Part III
Attachment III-E
Appendix III-E.4

SUMMARY OF HYDROGEOLOGIC TESTING IN SELECTED PIEZOMETERS

Pescadito Environmental Resource Center
MSW No. 2374
Webb County, Texas

PESCADITO
ENVIRONMENTAL RESOURCE CENTER

March 2015

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March 2, 2015

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Table of Contents

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1.0 INTRODUCTION

Hydrogeologic testing was conducted in ten piezometers installed as part of the Phase III site investigation at the Pescadito Environmental Resource Center (PERC) site. Phase III piezometers were installed in what appeared to be potentially transmissive zones, i.e., isolated sandy and/or silty intervals in the predominantly clay matrix based on the evaluation of previous Phase I, II, and III boring logs and geophysical data. Information on the piezometer installations can be found in Appendix III-E.2, *Subsurface Investigation Report*.

The hydrogeologic tests included falling head and rising head tests induced by inserting and removing solid slugs (i.e., slug tests). Based on the results of the slug tests, a subset of five piezometers indicating the highest transmissive potential were selected to conduct higher-stress, single-well, pump-down tests.

2.0 SLUG TESTS

Slug tests were conducted on ten piezometers (B-11A, B-101, B-102, B-106, B109A, B-114A, B-115, B-118, B-124, and B-126) located within the footprint of the proposed facility in Webb County, Texas. The slug tests were conducted between January 12, 2012 and January 22, 2012.

Each slug test consisted of one falling head test followed by one rising head test. To confirm repeatability of the results, multiple slug tests were conducted at each piezometer and various slug sizes were employed during each slug test. The slug test procedures and results are summarized in Table 1 attached.

2.1 Setup

Prior to conducting each slug test, a pressure transducer was programmed using a laptop computer. The date, time, site information, and logging instructions were programmed. The logging instructions consisted of recording the date, actual time, elapsed time, barometric pressure, water pressure, and the level of the water column over the pressure transducer (in feet).

In addition, the sample frequency/schedule of the transducer was configured to record data at one-second intervals. The piezometer construction details, static water elevation in the piezometer, and the length of the slug were used to determine the position of the transducer in the piezometer for each slug test. The pressure transducer was placed in the piezometer between four to five feet below the approximate elevation of the bottom of the slug. The transducer cable was secured at the top of the piezometer so that the pressure transducer level in the piezometer was not altered during the test. Any transducer cable extruding out of the piezometer was placed away from areas of walking or vehicle traffic.

The static water level in the piezometer was measured with both the pressure transducer and a water level meter to confirm the transducer was functioning properly. In addition, the hydrostatic pressure at the transducer elevation was calculated and compared to the pressure measured by the transducer.

2.2 Falling Head Test and Rising Head Test

Once it was confirmed that the transducer was functioning properly, the slug was lowered into the piezometer in a quick and controlled manner as to prevent creating large disturbances in the water level. The increasing head of the water column was monitored by the field personnel with a laptop computer. Once the maximum displacement was observed, the line suspending the slug was secured to the top of the piezometer. The transducer recorded the falling head of the water column for the rest of the falling head test.

The slug was removed completely out of the water column and piezometer in a quick and controlled manner to begin the rising head test.

Information on slug dimensions (length and displacement volume) and corresponding test duration for each test are included in Table 1.

2.3 Slug Test Data Evaluation and Results

All slug test data was first evaluated by reviewing the time-drawdown data to verify transducer function, etc. For actual analysis, the normalized falling and rising head data (i.e., instantaneous displacement divided by initial displacement or ht/Hi) with respect to time was plotted for each test. Normalized time-drawdown offers additional advantages as well:

- Allows head-to-head comparison between tests run with different slug displacements, etc., in the same piezometer;
- Allows head-to-head comparison between rising head and falling head tests run in the same piezometer, etc.;
- Assists in evaluating piezometer installation quality by comparing repeatability of results from multiple tests; and
- Assists in data validation, e.g., test repeatability, “data signature” appropriate for analysis, etc.

