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GEOSYNTHETIC RESEARCH INNOVATION & DEVELOPMENT LABORATORY

TECHNICAL REPORT

GCL Chemical Compatibility (Landfill 'X' Leachate)

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Report Revision: 01
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Geofabrics Centre for GEOSYNTHETIC RESEARCH, INNOVATION & DEVELOPMENT

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Geofabrics Centre for GEOSYNTHETIC RESEARCH, INNOVATION & DEVELOPMENT

CONTENTS

1. SUMMARY

With the increasing acceptance of Geosynthetic Clay Liners (GCL) as hydraulic barriers over traditional Compacted Clay Liners (CCL), it is critical to understand the hydraulic performance of the Bentonite layer when subjected to site-specific liquors. This report presents analysis performed on Landfill Leachate 'X' to determine the hydraulic performance of the GCL in direct contact with the leachate to establish a conservative estimate of leakage rates.

The permeability test was conducted in accordance with ASTM D6766-12 – *Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Liquids.*

A summary of results is presented below.

Table 1: Summary of results

Property	Test Standard	Units	RESULT
Hydraulic Conductivity of X2000	ASTM D6766-12	m/s	**2.03E-11**

2. HYDRAULIC PROPERTIES OF GCLs

2.1. TEST METHOD

ASTM D6766-12 *Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Liquids*

2.2. DESCRIPTION

The test method applies to one-dimensional, laminar flow of water and/or other aqueous solution, such as chemical solutions, landfill leachate or contaminated water (referred to as 'the test liquid'), through a saturated/hydrated 100-mm diameter GCL specimen that is consolidated and permeated under certain conditions. These conditions include one of two scenarios; the GCL specimen is either hydrated first with DI water and then permeated using the test liquid (Scenario 1), or the GCL specimen is both hydrated then permeated with the test liquid (Scenario 2). Results are given in terms of Hydraulic Conductivity (m/s).

2.3. APPARATUS

1. Laboratory balance
2. Weighing Paper
3. Graduated Cylinder
4. U.S. Standard Sieve
5. Mortar and Pestle or Laboratory Hammer Mill
6. ASTM Calibration Immersion Thermometer
7. Mixer
8. Mixing Container
9. Timers
10. Spatula
11. Covered or Sealed Container
12. Ambient Temper/Low-Pressure Filter Press
13. Filter Paper

2.4. CALCULATION

Flux

$$q_t = V/At$$

q_t = Flux, (m^3/m^2)/s

V = Quantity of flow, taken as the average of inflow and outflow, m^3

A = Cross sectional area of nominal 100-mm diameter porous end piece, 0.00785 m^2

t = Interval of time, s, over which the flow occurs.

Falling-Head with Rising Tailwater:

$$k_t = \left(\frac{aL}{2At}\right) ln\left(\frac{h_1}{h_2}\right)$$

k_t = Hydraulic conductivity, m/s

Q = Quantity of flow, taken as the average of inflow and outflow, m^3

L = Length of specimen along the path of flow, m

a = Cross sectional area of the reservoir containing the specimen, m^2

A = Cross sectional area of the specimen, m^2

t = Interval of time, s, over which the flow occurs.

h_1 = Head loss across the specimen at time t_1

h_2 = Head loss across the specimen at time t_2

2.5. METHOD DEVIATION

Nil

2.6. SAMPLE DESCRIPTION

Test 1:
Product Name: ELCOSEAL
Product Code: X2000
Product Type: Needle-punched, thermally-locked, scrim-reinforced Geosynthetic Clay Liner
Roll/Batch ID: 1027726

2.7. SPECIMEN DIMENSIONS

1 x (100mm Ø)

