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**ASSESSMENT AND INTERPRETATION
OF CROSS- AND DOWN-HOLE SEISMOGRAMS
AT THE PADUCAH GASEOUS DIFFUSION PLANT**

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September 1991

MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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GASEOUS DIFFUSION PLANT
SAFETY ANALYSIS REPORT UPGRADE PROGRAM

ASSESSMENT AND INTERPRETATION
OF CROSS- AND DOWN-HOLE SEISMOGRAMS
AT THE PADACUH GASEOUS DIFFUSION PLANT

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for the
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MASTER

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ABSTRACT

This paper is an assessment and interpretation of cross-and down-hole seismograms recorded by Automated Sciences Group (ASG), 1991, at four sites in the vicinity of the Paducah Gaseous Diffusion Plant (PGDP). Arrival times of shear (S-) and compressional (P-) waves are recorded on these seismograms in milliseconds. Together with known distances between energy sources and seismometers lowered into boreholes, these arrival times are used to calculate S- and P-wave velocities in unconsolidated soils and sediments that overlie bedrock approximately 320 ft beneath PGDP.

Tabulated S- and P-wave velocity estimates at Sites 1 through 4 are presented in Appendices 1 through 4, respectively. Comparisons of velocity estimates among the four sites are tabulated in Appendix 5. S- and P-wave velocity estimates to be used in four soil columns (unconsolidated soils from the surface to bedrock) are also in Appendix 5.

The soil columns are modified after an earlier draft by ERC Environmental and Energy Services Company (ERCE), 1990. In addition to S- and P-wave velocity estimates from this paper, the soil columns contain ERCE's lithologic and other geotechnical data for unconsolidated soils and sediments from the surface to bedrock. Soil columns for Sites 1 through 4 and a site location map are in Plates 1 through 5 of Appendix 6.

The velocities in the four soil columns are input parameters for the SHAKE computer program, a nationally recognized computer model that simulates ground response of unconsolidated materials to earthquake generated seismic waves (Schnabel et al. 1974). The results of the SHAKE simulation are combined with predicted ground responses on rock foundations (caused by a given design earthquake) to predict ground responses of facilities with foundations placed on unconsolidated materials.

1. INTRODUCTION

Oak Ridge National Laboratory staff were asked to provide an assessment and interpretation of ASG's (1991) data package, "Seismic Wave Study of Subsurface Conditions in the Vicinity of the Paducah Gaseous Diffusion Plant." As a byproduct of this assessment an independent quality assurance of S- and P-wave velocity data presented in ASG's data package was also obtained.

ASG provided cross-hole seismic data in shallow holes (up to 135 ft deep) at each of four sites and down-hole seismic data in deep holes (300 and 350 ft deep) at Sites 3 and 4. A limited amount of shallow down-hole data are available for Site 2, and no down-hole data are available for Site 1. Cross- and down-hole data are discussed separately in the following sections. Tables and figures for cross- and down-hole data are presented in Appendices 1 through 4 for Sites 1 through 4, respectively. Appendix 5 contains a summary of seismic information to be used as input for Sites 1 through 4 revised soil columns as presented by ERCE's (1990) draft document, "Recommended Soil Columns for Use in Amplification Studies, Paducah Gaseous Diffusion Plant." Soil columns for Sites 1-4 and a site location map are in Plates 1 through 5 of Appendix 6.

Formats for tables and figures in Appendices 1 through 3 are consistent throughout this report. The format in Appendix 4 differs because seismic cross-hole velocities at Site 4 were only measured in one direction, rather than in both forward and reverse directions.

Tables 1 and 2 of Appendices 1 through 3 present forward and reverse measured S-wave velocities (as measured by the cross-hole method) at 5-ft-depth intervals from 5 ft below the surface to depths ranging from 65 to 135 ft. Table 3 compares revised S-wave velocities as a function of depth measured in both forward and reverse directions and provides mean values and differences of these velocities. Table 4 provides information similar to that in Table 3 for measured cross-hole P-wave velocities. Table 5 (Appendix 3 only) lists measured down-hole S-wave velocities and calculated down-hole P-wave velocities to bedrock for Site 3.