The normalized head data was analyzed using AQTESOLV^{TM} software. During the pre-analysis processing phase of the data evaluation, it was determined that the rising head/falling normalized head responses from all of the slug tests performed on piezometer B-124 were unusable due to a malfunction of the transducer. This data was omitted from further hydrogeologic evaluation.

Hydraulic conductivity was determined for each falling head and rising head test using the Bouwer-Rice method and the Hvorslev method. Much of the time-drawdown data exhibited "double straight-line" signatures (Bouwer & Rice, 1989). In these instances, the later time data (second straight line) was favored for Bouwer & Rice and Hvorslev analyses because it typically represents formation characteristics. Early time data typically represents filter pack characteristics, etc. The time-drawdown data from slug tests performed on piezometers B-101, B-102, B-106, B-114A, B-118, and B-126 indicated a concave up response in the later part of the time-drawdown plots. The concave-upward curving signatures implied storage effects were present and analysis by Bouwer-Rice and/or Hvorslev methods would be questionable. Accordingly, the Cooper, Bredehoeft & Papadopulos (Cooper, *et al*, 1967) [or Papadopulos, Bredehoeft, and Cooper Method (1973)] method was also used to determine transmissivity, storativity (estimation), and hydraulic conductivity for all tests conducted at piezometers screened in the Eocene units (i.e., all piezometers except for B-114A).

The calculation of hydraulic conductivity and transmissivity values from the slug test data generated from each piezometer was performed using equations pertinent for groundwater-bearing units under confined conditions, with the exception of the data generated from piezometer B-114A, which was determined to be under unconfined conditions. A determination of whether a piezometer was under confined or unconfined conditions was based on a review of the lithologic data in the boring logs and piezometer construction logs. An anisotropy ratio (K_v/K_h) of 0.1 was used in the calculation of the hydraulic conductivity and transmissivity values. It has long been established (consensus opinion) that horizontally bedded and/or stratified sedimentary deposits – such as the Eocene – have significant anisotropy and a permeability anisotropy of (K_v/K_h) of 0.1 was assumed as a conservative upper limit. Note that the *Yegua-Jackson Groundwater Availability Model* (TWDB, 2010) used 0.01 or less.

Hydraulic conductivity values calculated using the Hvorslev method were determined using Hvorslev Method F as this method was most appropriate based on subsurface conditions and the piezometer construction. Method F is for a well-screen under approximately confined conditions, etc. Also, for the available well-screen method choices, Method F will be the most conservative for estimating permeability. The filter pack length was used in the calculations in place of the actual screened interval due to the significant difference between the hydraulic conductivity of the filter pack and the surrounding formation.

The AQTESOLV^{TM} results showed a significant range in estimated hydraulic conductivity for the eight piezometers screened in the confined Eocene units. Hydraulic conductivity values determined using the Bouwer-Rice method ranged from 1.9×10^{-8} centimeters per second (cm/sec) in B-11A to 1.7×10^{-5} cm/sec in B-126. Hydraulic conductivity values determined using the Hvorslev method ranged from 2.9×10^{-8} cm/sec in B-11A to 2.5×10^{-5} cm/sec in B-126. Using the Cooper, et al method, hydraulic conductivity values ranged from 5.8×10^{-10} cm/sec in B-115 to 5.2×10^{-5} cm/sec in B-126; and transmissivity values ranged from 2.7×10^{-7} cm^2/sec in B-115 to 3.8×10^{-2} cm^2/sec in B-126.

Hydraulic conductivity values determined for the piezometer screened in the shallow alluvium (B-114A; unconfined hydrogeologic conditions) ranged from 1.5×10^{-7} cm/sec to 1.7×10^{-5} cm/sec using the Bouwer-Rice method and 2.0×10^{-7} cm/sec to 2.4×10^{-5} cm/sec using the Hvorslev method.

AQTESOLV^{TM} results were confirmed by separate analyses. Semi-log plots of drawdown versus log time were manually prepared for multiple tests from piezometers B-102, B-106, B-114A, B-118, and B-126. The resulting plots had a typical "S-curve" signature. Plots showed data could be reasonably analyzed using "straight-line" solution methods, e.g., Hvorslev, applied to the mid-section of the signature and/or curve-matching using the Cooper, Bredehoeft & Papadopulos Method (1967) [or Papadopulos, Bredehoeft, and Cooper Method (1973)] . More importantly, the plots conclusively showed that the later time-drawdown data was representative of the formation – at least in near proximity to the borehole.