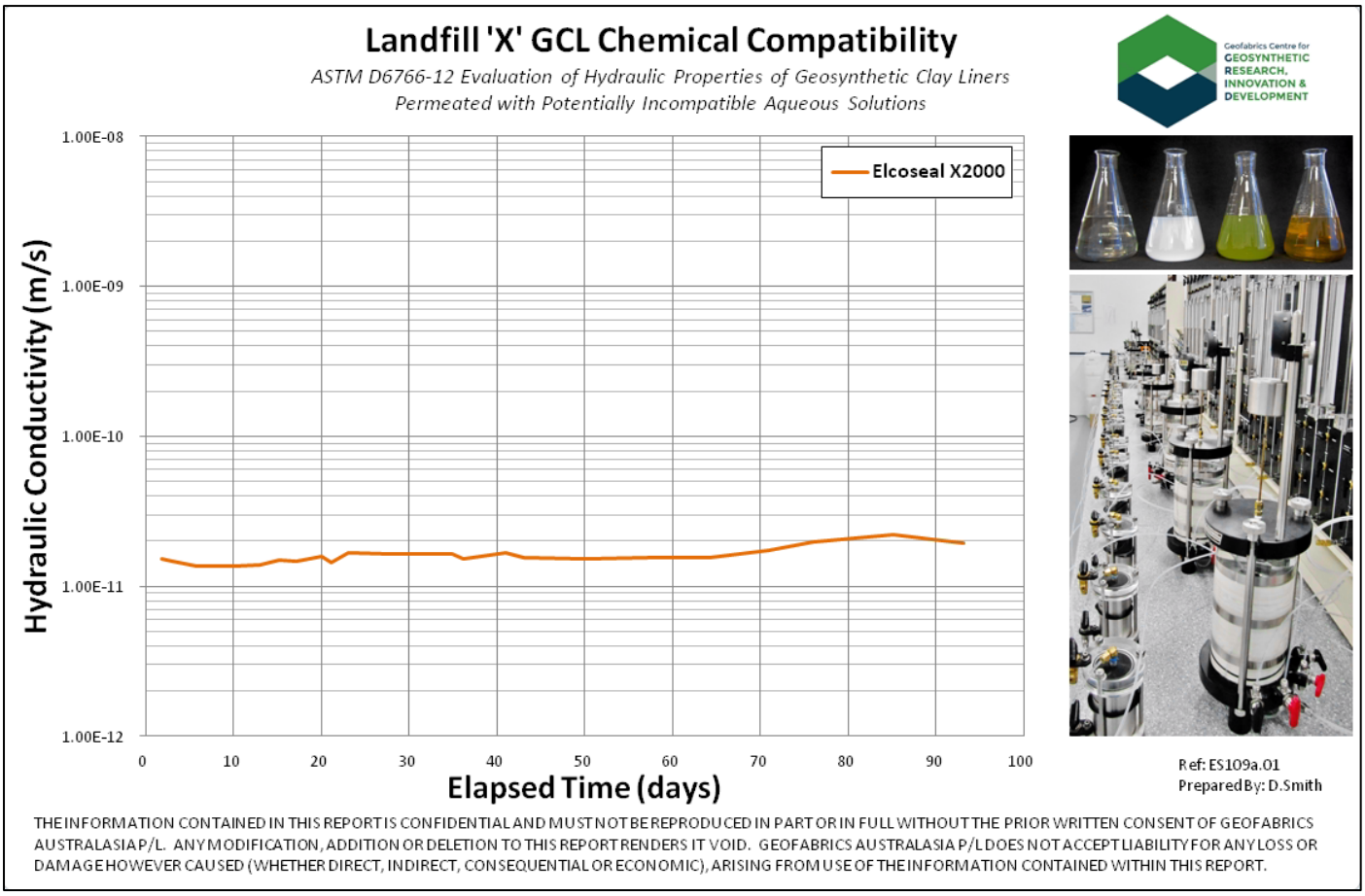
2.8. CONDITIONING AND ATMOSPHERE

No pre-conditioning and tested in a non-standard atmosphere.

