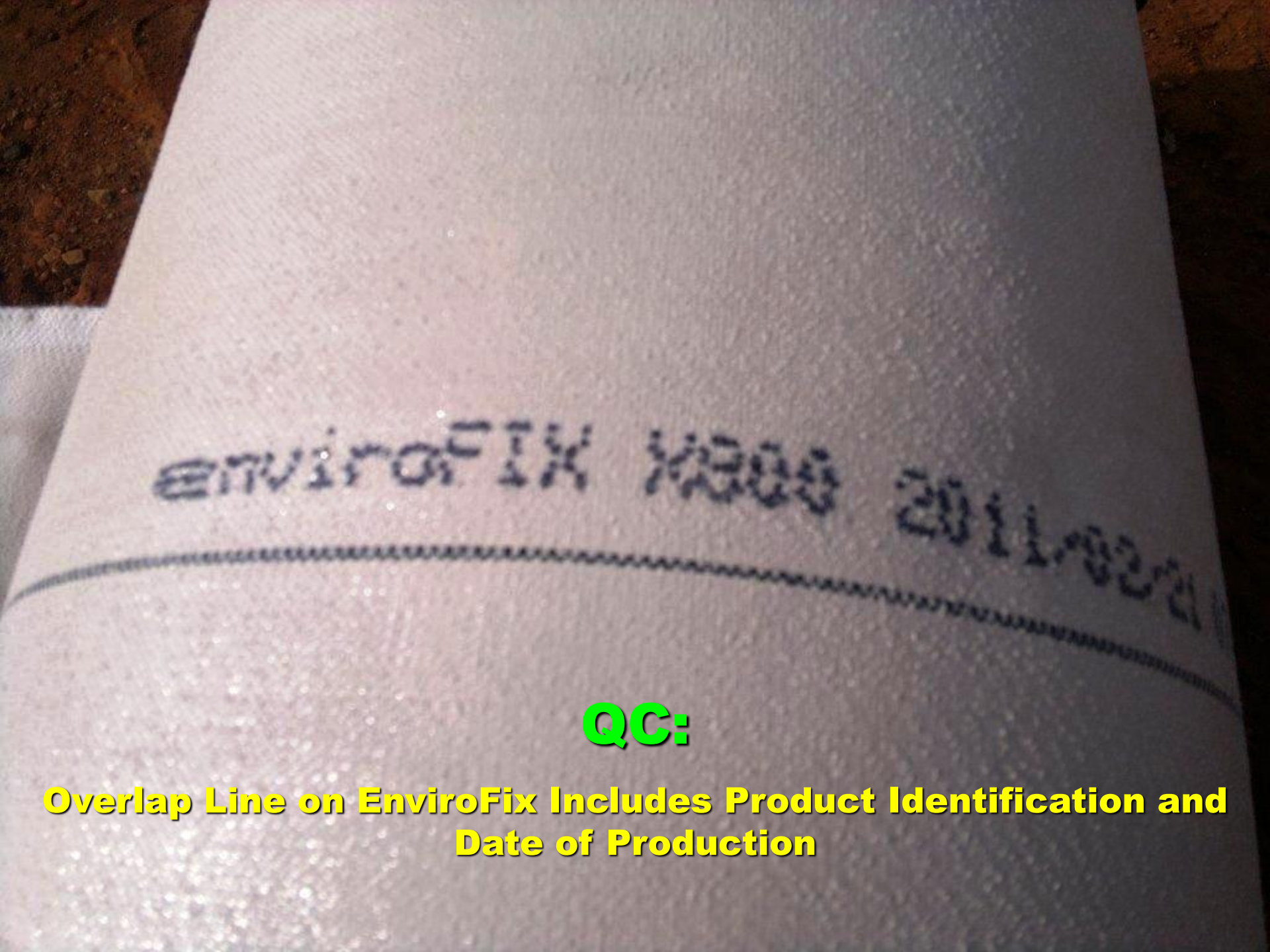

190 000 m² x EnviroFix X800 & 1.5 mm HDPE (2013)
Brine Water Dam at New Denmark Colliery
(Golder-Liviero-Engineered Linings)

Classification “A” (Formerly H:H / H:h) Leachate Lagoon




Total Double Composite Liner Thickness
= 217.5 mm Thick (837 mm More Airspace Above Lining)


