

Golder Associates Ltd.

2390 Argenta Road
Mississauga, Ontario, Canada L5N 5Z7
Telephone 905-567-4444
Fax 905-567-6561



**DRAFT
REPORT ON**

**DIFFUSION TESTING
ON CORE SAMPLES
CASWALIA, CALIFORNIA**

DRAFT

Submitted to:

**MACTEC ENGINEERING
1150 Sanctuary Parkway, Suite 300
Alpharetta, Georgia 30004
United States**

DISTRIBUTION:

- 1 copy - Mactec Engineering, Alpharetta, GA.
- 1 copy - Golder Associates Ltd., Mississauga, Ontario

July 2005

05-1113-030



Golder Associates Ltd.

2390 Argenta Road
Mississauga, Ontario, Canada L5N 5Z7
Telephone 905-567-4444
Fax 905-567-6561



July 27, 2005

DRAFT

05-1113-030

Mactec Engineering
1150 Sanctuary Parkway
Suite 300
Alpharetta, Georgia 30004
United States

Attention: Mr. Bill Feller

RE: MATRIX DIFFUSION TESTING ON ROCK SAMPLES

Dear Mr. Feller:

Please find attached our draft report entitled "*Diffusion Testing on Core Samples, Casmalia, California*".

Should you have any questions regarding the work, please do not hesitate to contact us.

Yours truly,

GOLDER ASSOCIATES LTD.

DRAFT

Meagan Wheeler Cuddihy, B.A.Sc.
Environmental and Corporate Services

DRAFT

Frank S. Barone, Ph.D., P.Eng.
Associate

MWC/FSB/sa

n:\active\2005\1113\05-1113-030 -mactec-manix diffusion testing-casmalia, california\05-1113-030 mactec rpt 27 july 05 diffusion draft.docx



TABLE OF CONTENTS

SECTION	PAGE
1.0 INTRODUCTION	1
2.0 DEFINITION OF MATRIX DIFFUSION COEFFICIENT AND TORTUOSITY FACTOR	1
3.0 THEORETICAL DESCRIPTION OF THE DIFFUSION TEST	2
4.0 DIFFUSION TEST PROCEDURES	4
5.0 RESULTS	6

LIST OF TABLES

TABLE 1	-	Description of the Core Specimens Used for the Diffusion Tests
TABLE 2	-	Summary of Test Results
TABLE 3	-	Tortuosity Factors for Various Rock Types

LIST OF FIGURES

FIGURE 1	-	Schematic Drawing of the Chloride Diffusion Cell
FIGURE 2	-	Diffusion Test Results - Sample 04-50 (RIMW-2, 2.7 m)
FIGURE 3	-	Diffusion Test Results - Sample 04-51 (RIMW-8, 17.6 m)
FIGURE 4	-	Diffusion Test Results - Sample 04-52 (RIPZ-10B, 17.6 m)
FIGURE 5	-	Diffusion Test Results - Sample 04-53 (RIPZ-18, 6.8 m)

APPENDIX A - Diffusion Test Data

TABLE A.1	-	Specific Details of the Chloride Diffusion Tests
TABLE A.2	-	Diffusion Test Data - Sample 04-50 (RIMW-2, 2.7 m)
TABLE A.3	-	Diffusion Test Data - Sample 04-51 (RIMW-8, 17.6 m)
TABLE A.4	-	Diffusion Test Data - Sample 04-52 (RIPZ-10B, 17.6 m)
TABLE A.5	-	Diffusion Test Data - Sample 04-53 (RIPZ-18, 6.8 m)

APPENDIX B - Additional Test Records

- Water Content
- Specific Gravity Test Results
- Total Organic Carbon Content

1.0 INTRODUCTION

This report presents the methodology and the results of diffusion tests carried out on four (4) core samples (ranging in diameter from 4.9 cm to 5.2 cm) to evaluate the matrix diffusion coefficient (D) for chloride and the corresponding tortuosity factor (τ). The core samples were provided by Mactec Engineering, Inc. in January 2005. A description of the core samples is given in Table 1.

Also presented in this report are the results of analyses for water content, specific gravity, total organic carbon content and natural chloride concentration in the porewater phase, performed on the core samples as part of the scope of work.

The above testing was conducted between January 2005 and April 2005, at Golder Associates' laboratory in Mississauga, Ontario. All analyses for chloride concentrations were carried out at Maxxam Analytics Inc. laboratory in Mississauga, Ontario.

2.0 DEFINITION OF MATRIX DIFFUSION COEFFICIENT AND TORTUOSITY FACTOR

The diffusion coefficient (D) is a solute transport parameter, which relates the diffusive mass flux of a solute to its concentration gradient via Fick's first law, i.e.:

$$f = -n' D \frac{\delta c}{\delta z} \quad [1]$$

- where:
- f = solute diffusive mass flux (mass of solute transported per unit area per unit time) [$M/L^2/T$],
 - n' = porosity available for diffusion (i.e. effective porosity),
 - D = solute diffusion coefficient in the porous media [L^2/T],
 - c = solute concentration in the porewater [M/L^3], and
 - z = distance in the direction of diffusion [L]

The magnitude of the diffusion coefficient is influenced by temperature, characteristics of the solute itself and its co-diffusing species (e.g. size and concentration) and the fabric of the porous media (e.g. pore size and pore structure).

For a given temperature, the diffusion coefficient can be expressed as the product,

$$D = \tau D_o \quad [2]$$

where: D_o = species diffusion coefficient in a purely aqueous solution at the given temperature [L^2/T], and
 τ = tortuosity factor for the porous media

The porous media tortuosity factor (τ) is an empirical factor ($0 < \tau < 1.0$) which accounts for the fact that the rate of diffusion in a porous media is slower than that in aqueous solution due to diffusion pathways around solid particles being much longer and more “tortuous” than the direct pathways in aqueous solution. The tortuosity factor is considered to be independent of temperature and is assumed to be strictly a physical property of the porous media, dependant on the matrix fabric (i.e. pore structure and pore size) rather than on the nature of the solute species (e.g. Rowe, 1987).