Tables 1 and 2 of Appendix 4 (Site 4) provide shallow measured cross-hole S- and P-wave velocities, respectively. Table 3 presents a measured down-hole S-wave velocity and calculated down-hole P-wave velocities to bedrock for Sites 1, 2, and 4.

Five tables are provided in Appendix 5 (Summary). Table 1 lists mean value measured cross-hole S-wave velocity estimates at 5-ft intervals for shallow depths ranging up to 135 ft for all four sites. Table 2 lists linear least-squares fit measured down-hole S-wave velocity estimates at selected intervals from a depth of 123 ft to 334 ft, respectively, and calculated P-wave velocities for the same intervals for all sites. Table 3 lists mean value measured cross-hole P-wave velocity estimates for Sites 1 through 3 and single valued measured P-wave estimates for Site 4. Tables 4 and 5 list S- and P-wave velocity estimates, respectively, for inclusion in ASG's soil columns at all 4 sites.

2. CROSS-HOLE SEISMOGRAMS

2.1 S-WAVES

The evaluation of ASG's original S-wave velocity estimates derived from cross-hole seismograms allows for three possible outcomes. Either (1) the interpretation of the seismogram is correct and the S-wave velocity need not be revised, (2) the interpretation is incorrect and the S-wave velocity must be revised, or (3) the seismogram is of such poor quality that the S-wave velocity must be rejected.

Tables 1 and 2 of Appendices 1 through 3 (Sites 1 through 3) present S-wave data. Table 2 presents seismic data recorded in the reverse direction from that of Table 1. The first two columns provide depths and S-wave velocities in 5-ft increments from Appendix B of ASG's document (1991). The next two columns indicate whether the S-wave velocity in column 2 at a given depth in column 1 was rejected or revised. Subsequent columns constitute a checklist of reasons why the original data were rejected or revised. First arrivals were often weak or interfered by noise (for example, operating plant equipment at Site 2). Also, the identification of the arriving S-wave was often inconsistent, both between seismograms and within a given seismogram; that is, the polarity, sharpness, and character of the "first-arrival" S-waves differed. Finally, S-wave velocities measured from energy source to near receiver and from the reverse direction were inconsistent. The evaluation rejected most weak and noisy data and established consistency in identifying first arrivals.

Some S-wave velocity revisions are unrelated to the interpretation of seismograms. At Site 3, both S- and P-wave velocities in forward and reverse directions between energy sources and near and far receivers were inconsistent even though the quality of seismograms was excellent (ASG 1991, Appendix B). These inconsistencies suggest that the distances between the energy source and receivers were calculated incorrectly (incorrect borehole deviation data). ASG recomputed the borehole deviations for all four sites. These changes produced slightly revised results for Sites 1 and 2 and changed the results at Site 3 significantly. S- and P-wave velocity estimates in forward and reverse directions are now consistent at Sites 1 through 3, and recalculated distances between energy sources and receivers are believed to be correct. At Site 4, S- and P-wave velocities were measured in only one direction. Therefore, only single valued estimates are available at Site 4, and measured velocities are not known with the same degree of confidence as at Sites 1 through 3.

Table 3 presents revised S-wave velocities of Tables 1 and 2 side-by-side for comparison, mean values, and differences for forward and reverse recordings as a function of depth for Sites 1, 2, and 3 (Appendices 1 through 3). S-wave velocities are generally consistent throughout. S-wave velocities in the forward and reverse directions differ from a few tens-of-feet per second to about 150 ft/s. Figures 1.1, 2.1, and 3.1 are forward and reverse S- and P-wave velocities for Sites 1, 2, and 3 (Appendices 1 through 3), plotted side-by-side for comparison. Cross-hole P-wave velocities (discussed in greater detail in Sect. 2.2) in the forward and reverse directions differ from a few tens-of-feet per second to about 650 ft/s, 1200 ft/s, and 1800 ft/s for Sites 1 through 3, respectively.