1 x Roll *EnviroFix* Grade X800 = 214 m²
This 7t Truck is Carrying 1 070 m²
BENEFIT: Equal to 642 m³ of Dense (10⁻⁹ m/s) Clay Liner
x 600 mm Thick (or 90 x 7 m³ Truckloads)
Enviromat
geosynthetic clay liner



QC:

Overlap Line on EnviroFix Includes Product Identification and Date of Production

300 mm Overlap is Pressed Down Onto Paste


KAYTECH
ENGINEERED FABRICS

enviroFIX®

Geosynthetic Clay Liner

Contents

All Operations Specified in the installation Instructions

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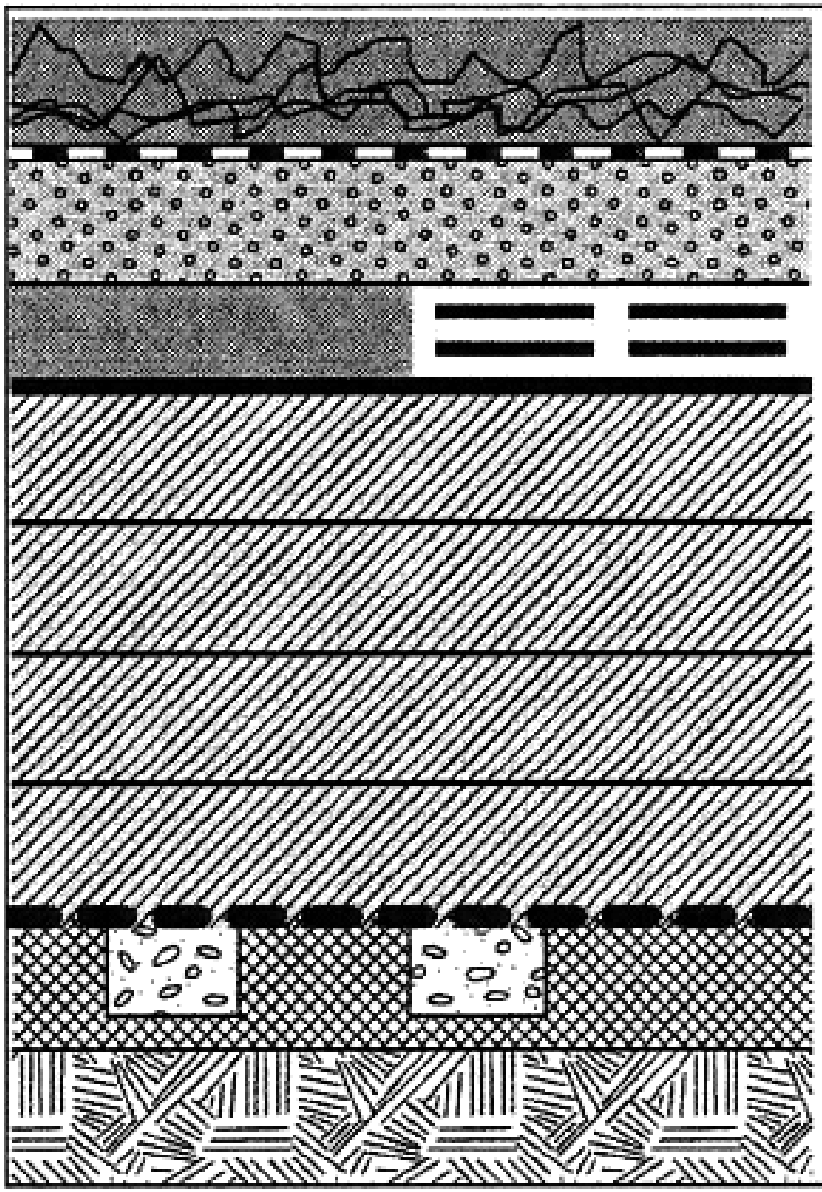
(b) Class B Landfill:



Waste body

Geotextile
150 mm Stone leachate collection system

100 mm Protection layer of silty sand or a Geotextile of equivalent performance

1,5 mm HDPE Geomembrane

Primary Composite Liner

600 mm Compacted clay liner (in 4 x 150 mm layers)

Max Outflow 0.3 m/y

(1 x 10^{-6} cm/s)