The species aqueous diffusion coefficient (D_o) for a given temperature is dependant on properties of the porewater phase (e.g. viscosity) and properties of both the solute itself and its co-diffusing species (e.g. size and concentration). Aqueous diffusion coefficient values can be obtained from the literature (e.g. Li and Gregory, 1974, and Reid et. al., 1987).

3.0 THEORETICAL DESCRIPTION OF THE DIFFUSION TEST

A schematic drawing of the diffusion cell used for this study is presented in Figure 1. A source solution consisting of distilled water spiked with sodium chloride was placed on one side of the core sample and a collector solution consisting of distilled water was placed on the opposite side.

The core sample was coated with a thin circumferential layer of vacuum (silicone) grease and was placed within a latex membrane between the source solution and the collector solution. Pressure 50 kPa was applied around the sample to ensure a tight seal between the membrane and the sample.

The source solution constituents (i.e. sodium and chloride) were allowed to diffuse through the core sample and into the collector solution compartment over a period of 27 days. During this period, the source and collector solution compartments were periodically sampled in order to monitor the chloride concentration variation with time.

Assuming that the chloride concentration decreases with time in the source solution is due only to diffusion through the core sample (i.e. no short circuiting of chloride along the contact between the core and the latex membrane) the boundary condition representing the chloride concentration in the source solution can be written as (e.g. see Rowe and Booker, 1985):

$$c_s(t) = c_{os} - \frac{1}{H_s} \int_0^t f_s(t) dt \quad [3]$$

where: $c_s(t)$ = chloride concentration in the source solution at time t [M/L^3],
 c_{os} = initial chloride concentration in the source solution [M/L^3],
 H_s = equivalent height of source solution, calculated as the source solution volume divided by the cross-sectional area of the core sample perpendicular to the direction of diffusion [L], and
 $f_s(t)$ = mass flux across the core sample/source solution interface [$M/L^2/T$]

The mass flux across the sample/source solution interface $f_s(t)$, can be further related to the chloride concentration gradient across this interface $(\partial c/\partial z)_s$ by Fick's first law, viz.:

$$f_s(t) = -n'D \left(\frac{\partial c}{\partial z} \right)_s \quad [4]$$

where n' is the effective porosity of the core matrix.

The boundary condition representing the species concentration in the collector solution ($c_c(t)$) is given by:

$$c_c(t) = \frac{1}{H_c} \int_0^t f_c(t) dt - \frac{q_c}{V_c} \int_0^t c_c(t) dt \quad [5]$$

where: $c_c(t)$ = chloride concentration in the collector solution at time t [M/L^3],
 V_c = volume of the collector solution [L^3],
 $f_c(t)$ = mass flux into the collector [$M/L^2/T$], and
 q_c = average rate of sampling of the collector solution [sample volume/average sampling frequency] [L^3/T]
 H_c = Equivalent height of collector solution, calculated as the collector solution volume divided by the cross-sectional area of the core specimen, perpendicular to the direction of diffusion [L]

The mass flux into the collector $f_c(t)$ can be further expressed in terms of the concentration gradient across the sample/collector solution interface $(\partial c/\partial z)_c$, viz.:

$$f_c(t) = -n'D \left(\frac{\partial c}{\partial z} \right)_c \quad [6]$$

For these flux controlled boundary conditions, a semi-analytical solution to the one-dimensional diffusion equation,

$$\frac{\partial c}{\partial t} = D \frac{\partial^2 c}{\partial z^2} \quad [7]$$

has been implemented in the computer program POLLUTE (Rowe et. al., 1994). Using different values for the chloride diffusion coefficient, theoretical curves for the chloride concentration variation with time in the collector solution were generated using POLLUTE and then compared to the experimental concentration data. The diffusion coefficient that gave the best fit “by eye” to the experimental data was chosen as the experimental value. For all samples, the effective porosity, n' , was taken as the total porosity.

The diffusion test modelling using POLLUTE accounted for the initial porewater concentration for chloride in the test sample at the start of the diffusion test. The initial porewater concentration was estimated based on actual groundwater concentrations from monitoring wells located near to and screened at a similar depth to the location from which the diffusion test sample was taken. Table 2 summarizes the initial porewater concentrations used for each diffusion test sample.

4.0 DIFFUSION TEST PROCEDURES

The following outlines the general procedures used in the set-up and monitoring of the diffusion tests for the measurement of matrix diffusion coefficient for chloride. Note that the diffusion tests were conducted at room temperature (~23°C).

- (1) The core samples were extruded from the Shelby Tubes and then cut/trimmed to the dimensions given in Table A. 1 (Appendix A).
- (2) A thin layer of silicone vacuum grease was spread around the outer perimeter of each sample. A circular piece of non-woven geotextile, followed by a perforated plastic disc, were placed at each end of the sample. The sample and the end piece were then surrounded by a latex membrane, which adhered to the vacuum grease surrounding the sample.
- (3) The sample, capped at both ends by the geotextile and the perforated disc, was then placed between the two acrylic collars within the test apparatus. The latex membrane was secured to these collars by an “O” ring at each end. The positioning of the sample within the apparatus is shown in Figure 1.
- (4) Following the securing of the sample, the chamber surrounding the sample was filled with water. A confining pressure of 50 kPa was applied to the outside of the sample to create a tight seal between the sample and the membrane.