2.9. RESULTS

Test dates:	27/03/18 to 10/05/18	Analyst:	D. Smith
Specimen 1-1 PROPERTIES		**Specimen 1-1 TEST CONDITIONS:**	
Initial Total Mass (g/m^2)	5,236	Consolidation Time (h):	144.95
Initial Clay Mass (g/m^2)	4,473	Hydrating Liquid:	Elution leachate
Initial Clay Thickness (mm)	2.03	Permeant Liquid:	Elution leachate
Hydrated Total Mass (g/m^2)	12,199	Cell Pressure (kPa)	550
Hydrated Clay Mass (g/m^2)	11,437	Influent Pressure (kPa)	530
Hydrated Clay Thickness (mm)	6.58	Effluent Pressure (kPa)	515
Dried Total Mass (g/m^2)	5,228		
Dried Clay Mass	4,465		
Dried Total Thickness (mm)	9.33		
Initial Moisture Content (%)	8.49		
Final Moisture Content (%)	156.1		
Bentonite Swell Index (ml/2g):	19.0	Bentonite Fluid Loss (ml):	33.76
SPECIMEN 1-1 RESULTS:			
Average Hydraulic Gradient:	234.9	Final Inflow/Outflow Ratio:	0.95
Average Index Flux (last 3 values) (m^3/m^2/s)	5.03E-09	24h Hydrated Clay SG:	2.65
Average Hydraulic Conductivity (last 3 values) (m/s):	2.03E-11	Pore Volumes Passed:	2.92

2.10. GRAPHS



2.11. LEACHATE CHEMISTRY (NEW ZEALAND LANDFILL DATA vs GRID DATABASE)

	Unit	Min	Max	Mean	Median	Tested Leachate
pH lab		**5.85**	**9.2**	**7.34**	**7.31**	**8.55**
Conductivity	**mS/m 20°C**	**230**	**5690**	**816**	**655**	**4150**
TDS	**g/m³**	**487**	**57900**	**5989**	**5245**	**2360**
Calcium total	**g/m³**	**63.6**	**721**	**168.9**	**127**	**539**
Potassium	**g/m³**	**109**	**849**	**383**	**344**	**399**
Sodium	**g/m³**	**396**	**2140**	**1168**	**1225**	**266**
Magnesium total	**g/m³**	**57.5**	**198**	**129**	**126**	**<1**
Alkalinity	g/m³	1460	7300	5193	5550	
Aluminium total	g/m³	0.05	4.26	0.626	0.19	0.53
Ammonia total	g/m³ as N	50	1340	699	735	<0.01
Antimony total	g/m³	0.0044	0.014	0.00741	0.0063	0.25
Arsenic total	g/m³	0.005	0.34	0.089	0.062	0.312
Barium	g/m³	0.837	6.4	4.27	4.5	0.144
Bismuth total				<0.0021		0.007
BOD5	g/m³ O_2	7	22400	768.9	168.5	38
Boron total	g/m³	1.45	186	16.2	15.5	0.08
Cadmium total	g/m³	0.0001	0.0117	0.00221	0.0012	0.0444
Caesium total		0.0098	0.046	0.018	0.015	0.172
Chloride	g/m³	45	2700	1320	1350	268
Chromium total	g/m³	0.0189	50.4	0.651	0.190	0.016
Cobalt total	g/m³	0.0028	0.292	0.037	0.028	0.001
COD	g/m³ O_2	17	11100	2026	1550	
Conductivity	mS/m 25°C	84.5	2090	1217	1190	
Copper total	g/m³	0.007	0.989	0.165	0.096	0.58
Fluoride	g/m³	0.1	1.9	0.526	0.370	1.4
Hardness	g/m³ $CaCO_3$	527	2550	932	820	
Iron	g/m³	0.7	198	11.348	1.85	9.37
Lanthanum total				<.0021		<0.001
Lead total	g/m³	0.001	0.175	0.0230	0.0103	2.31
Lithium total		0.48	1.4	0.70	0.64	0.002
Manganese	g/m³	0.25	5.5	0.78	0.48	0.32
Mercury total	g/m³	0.00009	0.0065	0.000556	0.00023	
Molybdenum	g/m³	0.003	0.0062	0.004722	0.0049	1.07
Nickel total	g/m³	0.0172	19.5	0.326	0.126	0.002
Nitrate	g/m³ as N	0.012	1.1	0.229	0.160	0.04
Total Kjeldahl Nitrogen	g/m³	791	830	810.5	810.5	3.6
Phosphorus total	g/m³	0.325	12	5.159	4.5	0.11
Phos (DRP)	g/m³	0.021	9.5	3.386	3.595	
Rubidium total		0.34	0.65	0.459	0.455	1.38
Selenium	g/m³	0.038	0.038	0.038	0.038	0.08
Silver	g/m³			<.0022		0.108