Under drainage and monitoring system and 150 mm Base preparation layer

In situ soil

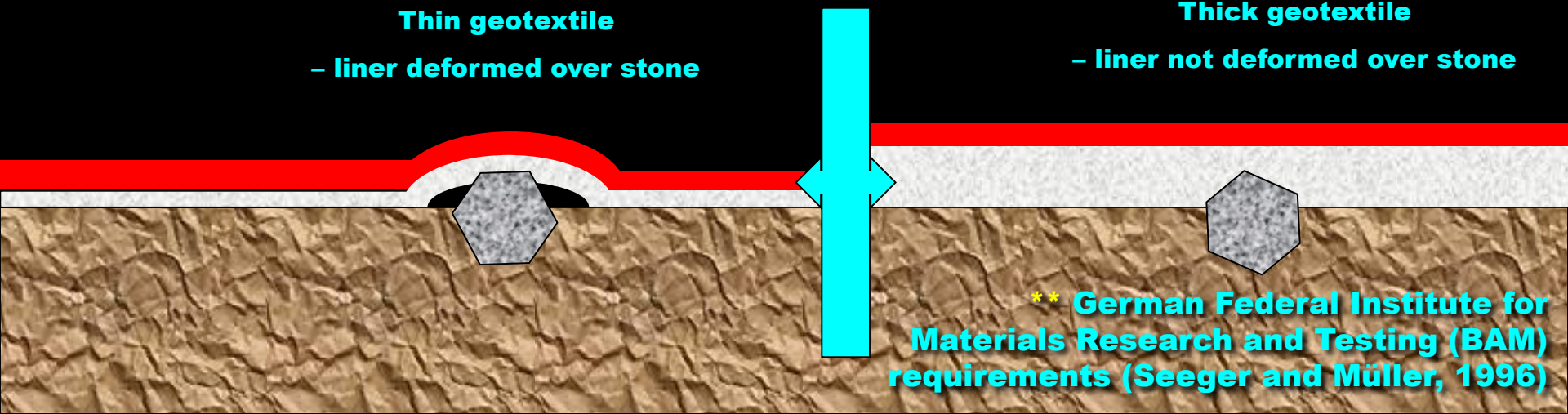

Select Waste
Bidim A5 (min) Separating Geotextile
150 mm Thick (38 mm dia) Stone
Leachate Collection Drain
Bidim A10 Liner Protection Geotextile
EnviroFix X800 Geosynthetic Clay liner
150 mm Thick Fine / Lightly Compacted Damp Sand
ZipCore Pro N Cuspated Sheet filled with Fine Damp Sand
Bidim A2 Geotextile
MegaFlo Trench Filled
With Clean Washed Sand
'Base Preparation Layer'

Lining Protection Issues

1). Protection Geotextile Must be Robust Enough to Prevent Puncturing of Geomembrane by Sharp Soil Particles

2). In Particular HDPE Liners Must Be Deformed Over Substrate Particles as Little as Possible – or Environmental Stress Cracking (ESC) May be Induced.