- (5) With the apparatus in a near horizontal position, distilled water was injected into the collector compartment through the injection port located on the collector reservoir. The second injection port was left open to allow air to escape the reservoir while it was being filled. The total volume of distilled water injected into the collector compartment ranged from 118 mL to 123 mL (refer to Table A.1).
- (6) With the apparatus still in a horizontal position, the source solution consisting of distilled water spiked with 1.65 g/L sodium chloride was injected into the source reservoir. The second injection port was left open to allow air to escape the reservoir while it was being filled. The total volume of sodium chloride source solution injected into the source compartment ranged from 258 mL to 356 mL (refer to Table A.1).
- (7) Immediately after inserting the source solution, the injection ports were sealed using fitted rubber stoppers. The cell was then gently rotated in an attempt to remove any air from the interface between the source and/or collector solution and the sample. The apparatus was then placed in a horizontal position and the start time for diffusion (i.e. $t = 0$) was recorded.
- (8) A 3 mL sample was taken from the collector reservoir periodically (approximately once per 6 days) through the sampling port. Once each sample was taken, an equal volume of fresh collector solution (i.e. distilled water) was re-injected into the collector compartment.
- (9) All source and collector solution samples were analyzed for chloride by ion chromatography at Maxxam Analytics Inc. (Mississauga, Ontario).

Using the above procedure, a chloride diffusion test was carried out for each of the four core specimens. Specific details of the diffusion tests, such as the volumes of the source and collector solutions, initial chloride concentrations in the source and collector solutions, and core specimen dimensions are presented in Table A.1.

In addition to the chloride diffusion tests, a pore water squeeze test was carried out on each of the samples to assess the amount of chloride initially present within the porewater of the samples. To obtain a sample of the porewater, a paste was made by crushing a measured quantity of the sample and mixing it with a measured quantity of distilled water of known chloride content. This mixture was then compressed and a sample of the porewater collected and sent to the chemical laboratory for chloride analysis. The laboratory results were then used in conjunction with the water contents of the paste and undisturbed core sample to back-calculate the initial chloride concentration in the porewater phase of the core specimen. This initial chloride porewater concentration was incorporated into the POLLUTE modelling for each of the samples.

5.0 RESULTS

The chloride diffusion test concentration data is presented on Figures 2 to 5 for the four core specimens. For each specimen, the data is presented in the form of collector solution concentration variation with time. The actual concentration data is provided in Appendix A, Tables A.2 to A.5.

The theoretical fitting of the diffusion test concentration data is presented on Figures 2 to 5. The best-fit (by eye) chloride diffusion coefficient values and corresponding core matrix tortuosity factors (calculated using Equation 2) are summarized in Table 3. The tests indicate chloride diffusion coefficient (D) values ranging from $1 \times 10^{-7} \text{ cm}^2/\text{s}$ to $8 \times 10^{-6} \text{ cm}^2/\text{s}$ at 23°C .

As noted in Section 3.0, the theoretical fitting of the diffusion test data assumed that the effective porosity of the core matrix (i.e. n' in Equations 4 and 6) is equivalent to the total porosity (n). Values obtained for total porosity of the core specimens are presented in Table 3 and range from 29.5 % to 50.5 %. For fine to coarse-grained rock the assumption of effective porosity equal to total porosity is considered reasonable since pores are generally larger and more interconnected. On the other hand, for very fine-grained rock the effective porosity (n') for diffusion of chloride may be lower than the total porosity (n) since a portion of the porewater may not be accessible to diffusing chloride ions. This relates to pores not being large enough to accommodate hydrated chloride ions and/or pores not being interconnected.

The total organic carbon content values obtained for the rock core specimens by the Walkley-Black wet oxidation method (Walkley, 1947), ranged from 0.09% to 2.34% of the dry mass of the specimen (Table 3).

GOLDER ASSOCIATES LTD.

Meagan Wheeler Cuddihy, B.A.Sc.
Environmental and Corporate Services

Frank S. Barone, Ph.D, P.Eng.
Associate

MWC/FSB/sa

n:\active\2005\1113\05-1113-030 -mactec-matrix diffusion testing-casmalia, california\05-1113-030 mactec rpt 27 july 05 diffusion draft.doc

REFERENCES:

- American Institute of Physics Handbook, 1972, 3rd. Ed., McGraw-Hill, New York, N.Y.
- Li, Y.H., and Gregory, S., 1974. *Diffusion of ions in sea water and in deep-sea sediments*"
Geochemica et Cosmochimica Acta, Vol. 38, pp. 703-714.
- Reid, R.C., Prausnitz, J.M., Poling, B.E., 1987. *The Properties of Gases and Liquids*, 4th ed.
McGraw-Hill Co., New York.
- Rowe, R.K., 1987. "*Pollutant Transport Through Barriers*". Proceedings of ASCE Speciality
Conference, Geotechnical Practice for Waste Disposal '87, Ann Arbor, June, pp. 159-
181.
- Rowe, R.K. and Booker, J.R., 1985. 1-D Pollutant Migration in Soils of Finite Depth. *Journal of
Geotechnical Engineering*, ASCE, Vol. III, pp. 479-499.
- Rowe, R.K., and Booker, J.R. and Fraser, M.J. 1994. "*POLLUTE-1D Pollute Migration Through
a Non-Homogeneous Soil: Users Manual*". Geotechnical Research Centre, University of
Western Ontario, London, Ontario.
- Walkley, A., 1947. A Critical Examination of a Rapid Method for Determining Organic Carbon
in Soils - Effect of Variations in Digestion Conditions and of Inorganic Soil
Constituents". *Soil Science*, Vol. 63, pp. 251-264.