2.2 P-WAVES

Unlike S-wave energy arrivals, P-wave energy arrivals were identified in a consistent manner. This evaluation does not challenge the interpretation of seismograms with respect to P-wave energy arrival times. However, in the original data package, calculated P-wave velocities in the reverse direction (energy source at Z11) were nearly twice as high as those in the forward direction (energy source at Z09) at Site 3. This suggests that the hole deviation corrections may have been in error. Hole deviation data were recalculated, and revised S- and P-wave velocities were determined for all sites. Discussion of the revised S-wave velocities is presented in Sect. 2.1.

Revised P-wave velocity estimates are presented in Table 4 of Appendices 1 through 3 (Sites 1 through 3) and in Table 2 of Appendix 4 (Site 4). Revised P-wave velocities in forward and reverse directions now compare favorably and are reasonable at Sites 1 through 3. However, few seismograms were recorded in the reverse direction at Site 4.

3. DOWN-HOLE SEISMOGRAMS

Shallow down-hole seismograms were recorded at Site 2 and deep down-hole seismograms were recorded at Sites 3 and 4. Since the purpose of the down-hole surveys is to obtain S- and P-wave velocities at depths below the bottom of the cross-hole survey holes, only the down-hole surveys at Sites 3 and 4 will be discussed further.

The original intention of the down-hole surveys was to determine interval velocities every 10 ft to the bottom of each hole. Unfortunately, the signals were too weak to determine arrival times with the required degree of accuracy (ASG 1991, Appendix C).

Alternatively, down-hole S-wave velocities were determined by plotting arrival times as a function of depth and applying linear least-squares fits to data from the deep holes. The onset (first arrival) of S-wave energy could not be identified throughout the depth of the hole. Instead, later cycles of the arriving energy were selected for various depth intervals (care was taken to pick the same cycle for a given depth interval). Separate sets of linear least-squares fits were provided for each depth interval in the deep holes.

The quality of down-hole seismograms was too poor to provide reliable estimates of P-wave velocities. As an alternative, down-hole P-wave velocities were calculated by using the equation,

$$\sigma = \frac{\left[1 - 2 \left(\frac{V_s}{V_p} \right)^2 \right]}{\left[2 - 2 \left(\frac{V_s}{V_p} \right)^2 \right]},$$

where

- σ = Poisson's ratio,
- V_s = S-wave velocity,
- V_p = P-wave velocity.

Then, V_p was calculated at appropriate depth intervals where V_s is known. Most likely values of P-wave velocities and upper and lower limit values are based on mean values of Poisson's ratio and one standard deviation values above and below the mean, respectively. Poisson's ratio is estimated from appropriate cross-hole seismograms where reliable S- and P-wave velocity estimates are both available (Tables 3 and 4, Appendices 2 and 3).

Measured S-wave down-hole velocity estimates are presented in Tables 5 and 3 of Appendices 3 and 4 (Sites 3 and 4), respectively. Calculated P-wave down-hole velocity estimates are also presented in these tables.

4. SUMMARY

Table 1 of Appendix 5 summarizes cross-hole S-wave velocity estimates where reliable data were available at all four sites. S-wave velocities are generally above 1200 ft/s below a depth of about 75 ft and generally less than 1200 ft/s at shallower depths, except at Site 4.

The increase in S-wave velocity as a function of depth is believed to be related to differences in lithology, age, and increasing overburden pressure. All sites are underlain by marine sands and silts of Paleogene age. Marine sediments have relatively uniform lithologies relative to continental sediments. These Paleogene sediments are also relatively old compared to the overlying Holocene and Pleistocene sediments (several tens-of-millions of years old compared to 10,000 to a few million years old). Their age and depth of burial combine to produce greater consolidation of Paleogene sediments relative to younger sediments at shallower depth. The modulus of rigidity increases (consequently, the S-wave velocity increases) as the degree of consolidation increases.