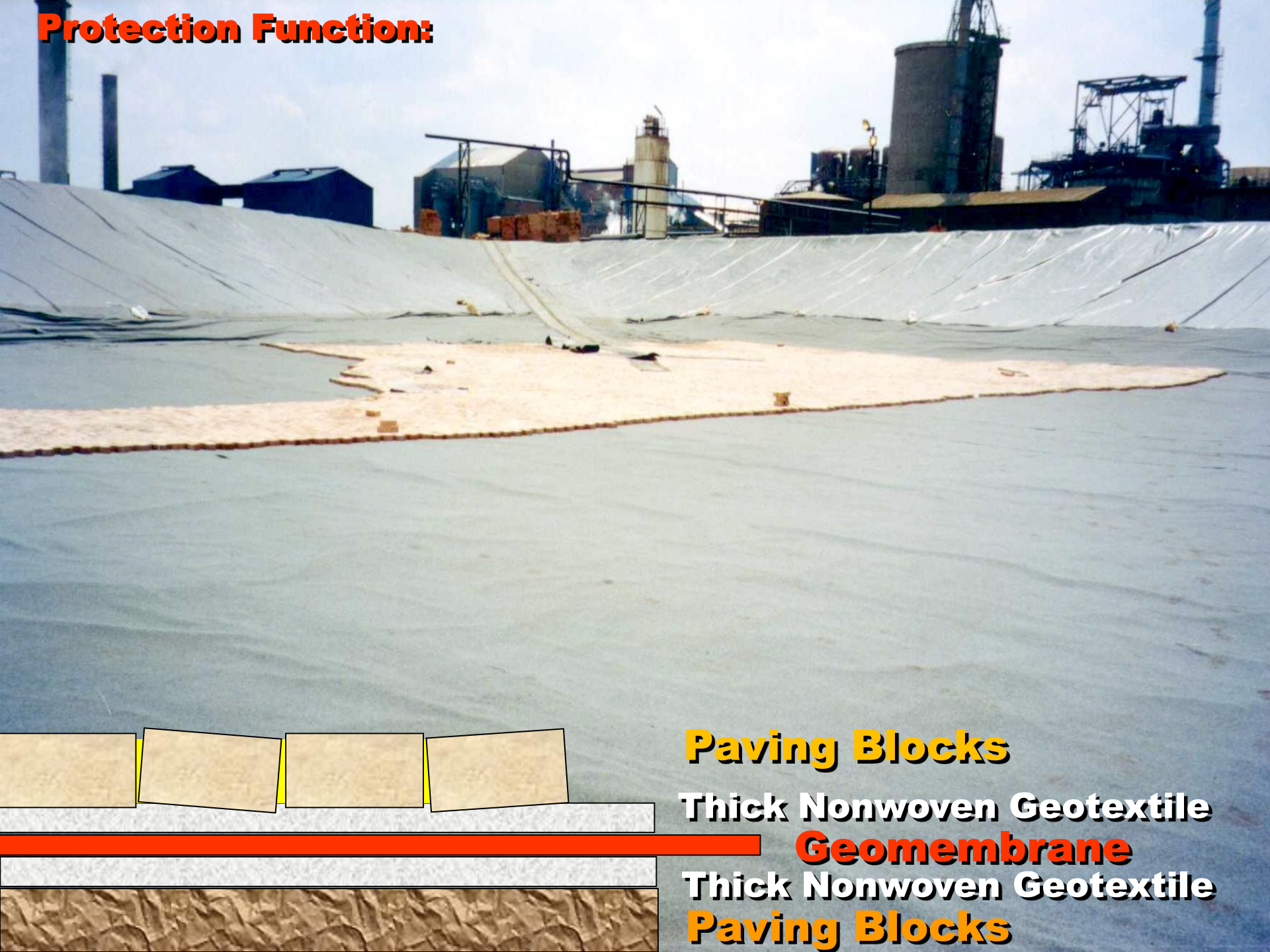
3). HDPE Should Not Deform More Than 0.25%** Out of Plane Over Protrusion to Avoid ESC. Thick geotextiles help achieve this



** German Federal Institute for Materials Research and Testing (BAM) requirements (Seeger and Müller, 1996)


Kupferberg Landfill Windhoek
Liner Protection: Multicell™
Filled With Cement-Stabilised Sand
Picture Courtesy of Engineered Linings / Jan Palm Consulting

Protection Function:



Paving Blocks

Thick Nonwoven Geotextile

Geomembrane

Thick Nonwoven Geotextile

Paving Blocks

Protection Function : Namaqualand Oxidation Dam

Thick Nonwoven PET Layer Over Coarse Soil Before HDPE Liner is Placed

Picture Courtesy of Engineered Linings

Protection Function : Sasol Secunda

262 000 m² x 750 g/m² Nonwoven PET Geotextile
(bidim A8) Under 1.5 mm HDPE Liner

Picture Courtesy of Golder Associates / WBHO / Aquatan

Environment Agency

LFE7 - Using nonwoven protector geotextiles in landfill engineering

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enhancing... improving... cleaning... restoring...
changing... tackling... protecting... reducing...
create a better place... influencing... inspiring...
advising... managing... adapting...

LFE 2 - Cylinder testing geomembranes and their protective materials

A methodology for testing protector geotextiles for their performance in specific site conditions

Contents

We derived this methodology from a technique originally developed at the University of Hannover. Our pass/fail criteria is less than or equal to 0.25 % strain based upon the maximum average local strain.