DESCRIPTION OF THE CORE SAMPLES USED FOR THE DIFFUSION TESTS

Golder Lab ID.	Sample No.	Sample Depth (m)	Sample Description
04-50	RIMW - 2	2.7	alluvium
04-51	RIMW - 8	17.6	weathered clay stone
04-52	RIPZ - 10B	17.6	unweathered clay stone
04-53	RIPZ - 18	6.8	alluvium

DRAFT

SUMMARY OF TEST RESULTS

Golder Lab ID.	Sample No.	Sample Depth (m)	Initial Water Content (%)	Dry Unit Weight (kN/m ³)	Dry Density (Mg/m ³)	Specific Gravity ¹	Total Porosity ² (%)	Total Organic Carbon Content ³ (%)	Chloride Matrix Diffusion Coefficient, D @ 23°C ⁴ (cm ² /s)	Matrix Tortuosity Factor, τ ⁵
04-50	RIMW - 2	2.7	35.6%	16.33	1.66	2.54	34.50	0.38	3.0E-06	0.18
04-51	RIMW - 8	17.6	39.5%	12.17	1.24	2.51	50.50	0.09	1.0E-07	0.01
04-52	RIPZ - 10B	17.6	39.2%	14.03	1.43	2.62	45.30	2.34	5.0E-07	0.03
04-53	RIPZ - 18	6.8	53.0%	17.65	1.80	2.56	29.50	0.18	8.0E-06	0.48

1. ASTM Method 854-92

2. Total Porosity (n) of rock matrix for each sample was calculated using the equation:

$$n = 1 - \frac{\rho_d}{G_s \rho_w}$$

Where:

ρ_d = dry density [Mg/m³]

ρ_w = density of water at 23°C=0.998 Mg/m³

G_s = specific gravity of the rock matrix

3. Walkley and Black Wet Oxidation Method (Walkley, 1947).

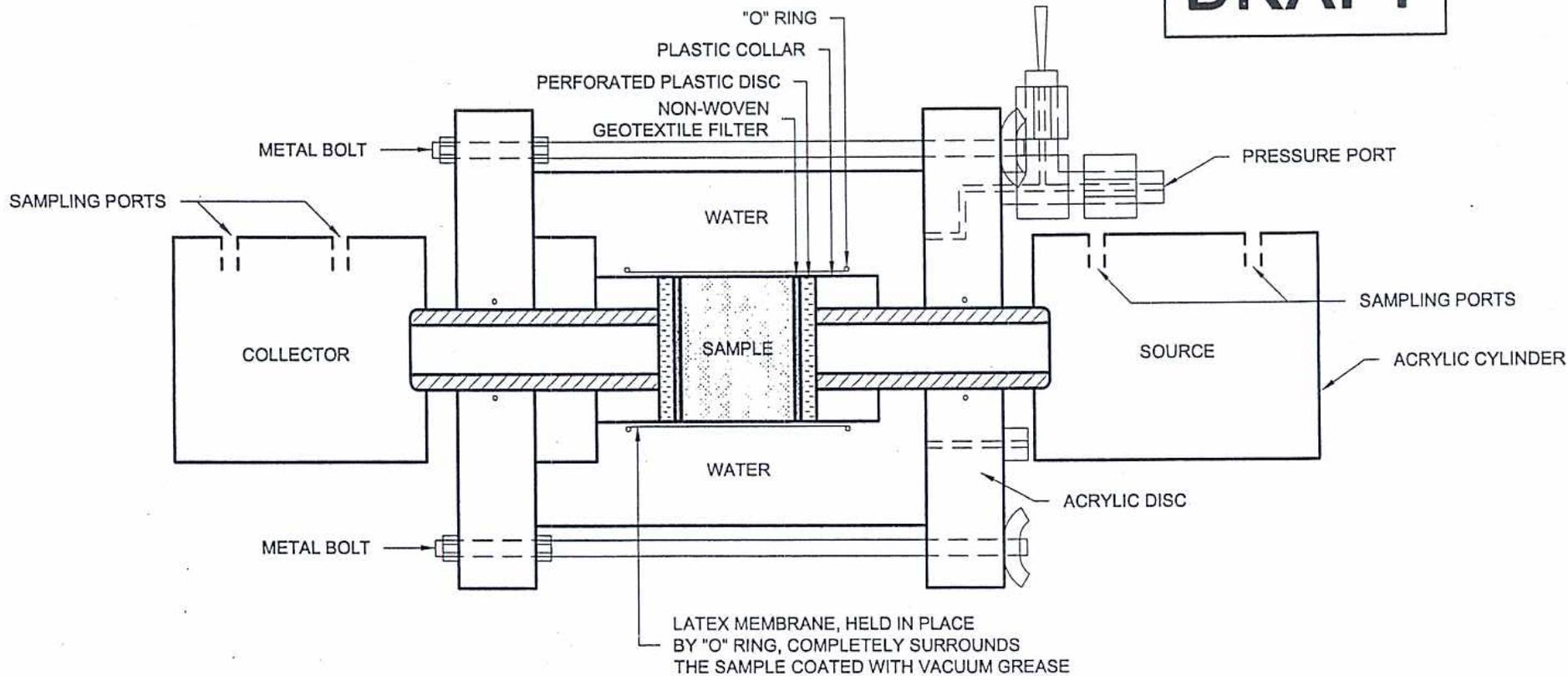
measurable range of hydraulic conductivity for the equipment used.

4. Chloride matrix diffusion coefficient (D) obtained at 23°C using the test method described in this report (see Figures 2 to 5).

5. Matrix tortuosity factor (τ) calculated as D_{Cl}/D_{eCl} where D_{eCl} is the aqueous diffusion coefficient for chloride when diffusing together with sodium from a source solution containing 0.03 Molar NaCl at 23°C. The value used for D_{eCl} is 16.8×10^{-6} cm²/s (American Institute of Physics Handbook, 1972).