The highest hydraulic conductivity and transmissivity values were observed in piezometers B-126 (lower 10^{-5} cm/sec range) and B-102 (upper 10^{-6} to lower 10^{-5} cm/sec range). The lowest hydraulic conductivity and transmissivity values were observed in piezometers B-11A, B-109A, B-115, and B-118, all of which were in the upper 10^{-8} to lower 10^{-7} cm/sec range.

3.0 PUMP-DOWN TESTS

Pump-down tests on piezometers B-101, B-102, B-114A, B-124, and B-126 were conducted between April 2, 2012 and April 5, 2012. The rationale for conducting pump-down tests was to place maximum stress on the potentially transmissive unit by completely evacuating water from the piezometers (to the extent possible allowed by the submersible pump). The water-level recovery of these piezometers was then analyzed to determine hydrogeologic parameters.

3.1 Setup

Prior to conducting each pump-down test, a pressure transducer was programmed using a laptop computer. The date, time, site information, and logging instructions were programmed. The logging instructions consisted of recording the date, actual time, elapsed time, barometric pressure, water pressure, and the level of the water column over the pressure transducer (in feet).

In addition, the sample frequency/schedule of the transducer was configured to record data at one-minute (60 second) intervals. The submersible pump was placed approximately one foot above the bottom of the piezometer. The pressure transducer was then placed in the piezometer approximately two feet above the top of the submersible pump. Note that, as a consequence of transducer placement, early recovery data could not be obtained. This was not considered a significant problem because (1) the complete time-drawdown signature could be inferred and (2) the relatively linear middle portion of the time-drawdown data was actually used for analyses. The transducer cable was secured at the top of the piezometer so that the pressure transducer level in the piezometer was not altered during the test. Any transducer cable extruding out of the piezometer was placed away from areas of walking or vehicle traffic.

The static water level in the piezometer was measured with both the pressure transducer and a water level meter to confirm the transducer was functioning properly. In addition, the hydrostatic pressure at the transducer elevation was calculated and compared to the pressure measured by the transducer.

3.2 Pump-Down Recovery Test

Following confirmation that the transducer was functioning properly, the pump was activated to purge groundwater from the piezometer to a level below the pump. The decreasing head of the water column was monitored by the field personnel with a laptop computer. Once the groundwater was purged to a level below the pump, the pump was allowed to run for approximately two to three minutes to ensure no late-time influx of groundwater flowed into the piezometer. Following this period of time the pump was then shut off and left in place while groundwater recovered into the piezometer.

The recovery test was considered complete when the water level had recovered to within ten percent of the original pre-pumping water levels or when at least 24 hours had elapsed since the pump was deactivated. Due to the very slow recovery of groundwater in piezometers B-114A and B-124, only one pump-down test was performed.

3.3 Pump-Down Data Evaluation and Results

The recovery data was first evaluated by plotting recovery (i.e., head) with respect to time. This pre-analysis processing step was performed to determine whether the transducer was properly measuring and recording recovery. A review of the recovery curves with respect to time determined the recovery data was usable and was ready for hydrogeologic evaluation.

Hydraulic conductivity was determined for each recovery test using Hvorselv Method F as this method was most appropriate based on the subsurface conditions and the piezometer construction. Based on the curvature present in the recovery data from the slug tests, pump-down recovery data was also analyzed using Cooper, et al method to determine transmissivity. The hydrogeologic conditions (i.e., confined or unconfined) and piezometer construction parameters (i.e., filter pack length used for screen length, etc.) used to calculate hydraulic conductivity/transmissivity from the slug test data was used in the calculation of the pump-down recovery data. Additional details necessary for the calculations, such as piezometer construction details, are provided in the attached Table 2.

