Ardaman & Associates, Inc.

Geotechnical, Environmental and
Materials Consultants

July 29, 2004
File Number 04-081

Youngquist Brothers, Inc.
15465 Pine Ridge Road
Fort Myers, Florida 33908

Attention: Mr. Edward McCullers

Subject: Laboratory Testing of Rock Core Samples from Great Pine Island Water Association Injection Well

Gentlemen:

As requested, permeability and specific gravity tests have been completed on five rock core samples provided for testing by your firm from the Great Pine Island Water Association Injection Well. The permeability tests were performed in general accordance with ASTM Standard D 5084 "Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible-Wall Permeameter" using the constant-head method (Method A). The specific gravity was determined in general accordance with ASTM Standard D 854 "Specific Gravity of Soils".

Permeability Tests

The permeability test results are presented in Table 1. The vertical permeability tests were performed first on specimens typically maintained at the as-received diameter and cut to lengths of 6.6 to 9.1 cm. After completing the vertical permeability tests, the horizontal permeability test specimens were obtained by coring 5.0 cm diameter cylinders from the vertical specimens. The horizontal specimens were then trimmed to lengths of 8.0 to 8.4 cm to provide flat, parallel ends. (Due to the irregular shape and short length of Core 1, a horizontal permeability test could not be performed on that sample.) The final moisture contents of vertical test specimens that were cored for horizontal test specimens were not measured. The dry density and degree of saturation of those vertical test specimens, therefore, were estimated using the final moisture contents from the corresponding horizontal permeability test specimens.

The vertical permeability test specimens were air-dried, deaired under vacuum, and then saturated with deaired tap water from the bottom upward while still under vacuum. After testing, the vertical specimens were maintained submerged in water until cored for the horizontal specimens and retested for measurement of horizontal hydraulic conductivity. Each specimen was mounted in a triaxial-type permeameter and encased within a latex membrane. The specimens were confined using an average isotropic effective confining stress of 30 lb/in^2 and permeated with deaired tap water under a back-pressure of 160 lb/in^2. Satisfactory saturation was verified by a B-factor equal to or greater than 95 percent, or a B-factor that remained relatively constant for two consecutive increments of applied cell pressure. The inflow to and outflow from each specimen were monitored with time, and the hydraulic conductivity was calculated for each recorded flow increment. The tests were continued until steady-state flow conditions were obtained, as evidenced by an outflow/inflow ratio between 0.75 and 1.25, and until stable values of hydraulic conductivity were measured.

The final degree of saturation was calculated upon completion of testing using the final dry mass, moisture content and volume, and the measured specific gravity. Although some of the calculated

final degrees of saturation are low (i.e., less than 95%), the B-factors indicate satisfactory saturation. The calculated final degrees of saturation are potentially affected by occluded voids within the specimens, surface irregularities, and the use of final moisture contents for vertical permeability specimens from corresponding horizontal permeability specimens.

Specific Gravity Tests

The specific gravity of each sample was determined on a representative approximately 100 gram specimen ground to pass the U.S. Standard No. 40 sieve. The specific gravity measured on each sample is presented in Table 1.

Total Porosity

The total porosity, n, of each permeability test specimen was calculated using the measured dry density, γ_d, and measured specific gravity, G_s, from the equation: $n = 1 - [\gamma_d/(G_s)(\gamma_w)]$ where γ_w = unit weight of water. The calculated total porosities are presented in Table 1.

If you have any questions or require additional testing services, please contact us.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.

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Table 1

PERMEABILITY TEST RESULTS
GREAT PINE ISLAND WATER ASSOCIATION INJECTION WELL

Core No.	Depth (ft)	Received Length (in)	D-5084 Test Method*	Test Specimen Orientation	G_s	Initial Conditions					$\bar{\sigma}_c$ (lb/in^2)	u_b (lb/in^2)	B Factor (%)	Average Hydraulic Gradient	Final Conditions			Hydraulic Conductivity k_{20} (cm/sec)
						Length (cm)	Diameter (cm)	w_c (%)	γ_d (lb/ft^3)	n					w_c (%)	γ_d (lb/ft^3)	S (%)	
1	1805	5.0	A	Vertical	2.83	8.78	5.02	1.2	170.2	0.04	30	160	100	86	1.2	170.2	87	1.5×10^{-10}
2	1829	3.8	A A	Vertical Horizontal	2.79	6.64 8.11	10.08 5.01	7.1 7.1	141.6 145.1	0.19 0.17	30 30	160 160	96 98	37 34	7.1† 7.1	141.6 145.1	86 99	4.6×10^{-8} 1.6×10^{-7}
3	1959	6.0	A A	Vertical Horizontal	2.76	9.12 8.14	10.09 5.01	8.4 8.4	137.3 139.8	0.20 0.19	30 30	160 160	93** 93**	24 26	8.4† 8.4	137.3 139.8	91 100	3.8×10^{-7} 8.3×10^{-7}
4	1988	3.6	A A	Vertical Horizontal	2.75	7.22 7.99	10.08 5.01	7.9 7.9	138.4 140.2	0.19 0.18	30 30	160 160	92** 93**	40 29	7.9† 7.9	138.4 140.2	90 97	1.4×10^{-7} 9.3×10^{-7}
5	2028	4.3	A A	Vertical Horizontal	2.84	8.08 8.42	10.07 5.00	2.0 2.0	167.4 167.6	0.06 0.05	30 30	160 160	100 85**	53 22	2.0† 2.0	167.4 167.6	97 99	2.4×10^{-9} 4.4×10^{-9}

Where: w_c = Moisture content; γ_d = Dry density; G_s = Specific gravity; n = Total Porosity; $\bar{\sigma}_c$ = Average isotropic effective confining stress; u_b = Back-pressure; and S = Calculated degree of saturation using measured specific gravity.

* Method A = Constant-head test.

** B-Factor remained relatively constant for two consecutive increments of applied cell pressure.

† Vertical permeability test specimen was cored upon completion of testing to obtain horizontal permeability test specimen. The final moisture content of the vertical test specimen was not measured, and was assumed to be the same as the horizontal permeability test specimen.

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