DRAFT

DRAFT



SCALE	N.T.S.
DATE	JULY 27, 2005
DESIGN	RO
CAD	FC/TDR
CHECK	MWC
REVIEW	FSB

TITLE

SCHEMATIC DRAWING OF THE CHLORIDE DIFFUSION CELL

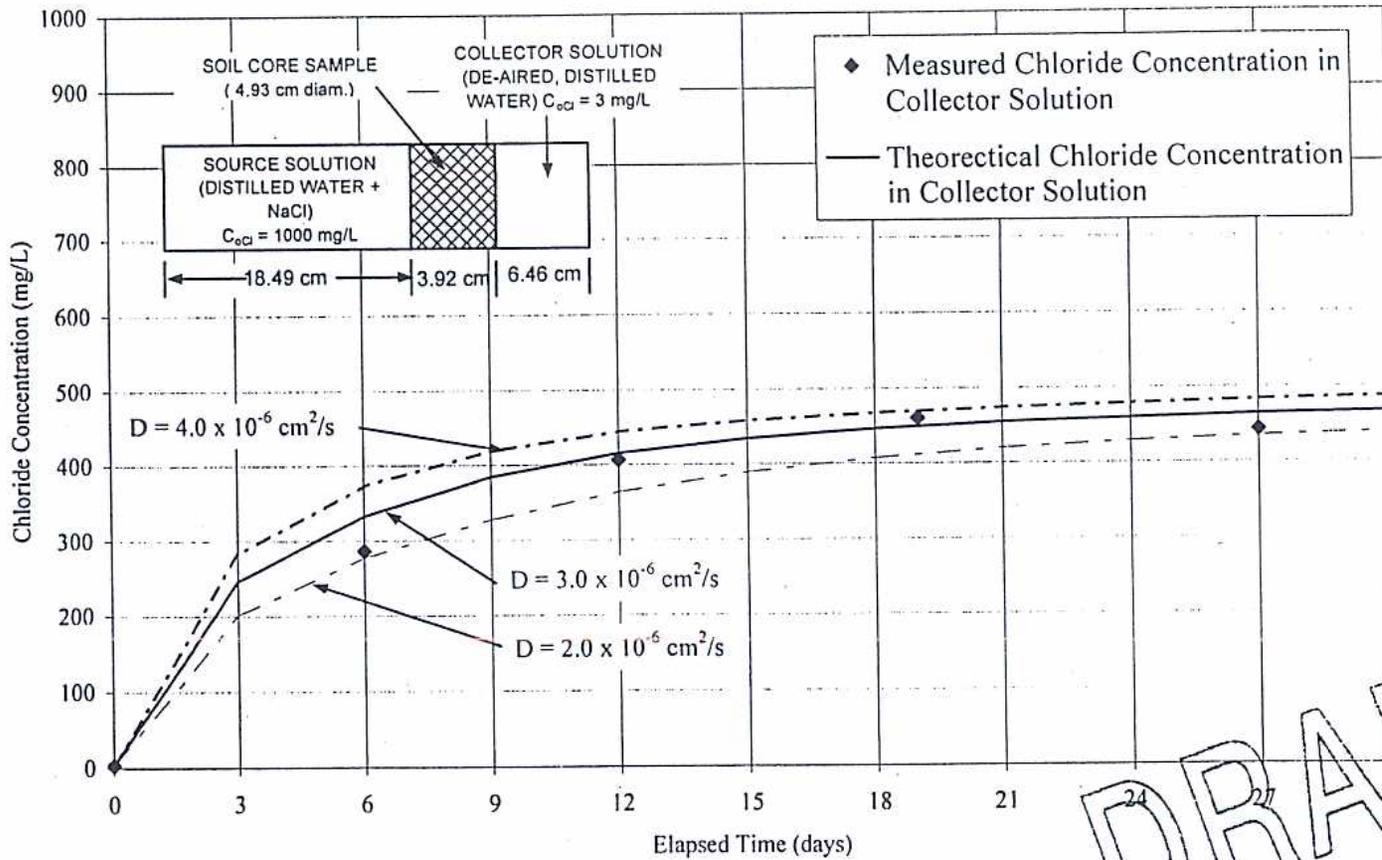
FILE No.	051113030BA1.dwg
PROJECT No.	05-1113-030
REV.	A