Hydraulic conductivity values calculated using the Hvorslev method for the piezometers screened in the confined Eocene sand units showed a range of hydraulic conductivity values that ranged approximately two orders of magnitude. Hydraulic conductivity values calculated from tests conducted at piezometer B-101 ranged from 4.75 x 10^{-6} cm/sec to 3.87 x 10^{-6} cm/sec. Hydraulic conductivity values calculated from tests conducted on B-102 ranged from 1.11 x 10^{-5} cm/sec to 1.09 x 10^{-5} cm/sec. Hydraulic conductivity calculated from the test performed on B-

124 was 6.18 x 10^{-7} cm/sec. Hydraulic conductivity calculated from tests performed on B-126 ranged from 7.59 x 10^{-6} cm/sec to 4.95 x 10^{-6} cm/sec.

The hydraulic conductivity value determined for the piezometer screened in the shallow alluvium (B-114A; unconfined hydrogeologic conditions) was calculated to be 6.58 x 10^{-7} cm/sec.

Analysis of the recovery data for all five piezometers was attempted using the Cooper, *et al* method; however, none of the field recovery curves matched to the Cooper, *et al* method function curves, with the exception of the data collected from B-124. Since the recovery curves generated from tests conducted on piezometers B-101, B-102, B-114A, and B-126 did not match the Cooper-type function curves; this method was determined not to be appropriate. The transmissivity calculated from the data generated from the test on B-124 was 2.05 x 10^{-3} cm^2/sec. Using the saturated thickness parameters provided in Table 2, the hydraulic conductivity calculated using the Cooper, *et al* method was 4.50 x 10^{-6} cm/sec.

AQTESOLV™ results were confirmed by separate analyses. Semi-log plots of drawdown versus log time were manually prepared for piezometers B-101, B-102, B-114A, B-124, and B-126 and the “straight-line” portion of the time-drawdown signature was analyzed using Hvorslev Method F.

4.0 SUMMARY AND CONCLUSIONS

Note that analytical results obtained at a given piezometer using all three methods, Bouwer-Rice, Hvorslev, and Cooper *et al*, were comparable as illustrated in Tables 1 and 2. The results also show that testing of what was assumed to be the most transmissive units in the subsurface showed that those units weren't very transmissive. To put the results in perspective, it is instructive to compare the obtained results to a common classification system illustrated below:

Permeability and Drainage Characteristics of Soils

Original reference: *Soil Mechanics in Engineering Practice*, Terzaghi and Peck, 1948 (based on earlier work, *Notes on Soil Testing for Engineering Purposes*, Casagrande and Fadum, 1940). Widely published since in various textbooks and reference books.

k, cm/sec (log scale)	**$<10^{2}$**	**$<10^{1}$**	**$<10^{0}$**	**$<10^{-1}$**	**$<10^{-2}$**	**$<10^{-3}$**	**$<10^{-4}$**	**$<10^{-5}$**	**$<10^{-6}$**	**$<10^{-7}$**	**$<10^{-8}$**	**$<10^{-9}$**
Drainage	**Good**						**Poor**		**Practically Impervious**			

Based on the system shown above, the test results would all fall in the poorly permeable to practically impervious range.