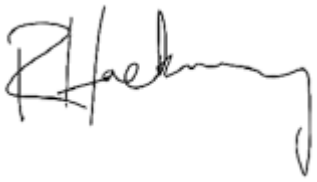
	Unit	Min	Max	Mean	Median	Tested Leachate
Strontium total		4.7	7.3	5.94	5.9	6.42
Sulphate	g/m³	0.9	355	37.05	14	2210
Sulphide total	g/m³	0.02	96	9.055	3.835	
Sulphur total	g/m³	10.2	134	31.7	28.5	
Susp solids	g/m³	4	1860	116.8	26.5	
Thallium	g/m³			<.0011		0.004
Tin	g/m³	0.002	0.032	0.0131	0.0115	0.51
Uranium total	g/m³			<.00042		<0.001
Vanadium	g/m³	0.046	0.11	0.069	0.065	<0.01
Zinc total	g/m³	0.017	50.5	2.451	0.412	3.81

2.12. COMMENTS

Individual hydraulic conductivity results may be influenced by one or more of the following variables:

1. Testing with site-specific leachate as opposed to deionized water
2. Single specimens tested as opposed to a statistically-significant dataset containing a large number of tests
3. Extremely low levels of hydraulic conductivity
4. Final bentonite clay core thickness

2.13. AUTHORISATION



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3. TERMS AND CONDITIONS

It should be noted that the Geofabrics Australasia Pty Limited GRID Laboratory is not a NATA accredited facility. Notwithstanding this, all tests are conducted in general accordance with the stated standard test method.

1) This test report has been prepared based on the test(s) requested by the customer on the specific samples submitted to Geofabrics Australasia P/L. Results quoted on test reports refer only to the samples submitted by the customer.

2) Any opinion, interpretation or comments expressed in relation to this report are for information purposes only. Geofabrics Australasia P/L accepts no responsibility for the interpretation of test results and no warranty is granted, implied or otherwise. Geofabrics Australasia P/L shall not be liable for any consequential loss or damage incurred by the customer as a result of any information supplied.

3) Unless noted on the corresponding test report, all tests are performed in general accordance with the applicable test method.

4) All test reports are confidential to the customer and will not be issued to any third party without the written authorization of the customer.

5) Customers wishing to copy a report must obtain prior written permission from Geofabrics Australasia P/L. Only complete test reports (including cover pages and information relevant to the report) may be copied and issued to third parties. No omissions or additions are allowed. Results supplied in our reports may not be used in advertising or promotional literature without the prior written approval of Geofabrics Australasia P/L. Geofabrics Australasia P/L has no liability to any third party making use of such reports.

6) Faxed copies of test reports may be sent where requested by the customer. These reports must be destroyed once the original reports are received by the customer.

7) Where testing requested may be required for any legal action, to resolve a dispute or if it may be presented as evidence, the customer must inform Geofabrics Australasia P/L prior to the testing. We must be provided with full particulars of any such action and may, at our absolute discretion, refuse to undertake the testing or issue a report.

8) Geofabrics Australasia P/L shall endeavour to complete the testing promptly. However, under no circumstances will Geofabrics Australasia P/L accept liability for any loss arising from the delay in production of test results.

9) Samples supplied by the customer for testing shall be retained by Geofabrics Australasia P/L for a period of one (1) month from the date of testing. Thereafter the samples will be disposed of unless otherwise requested by the customer.

EFFECTIVE: **14th September, 2009**

END OF REPORT