FIGURE

1

**DIFFUSION TEST RESULTS
SAMPLE 04-50 (RIMW-2, 2.7m)**

FIGURE 2



DRAFT

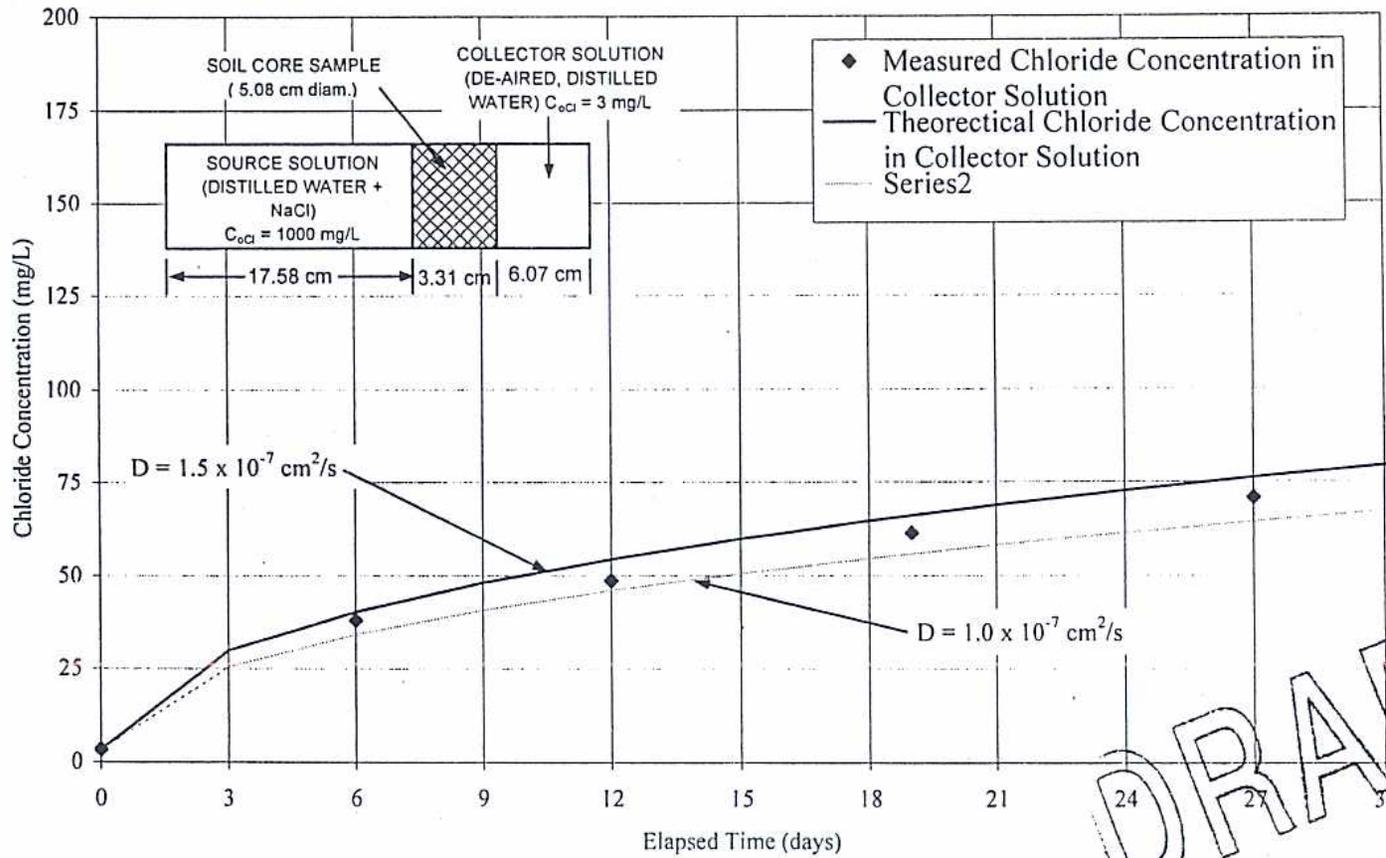
Date: June 2005
Project: 05-1113-030

DRAFT
Golder Associates

Drawn: MWC
Checked: FSB

DIFFUSION TEST RESULTS
 SAMPLE 04-51 (RIMW-8, 17.6 m)