At shallower depths, shown in Table 1, S-wave velocities are generally greater than 1100 ft/s at Sites 2 and 4 and generally less than 1100 ft/s at Sites 1 and 3. The relatively low S-wave velocities at shallow depth at Site 1 may be attributable to high moisture content in the Porters Creek Clay. The low S-wave velocities at shallow depth at Site 3 may be attributable to the presence of poorly consolidated Holocene sediments in relation to Pleistocene sediments at Sites 2 and 4.

Table 2 of Appendix 5 summarizes measured down-hole S-wave velocity estimates and calculated down-hole P-wave velocity estimates where reliable data were available from a depth of 123 to 334 ft at Sites 3 and 4. The down-hole S-wave velocity at Site 3 ranges from 1155 to 1545 ft/s, and the down-hole S-wave velocity is constant (1550 ft/s) at Site 4.

Table 2 of Appendix 5 also summarizes calculated down-hole P-wave velocities. At Site 3, down-hole P-wave velocities range from 5710 to 7635 ft/s, and at Site 4 the P-wave velocity is constant (7605 ft/s).

Table 3 of Appendix 5 summarizes cross-hole P-wave velocity estimates, where reliable data are available, at all four sites. There is wide variation in these results for Sites 2, 3, and 4. P-wave velocity estimates from 70 to 115 ft are generally high (greater than 6000 ft/s). P-wave velocity estimates between 70 and 85 ft at Site 4 are unusually high (greater than 7500 ft/s) for unconsolidated sediments. Rather uniform P-wave velocity estimates at Site 1 are believed to be attributable to a more uniform lithology in the marine Porters Creek Clay in contrast to the continental gravel, sand, and silt at the other sites.

Table 4 contains S-wave velocity estimates for use in the soil columns. At each site, cross-hole velocities from Tables 1 and 3 and down-hole velocities from Table 2 were used to compile information for the soil columns. Where S-wave velocity estimates vary by less than 100 ft/s throughout a given depth interval, that interval is considered to be one layer. Mean value velocity estimates are given for each layer in Table 4.

At Site 1, the mean value cross-hole S-wave velocity estimate is available only for the upper half of the Porters Creek Clay. This mean value velocity is extended downward

through the soil column to the contact between the Porters Creek Clay and the underlying Clayton-McNairy strata. This is acceptable because the lithology of the Porters Creek Clay is relatively uniform. Also, no S-wave velocity estimates are available at Site 1 for the Clayton-McNairy interval to the top of rock. Down-hole S-wave velocity estimates from the top of the Clayton-McNairy strata to the top of rock at Site 4 are transposed to Site 1 and extend from the Porters Creek-Clayton-McNairy contact to the top of rock [from 123 ft below the surface to the top of rock (assumed to be at the same depth as at Site 4 [322 ft])]. Seismic characteristics of the Clayton-McNairy stratigraphic section beneath Site 1 are expected to be similar to that beneath Site 4. This site is much closer to Site 4 than to Site 3, the only other site where deep down-hole seismic data are available. Sites 1 and 4 also have complete and nearly complete sections of Clayton-McNairy strata, respectively, whereas the top of the Clayton-McNairy section is eroded 10 ft deeper at Site 3 and replaced by the regional aquifer.

At Site 2, mean value cross-hole S-wave velocity estimates are available all the way to the contact between the regional aquifer and the underlying Clayton-McNairy strata. Again, no S-wave velocity estimates are available at Site 2 for the Clayton-McNairy strata to the top of bedrock. From the bottom of the regional aquifer to the top of rock, down-hole S-wave velocity estimates from Site 4 are transposed to Site 2 and extended from the regional aquifer-Clayton-McNairy contact at 120 ft below the surface to the top of rock [assumed to be at the same depth as at Site 4 (322 ft)]. Site 2 is also closer to Site 4 than Site 3. Also, the Site 2 Clayton-McNairy section is nearly complete, like that of Site 4.

At Site 3, mean value cross-hole S-wave velocity estimates are available to about 20 ft beneath the contact between the regional aquifer and the Clayton-McNairy strata (about 120 ft beneath the surface). From there, down-hole S-wave velocity estimates are available nearly to the top of rock (334 ft beneath the surface) at Site 3.