All of the UK Landfill Guidance Documents Can Be Found Here:

https://www.gov.uk/government/collections/environmental-permitting-landfill-sector-technical-guidance#landfill-engineering

Benefits of Using Geosynthetics

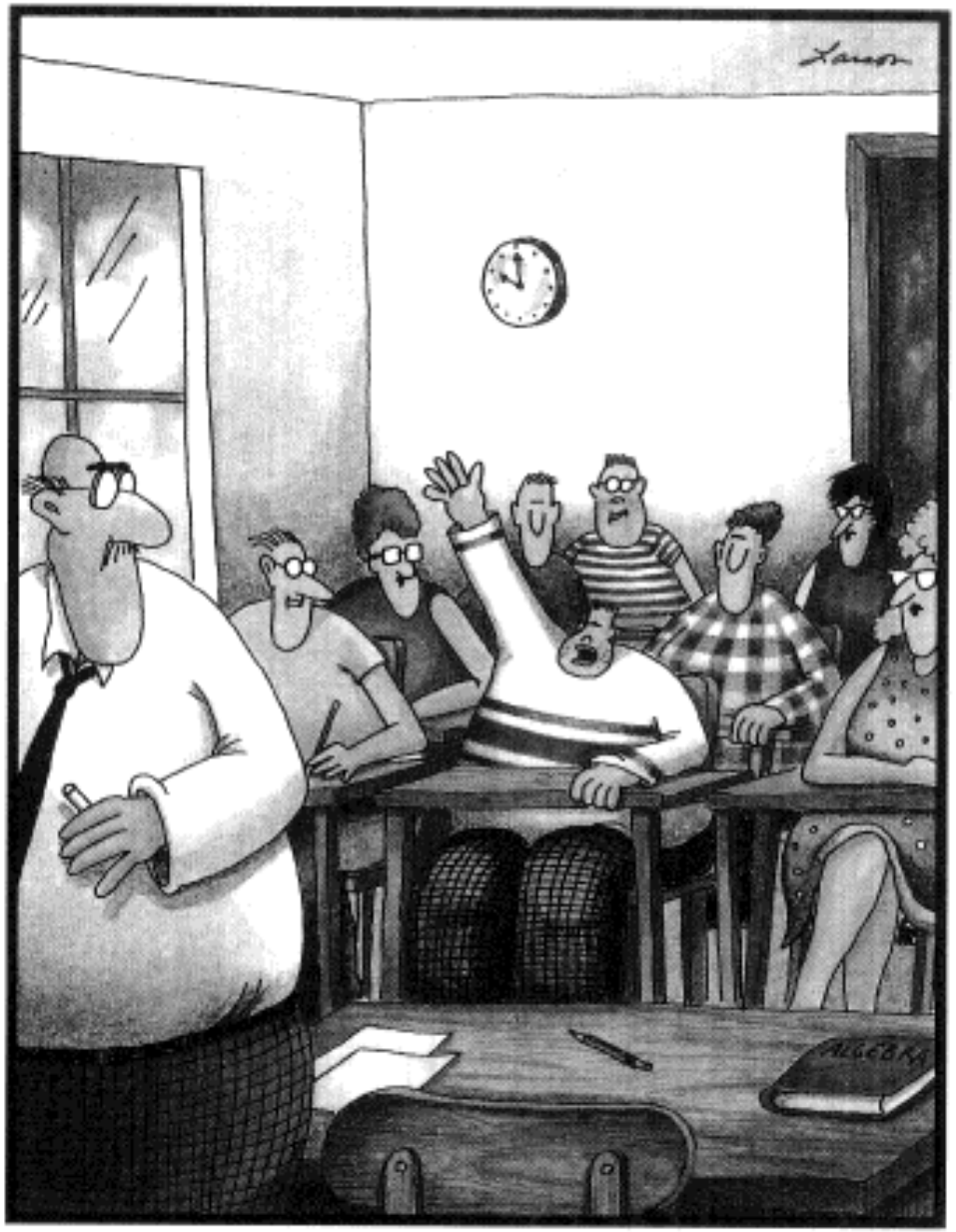
- Savings in Materials
- Labour-Saving *or Intensive*
- Savings In Plant
- Simpler Construction
- Savings In Maintenance
- Environmental Savings

So, Why Not Use Them?!

Thanks for Your Attention!

OVERLOAD?

That's All, Folks!



"Mr. Davies, may I be excused?

My brain is full."