FIGURE 3



DRAFT

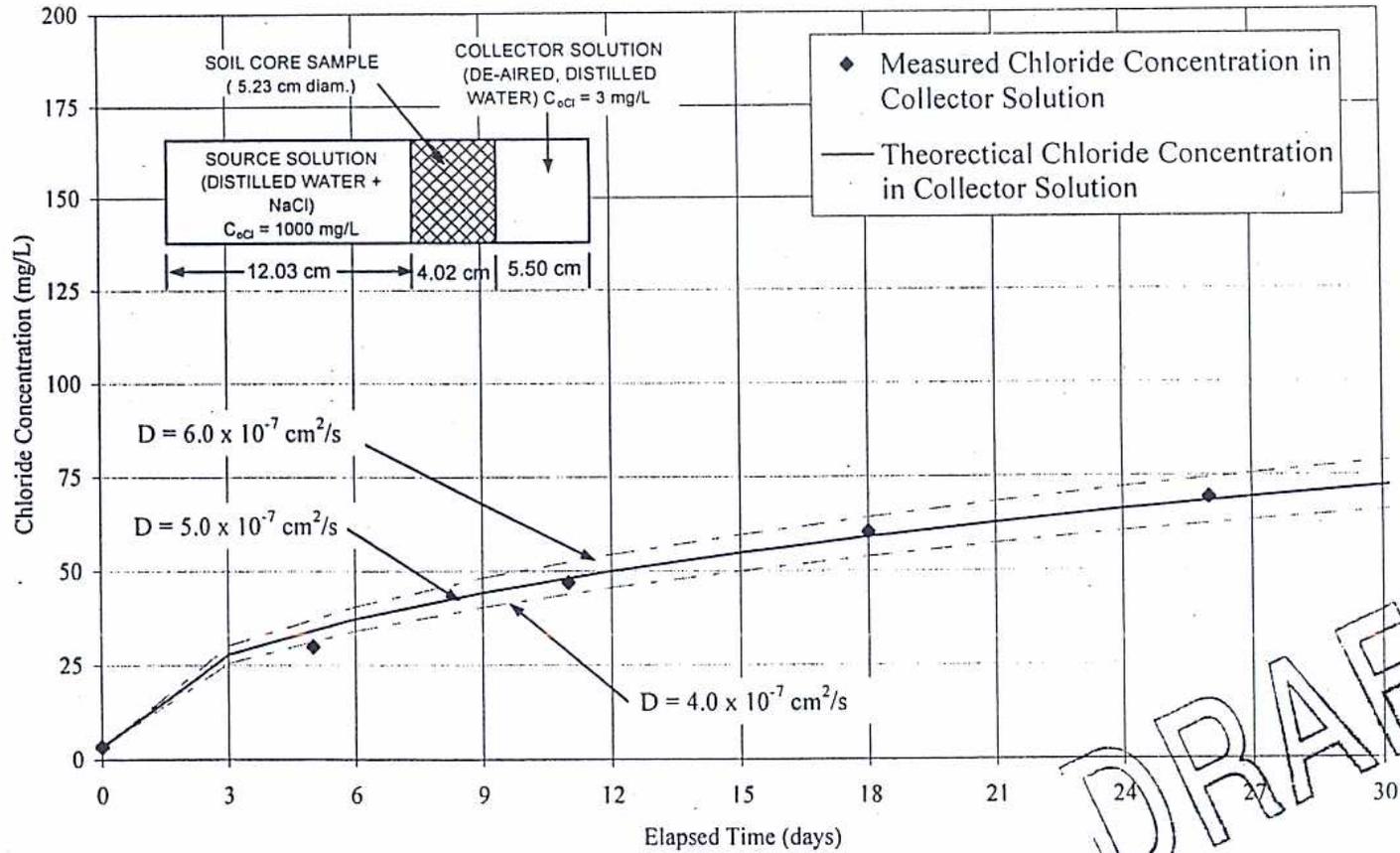
Date: July 2005
 Project: 05-1113-030

DRAFT
 Golder Associates

Drawn: MWC
 Checked: FSB

DIFFUSION TEST RESULTS
SAMPLE 04-52 (RIPZ-10B, 17.6 m)

FIGURE 4



DRAFT

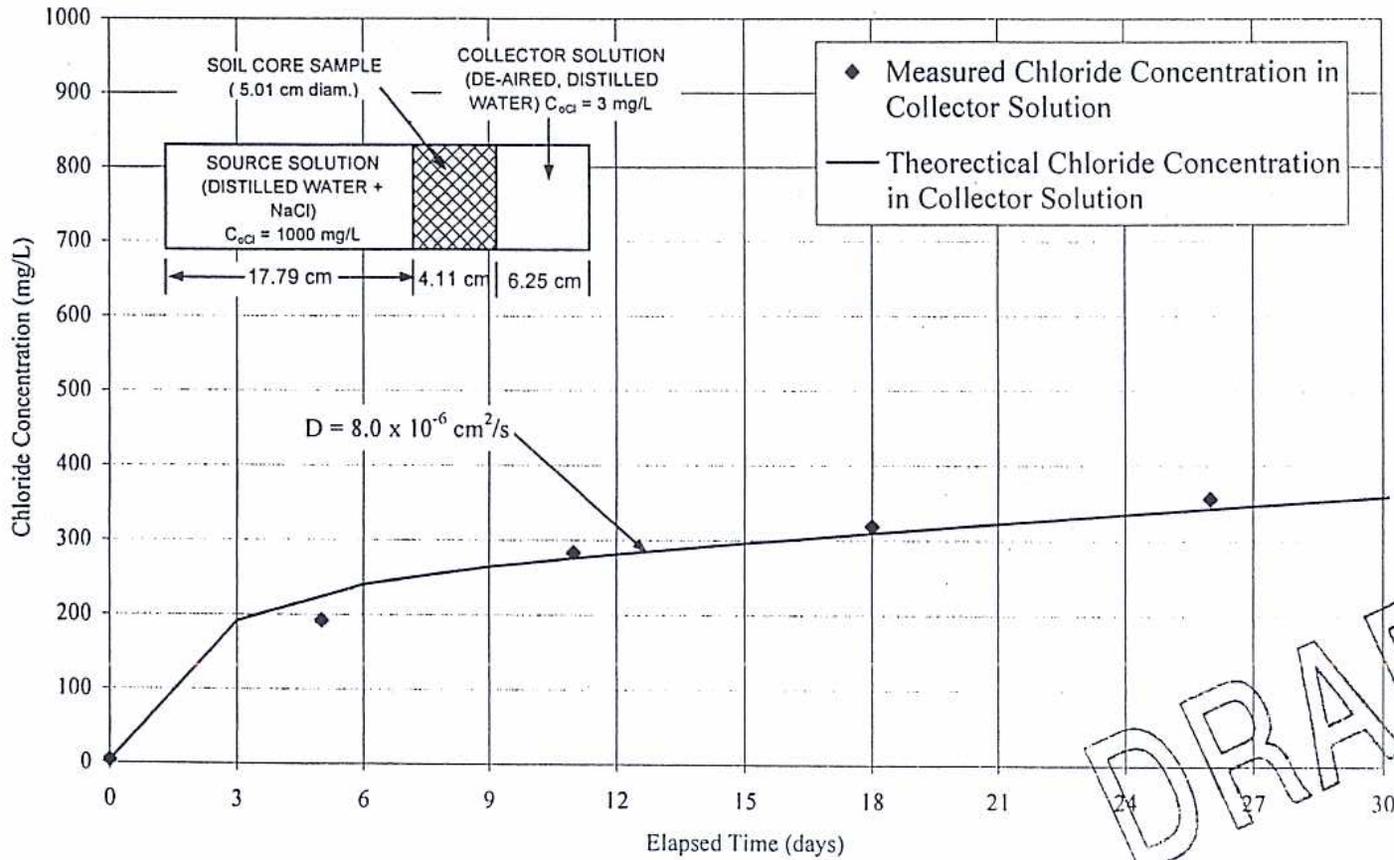
Date: July 2005
 Project: 05-1113-030

DRAFT
Golder Associates

Drawn: MWC
 Checked: FSB

DIFFUSION TEST RESULTS
 SAMPLE 04-53 (RIPZ-18, 6.8 m)