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TABLES

Appendix III-E.4

TABLE 1 - PIEZOMETER SLUG TEST RESULTS
Rancho Viejo Cattle Co.
Laredo, TX

										AQTESOLV INPUTS											AQTESOLV RESULTS				
Piezometer ID	Test	Date	Depth to Water (ft btoc)	Total Depth (ft btoc)	Duration (hrs)	h_t/H_i Recovery (%)	Time-Drawdown Response (log h_t/H_i vs. time)	Slug Length (ft)	Calculated Slug Volume Displacement	Observed Displacement	Static Water Column	Saturated Thickness	Filter Pack Length	Well Screen Penetration Depth	Anisotropy Ratio	Casing Radius	Wellbore Radius	Well Skin Radius	Effective Porosity Sand Pack	Aquifer Model	Bouwer-Rice Method	Hvorslev Method	Cooper-Bredehoeft-Papadopulos		
									s(0) (ft)	s(0) (ft)	H (ft)	D (ft)	L (ft)	H (ft)	k_v/k_h --	r (c) (ft)	r(w) (ft)	r(sk) (ft)	n --		K (cm/sec)	K (cm/sec)	K (cm/sec)	T (cm^2/sec)	S --
B-11A (Sands in Eocene using Sonic)	Slug In 1	1/12/2012	4.41	107.97	19.53	26.9%	Straight Line	8	3.320	-2.246	103.56	12	12	12	0.1	0.083	0.25	0.25	0.3	Confined	1.123E-07	1.732E-07	1.982E-07	7.250E-05	3.364E-06
	Slug Out 1	1/13/2012	2.5		24.42	7.4%	Straight Line	8	3.320	2.327	105.47										1.923E-08	2.964E-08	1.461E-09	5.343E-07	1.522E-02
	Slug In 2	1/14/2012	4.66		21.81	29%	Straight Line	4	1.660	-1.138	103.31										1.150E-07	1.755E-07	2.128E-07	7.784E-05	3.007E-06
	Slug Out 2	1/15/2012	3.89		25.22	21.1%	Straight Line	4	1.660	1.190	104.08										5.958E-08	9.184E-08	3.278E-08	1.199E-05	1.648E-03
	Slug In 3	1/16/2012	4.82		6.59	8.1%	Straight Line	8	3.320	-2.245	103.15										8.284E-08	1.277E-07	3.800E-08	1.390E-05	8.009E-04
	Slug Out 3	1/17/2012	3.01		25.05	13.8%	Straight Line	8	3.320	2.328	104.96										3.823E-08	5.893E-08	2.271E-08	8.305E-06	7.286E-04
																				Average	**6.004E-08**	**9.241E-08**	**3.469E-08**	**1.269E-05**	**2.300E-04**
B-101 (Sands in Eocene using GPI)	Slug In 1	1/12/2012	7.69	92.75	4.27	87.5%	Straight Line	8	3.320	-2.264	85.06	14	14	14	0.1	0.083	0.25	0.25	0.3	Confined	3.097E-06	4.734E-06	5.896E-06	2.516E-03	1.000E-05
	Slug Out 1	1/12/2012	7.23		17.31	78.0%	Concave Up	8	3.320	2.359	85.52										4.050E-08	6.658E-08	1.790E-06	7.639E-04	8.000E-04
	Slug In 2	1/13/2012	7.75		21.46	93.3%	Concave Up	12	4.980	-3.367	85.00										2.921E-07	4.724E-07	2.522E-06	1.076E-03	8.056E-04
	Slug Out 2	1/14/2012	7.51		4.46	82.8%	Concave Up	12	4.980	3.514	85.24										2.057E-06	3.107E-06	3.724E-06	1.589E-03	1.598E-04
	Slug In 3	1/14/2012	8.10		19.84	76.5%	Concave Up	8	3.320	-2.246	84.65										7.439E-08	1.086E-07	2.578E-06	1.100E-03	1.500E-04
	Slug Out 3	1/15/2012	7.49		3.35	75.7%	Concave Up	8	3.320	2.353	85.26										2.254E-06	3.406E-06	3.890E-06	1.660E-03	1.211E-04
																				Average	**4.826E-07**	**7.451E-07**	**3.159E-06**	**1.348E-03**	**1.629E-04**
B-102 (Sands in Eocene using GPI)	Slug In 1	1/12/2012	8.65	62.82	3.54	100%	Straight Line	10	4.150	-2.868	54.17	14	14	14	0.1	0.083	0.25	0.25	0.3	Confined	1.034E-05	1.580E-05	3.180E-05	1.357E-02	2.158E-08
	Slug Out 1	1/12/2012	8.66		8.87	96.2%	Concave Up	10	4.150	2.899	54.16										6.479E-06	9.820E-06	1.250E-05	5.336E-03	3.359E-04
	Slug In 2	1/13/2012	8.76		2.78	94.6%	Concave Up	13	5.395	-4.092	54.06										5.735E-06	8.691E-06	1.011E-05	4.313E-03	1.180E-03
	Slug Out 2	1/13/2012	8.60		1.43	84.5%	Concave Up	13	5.395	3.876	54.22										6.345E-06	9.621E-06	1.634E-05	6.971E-03	2.572E-05
	Slug In 3	1/14/2012	8.90		1.70	94.7%	Straight Line	15	6.225	-4.293	53.92										1.041E-05	1.593E-05	1.913E-05	8.164E-03	1.011E-05
	Slug Out 3	1/14/2012	8.36		1.12	77.3%	Concave Up	15	6.225	4.307	54.46										5.920E-06	8.973E-06	1.195E-05	5.101E-03	2.642E-04
																				Average	**7.291E-06**	**1.108E-05**	**1.571E-05**	**6.703E-03**	**2.894E-05**
B-106 (Sands in Eocene using GPI)	Slug In 1	1/12/2012	7.60	83.16	3.95	78.0%	Concave Up	10	4.150	-2.789	75.56	14	14	14	0.1	0.083	0.25	0.25	0.3	Confined	2.083E-06	3.205E-06	3.433E-06	1.465E-03	1.889E-04
	Slug Out 1	1/13/2012	7.55		5.93	73.3%	Concave Up	10	4.150	2.938	75.61										9.112E-07	1.358E-06	1.198E-06	5.110E-04	3.499E-03
	Slug In 2	1/13/2012	8.29		4.53	65.9%	Concave Up	13	5.395	-3.664	74.87										8.246E-07	1.246E-06	1.111E-06	4.741E-04	4.680E-03
	Slug Out 2	1/14/2012	7.58		4.53	69.0%	Concave Up	13	5.395	3.909	75.58										1.141E-06	1.738E-06	1.308E-06	5.580E-04	3.307E-03
	Slug In 3	1/14/2012	8.44		16.70	74.2%	Concave Up	10	4.150	-2.854	74.72										7.290E-08	1.116E-07	9.257E-07	3.950E-04	6.095E-03
	Slug Out 3	1/15/2012	7.67		4.73	71.7%	Concave Up	10	4.150	2.934	75.49										1.149E-06	1.746E-06	1.534E-06	6.544E-04	2.226E-03
																				Average	**7.286E-07**	**1.107E-06**	**1.428E-06**	**6.094E-04**	**2.275E-03**
B-109A (Sands in Eocene using Sonic)	Slug In 2	1/14/2012	6.71	83.99	16.81	29.5%	Straight Line	8	3.320	-2.320	86.04	12	12	12	0.1	0.083	0.25	0.25	0.3	Confined	1.389E-07	2.142E-07	9.900E-08	3.621E-05	8.920E-04
	Slug Out 2	1/15/2012	4.78		24.08	11.9%	Straight Line	8	3.320	2.342	87.97										3.409E-08	5.255E-08	1.839E-08	6.726E-06	8.444E-04
	Slug In 3	1/16/2012	6.88		23.20	27.8%	Straight Line	8	3.320	-2.250	85.87										9.978E-08	1.538E-07	1.965E-07	7.189E-05	1.156E-06
	Slug Out 3	1/17/2012	5.23		22.69	16.5%	Straight Line	8	3.320	2.395	87.52										4.839E-08	7.458E-08	1.150E-08	4.205E-06	6.806E-03
																				Average	**6.915E-08**	**1.066E-07**	**4.504E-08**	**1.647E-05**	**2.775E-04**
B-114A (Shallow Alluvium; Eocene-Quaternary Contact?)	Slug In 1	1/12/2012	10.24	22.78	2.47	61.8%	Concave Up	3	1.245	-0.783	12.54	12.54	10	12.54	0.1	0.083	0.25	0.25	0.3	Unconfined	3.743E-06	4.969E-06	--	--	--
	Slug Out 1	1/12/2012	9.72		18.97	37.5%	Concave Up	3	1.245	0.843	13.06	13.06		13.06							1.448E-07	2.046E-07	--	--	--
	Slug In 2	1/13/2012	10.28		2.06	52.8%	Concave Up	5	2.075	-1.310	12.50	12.50		12.50							2.546E-06	3.649E-06	--	--	--
	Slug Out 2	1/13/2012	9.68		1.60	15.1%	Straight Line	5	2.075	1.321	13.10	13.10		13.10							1.013E-06	1.423E-06	--	--	--
	Slug In 3	1/13/2012	10.78		18.02	54.4%	Concave Up	5	2.075	-1.259	12.00	12.00		12.00							1.457E-07	2.071E-07	--	--	--