FIGURE 5



DRAFT

Date: July 2005
 Project: 05-1113-030

DRAFT
 Golder Associates

Drawn: MWC
 Checked: FSB

APPENDIX A
DIFFUSION TEST DATA

DRAFT
TABLE A.1

SPECIFIC DETAILS OF THE CHLORIDE DIFFUSION TESTS

Parameter	Sample No. (Golder Lab ID.)			
	RIMW-2 (04-50)	RIMW-8 (04-51)	RIPZ-10B (04-52)	RIPZ-18 (04-53)
Initial Concentration of Chloride in the Source Solution Compartment (mg/L)	1000	1000	1000	1000
Source Solution Volume (mL)	352	356	353	350
Equivalent Height of Source Solution, H_s (cm)	18.5	17.6	16.4	17.8
Initial Concentration of Chloride in the Collector Solution Compartment (mg/L)	3.4	3.4	3.4	3.4
Collector Solution Volume (mL)	123	123	118	123
Equivalent Height of Collector Solution, H_c (cm)	6.5	6.1	5.5	6.3
Cross-Sectional Area of Sample (cm^2) (perpendicular to direction of diffusion)	19.0	20.3	21.4	19.7
Sample Thickness (cm)	3.9	3.3	4.0	4.1
Sample Diameter (cm)	4.9	5.1	5.2	5.0
Initial Porewater Chloride Concentration at Start of Test* (mg/L)	2,700	1,460	760	2,700
Soil Matrix Total Porosity (%)	34.5	50.5	45.3	29.5
Average Rate of Sampling of the Collector Solution, q^{**} (cm^3/day)	0.43	0.43	0.43	0.43

* Refer to Table 2

** Average rate of sampling of the collector solution (q , refer to Eqn. 5) was calculated as the volume of each sample (~3mL) divided by the average frequency of sampling (~7 days).

DIFFUSION TEST DATA
Sample No. RIMW-2, 2.7m
Golder Lab ID. 04-50

Sampling Date	Elapsed Time (days)	Chloride Concentration in the Source Solution (mg/L)	Chloride Concentration in the Collector Solution (mg/L)
February 23, 2005	0	1000	3
March 1, 2005	6	1070	286
March 7, 2005	12		406
March 14, 2005	19	1120	460
March 22, 2005	27		443

DIFFUSION TEST DATA
Sample No. RIMW-8, 17.6 m
Golder Lab ID. 04-51

Sampling Date	Elapsed Time (days)	Chloride Concentration in the Source Solution (mg/L)	Chloride Concentration in the Collector Solution (mg/L)
February 23, 2005	0	1000	3
March 1, 2005	6	938	38
March 7, 2005	12		48.6
March 14, 2005	19	960	61.3
March 22, 2005	27		70.7

DIFFUSION TEST DATA
Sample No. RIPZ-10B, 17.6 m
Golder Lab ID. 04-52

Sampling Date	Elapsed Time (days)	Chloride Concentration in the Source Solution (mg/L)	Chloride Concentration in the Collector Solution (mg/L)
February 24, 2005	0	1000	3
March 1, 2005	5	956	29.9
March 7, 2005	11		46.8
March 14, 2005	18	969	60.3
March 22, 2005	26		69.2

DIFFUSION TEST DATA
Sample No. RIPZ-18, 6.8 m
Golder Lab ID. 04-53

Sampling Date	Elapsed Time (days)	Chloride Concentration in the Source Solution (mg/L)	Chloride Concentration in the Collector Solution (mg/L)
February 24, 2005	0	1000	3
March 1, 2005	5	993	192
March 7, 2005	11		283
March 14, 2005	18	1060	319
March 22, 2005	26		356

APPENDIX B
ADDITIONAL TEST RECORDS

SUMMARY OF WATER CONTENT DETERMINATIONS

PROJECT NUMBER	05-1113-030
PROJECT NAME	Mactec / Matrix Diffusion Testing / Casmalia, California
DATE TESTED	February, 2005

Sample No.	Sample Depth (m)	Water Content (%)	Atterberg Limits LL, PL, PI
RIMW-2	2.7	35.6%	-
RIMW-8	17.6	39.5%	-
RIPZ-10B	17.6	39.2%	-
RIPZ-18	6.8	53.0%	-

SPECIFIC GRAVITY TEST RESULTS

ASTM D 854-00 TEST METHOD A

PROJECT NUMBER	05-1113-030
PROJECT NAME	Mactec / Matrix Diffusion Testing / Casmalia, California
DATE	March, 2005

Borehole No.	Sample No.	Specific Gravity
-	RIMW-2	2.54
-	RIMW-8	2.51
-	RIPZ-18	2.56
-	RIPZ-10B	2.62

Note: Test carried out on soil particles <4.75mm using distilled water.

TOTAL ORGANIC CARBON CONTENT (TOC)

PROJECT NUMBER	05-1113-030
PROJECT NAME	Mactec / Matrix Diffusion Testing / Casmalia, California
DATE TESTED	February, 2005

Borehole No.	Sample No.	Depth (m)	Soil	Grain Size Distribution				TOC	TOC*
			Passing 600mm (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	(<600mm soil) (%)	(whole soil) (%)
-	RIMW-2	2.7	100.0	-	-	-	-	0.38	0.38
-	RIMW-8	17.6	100.0	-	-	-	-	0.09	0.09
-	RIPZ-10B	17.6	100.0	-	-	-	-	2.34	2.34
-	RIPZ-18	6.8	100.0	-	-	-	-	0.18	0.18

Notes:

1. Samples dried at 110 degree centigrade prior to testing.
 2. Test performed on minus 600 micron soil fraction, using the method of Walkley and Black (Walkley, 1946)
 3. Grain size distribution of sand, silt and clay based on Unified Soil Classification.
- * Corrected TOC for whole (ie. unfractionated) soil assuming negligible organic carbon content associated with the plus 600 micron soil.