	Slug Out 3	1/14/2012	10.18		1.84	32.6%	Straight Line	5	2.075	1.329	12.60	12.60		12.60							2.306E-06	3.284E-06	--	--	--
	Slug In 4	1/17/2012	10.24		16.27	100%	Straight Line	5	2.075	-1.326	12.54	12.54		12.54							1.670E-05	2.361E-05	--	--	--
	Slug Out 4	1/18/2012	10.25		21.06	94.1%	Straight Line	5	2.075	1.327	12.53	12.53		12.53							1.541E-06	2.197E-06	--	--	--
																				Average	**1.365E-06**	**1.922E-06**	--	--	--
B-115 (Sands in Eocene using Sonic)	Slug In 1	1/15/2012	7.16	104.48	22.65	66.3%	Concave Up	10	4.150	-2.790	97.32	15	15	15	0.1	0.083	0.25	0.25	0.3	Confined	2.209E-07	3.357E-07	3.073E-07	1.405E-04	6.315E-04
	Slug Out 1	1/16/2012	5.92		8.43	7.4%	Straight Line	10	4.150	2.888	98.56										3.333E-08	5.082E-08	5.822E-10	2.662E-07	1.000E-01
	Slug In 2	1/16/2012	8.64		15.35	20.8%	Straight Line	10	4.150	-2.795	95.84										4.601E-08	6.343E-08	2.421E-09	1.107E-06	1.000E-01
	Slug Out 2	1/17/2012	6.35		25.18	39.8%	Concave Up	10	4.150	2.918	98.13										3.567E-08	5.439E-08	8.248E-08	3.771E-05	3.199E-02
																				Average	**5.896E-08**	**8.759E-08**	**1.375E-08**	**6.286E-06**	**2.120E-02**
B-118 (Silts in Eocene using Sonic)	Slug In 2	1/14/2012	11.95	87.55	15.59	82.9%	Concave Up	15	6.225	-4.160	75.60	12	12	12	0.10	0.083	0.25	0.25	0.3	Confined	7.170E-07	1.096E-06	1.335E-06	4.883E-04	6.667E-05
	Slug Out 2	1/15/2012	11.06		25.82	76.3%	Concave Up	15	6.225	4.330	76.49										1.616E-07	2.373E-07	4.273E-07	1.563E-04	2.784E-03
	Slug In 3	1/16/2012	12.14		20.48	81.5%	Concave Up	15	6.225	-4.138	75.41										4.076E-07	6.236E-07	8.257E-07	3.020E-04	4.570E-04
	Slug Out 3	1/17/2012	11.31		24.21	79.2%	Concave Up	15	6.225	4.326	76.24										1.874E-07	2.819E-07	5.982E-07	2.188E-04	1.120E-03
	Slug In 4	1/18/2012	12.25		8.78	56.0%	Concave Up	10	4.150	-2.755	75.30										4.954E-07	7.597E-07	6.644E-07	2.430E-04	6.638E-04
	Slug Out 4	1/18/2012	11.11		14.85	60.1%	Concave Up	10	4.150	2.933	76.44										2.325E-07	3.311E-07	3.284E-07	1.201E-04	3.342E-03
																				Average	**3.172E-07**	**4.751E-07**	**6.282E-07**	**2.298E-04**	**7.714E-04**
B-126 (Sands in Eocene using Sonic)	Slug In 1	1/13/2012	8.58	105.55	4.53	100%	Straight Line	10	4.150	-2.920	96.97	24	24	24	0.1	0.083	0.25	0.25	0.3	Confined	1.645E-05	2.467E-05	5.165E-05	3.778E-02	7.213E-09
	Slug Out 1	1/14/2012	8.47		2.78	99.2%	Concave Up	10	4.150	2.913	97.08										1.236E-05	1.833E-05	2.524E-05	1.846E-02	2.570E-06
	Slug In 2	1/14/2012	8.50		1.56	97.3%	Concave Up	13	5.395	-3.754	97.05										1.396E-05	2.088E-05	3.498E-05	2.559E-02	1.144E-06
	Slug Out 2	1/14/2012	8.46		1.32	97.2%	Concave Up	13	5.395	3.898	97.09										1.439E-05	2.155E-05	3.143E-05	2.299E-02	1.012E-06
	Slug In 3	1/14/2012	8.55		0.88	94.6%	Concave Up	13	5.395	-3.668	97.00										1.419E-05	2.111E-05	4.329E-05	3.167E-02	3.733E-08
	Slug Out 3	1/14/2012	8.37		1.02	93.7%	Concave Up	13	5.395	3.915	97.18										1.336E-05	2.002E-05	3.543E-05	2.592E-02	1.964E-07
																				Average	**1.407E-05**	**2.101E-05**	**3.606E-05**	**2.638E-02**	**2.323E-07**

ASSUMPTIONS

Confined Aquifer (except for B-114A); Filter pack interval will be used as the screen length during slug test analyses due to the relative difference between typical filter pack permeability and expected formation permeability

Appendix III-E.4

TABLE 2 - PIEZOMETER PUMP DOWN TEST RESULTS
Pescadito Environmental Resource Center
Laredo, TX

Piezometer ID	Test	Date	Depth to Water * (ft btoc)	Total Depth (ft btoc)	Duration (hrs)	Recovery (%)	Approximate Volume Purged (Gal)	Drawdown relative to static water level at Time 1	Time 1	Drawdown relative to static water level at Time 2	Time 2	Saturated Thickness	Filter Pack Length	Anisotropy Ratio	Piezometer Casing Diamater	Borehole/Filter Pack Diameter	Transformation Ratio	GWBU Condition	Hvorslev Method	Cooper-Bredehoeft-Papadopulos	
								H_1 (ft)	t_1 (sec)	H_2 (ft)	t_2 (sec)	D (ft)	L (ft)	k_v/k_h --	r (c) (ft)	r(w) (ft)	$(K_h/K_v)^{1/2}$ --		K_h (cm/sec)	K (cm/sec)	T (cm^2/sec)
B-101 (Sands in Eocene using GPI)	Test 04/03 - 04/04	4/3/2012	3.09	92.85	22.96	94.6%	17.25	39.494	6900.000	64.031	15420.000	4.5	14	0.1	0.167	0.5	3.162	Confined	3.874E-06	--	--
	Test 04/04 - 04/05	4/4/2012	9.29		21.10	99.4%	14	27.414	4140.000	54.176	10500.000								4.737E-06	--	--
																		Average	**4.283E-06**		
B-102 (Sands in Eocene using GPI)	Test 04/03 - 04/04	4/3/2012	6.1	63.05	21.46	94.5%	14	14.958	2160.000	36.018	5400.000	9	14	0.1	0.167	0.5	3.162	Confined	1.115E-05	--	--
	Test 04/04 - 04/05	4/4/2012	9.38		21.68	99.4%	8.5	15.034	2100.000	30.048	4380.000								1.096E-05	--	--
																		Average	**1.105E-05**	--	--
B-114A (Shallow Alluvium; Eocene-Quaternary Contact?)	Test 04/02 - 04/04	4/2/2012	9.55	22.97	52.08	79.6%	4.5	2.939	108720.000	6.037	151260.000	12.54	12	0.1	0.167	0.5	3.162	Unconfined	**6.58722E-07**	--	--
B-124 (Sands in Eocene using Sonic)	Test 04/02 - 04/04	4/2/2012	1.9	117.2	62.88	92.1%	18.75	40.211	20940.000	80.89	78060	15	15	0.1	0.167	0.5	3.162	Confined	**6.168E-07**	**4.501E-06**	**2.058E-03**
B-126 (Sands in Eocene using Sonic)	Test 04/03 - 04/04	4/3/2012	4.05	104.31	25.16	97.5%	22.5	30.640	4200.000	74.91	10320.00	24	24	0.1	0.167	0.5	3.162	Confined	7.598E-06	--	--
	Test 04/05 - 04/06	4/5/2012	3.04		19.16	93.6%	18	42.594	5820.000	76.30	13800.00								4.957E-06	--	--
																		Average	**6.137E-06**	--	--

NOTES

* - Measured with equipment in the piezometer

ASSUMPTIONS

Filter pack interval will be used as the screen length during slug test analyses due to the relative difference between typical filter pack permeability and expected formation permeability