At Site 4, single valued cross-hole S-wave velocity estimates are available to about 20 ft beneath the contact between the regional aquifer and the Clayton-McNairy strata. From there, down-hole S-wave velocity estimates are available nearly to the top of rock (322 ft beneath the surface) at Site 4.

Table 5 contains P-wave velocity estimates for use in the soil columns. At each site, measured cross-hole velocities from Table 3 and calculated down-hole velocities from Table 2 were used to compile P-wave velocity data for the soil columns. Where P-wave velocity estimates vary by less than 500 ft/s throughout a given depth interval, that interval is considered to be one layer. Mean value P-wave velocity estimates are given for each layer in Table 5.

At Sites 1 through 3 the same strategies used for compiling S-wave velocity data for the soil columns are also used for P-wave velocity data.

REFERENCES

- ASG (Automated Sciences Group, Inc.). 1991. "Final Data Package, Geophysical Study of Subsurface Conditions in the Vicinity of the Paducah Gaseous Diffusion Plant." Oak Ridge, Tennessee.
- ERCE (ERC Environmental and Energy Services Co., Inc.). 1990. Draft, "Recommended Soil Columns for Use in Amplification Studies, Paducah Gaseous Diffusion Plant." Knoxville, Tennessee.
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APPENDIX 1

SITE 1

Table 1. Shear (S-) wave cross-hole velocity data (ft/sec)
(energy source - Z03, near receiver - Z01, far receiver - Z02)

Depth (ft)	S-wave velocity between near and far receivers	Rejected (yes, no, or blank [not applicable])	Revised ^a (ft/sec, no, or blank [not applicable])	Reasons for rejection or revision ^a								
				Signal				Inconsistencies				
				Noise (receiver)		Weak (receiver)		Wave form			Results	
				Near	Far	Near	Far	Polarity	Sharpness	Character	Z03 (source to near receiver)	Z02 (near to far receiver)
5	---											
10	760	Yes						X		X		
15	---											
20	---											
25	---											
30	---											
35	1060	No	No									
40	1060	No	No									
45	1060	No	No									
50	1050	No	No									
55	1180	No ^b	No	X		X						
60	1270	Yes		X	X	X	X	X	X	X		X
65	1130	No	No									

^aMinor revisions are based primarily on recalculated hole deviations.

^bNo results or rejected in the first draft data package.

^aMinor revisions are based primarily on recalculated hole deviations.

^bNo results or rejected in the first draft data package.

Table 2. Shear (S-) wave cross-hole velocity data (ft/sec)
(energy source - Z02, near receiver - Z01, far receiver - Z03)

Depth (ft)	S-wave velocity between near and far receivers	Rejected (yes, no, or blank [not applicable])	Revised ^a (ft/sec, no, or blank [not applicable])	Reasons for rejection or revision ^a								
				Signal				Inconsistencies				
				Noise (receiver)		Weak (receiver)		Wave form			Results	
				Near	Far	Near	Far	Polarity	Sharpness	Character	Z02 (source to near receiver)	Z03 (near to far receiver)
5	---											
10	720	No	770	X			X		X		X	
15	---											
20	1590	Yes			X			X				
25	---											
30	---											
35	---	No	970			X						
40	980	No	No									
45	990	No	1010									
50	990	No	1000									
55	---											
60	780	Yes					X	X			X	X
65	1070	No	1100									

^aMinor revisions are based primarily on recalculated hole deviations (except for the seismogram recorded at 10 ft).

^bNo results or rejected in the first draft data package.

^aMinor revisions are based primarily on recalculated hole deviations (except for the seismogram recorded at 10 ft).

^bNo results or rejected in the first draft data package.

Table 3. Shear (S-) wave cross-hole velocity data
[comparison of forward (Z02) and reverse (Z03) direction results]

Depth	S-wave velocities (ft/sec)			
	Energy source ^a		Difference	Mean
	Z02	Z03		
5	---	---	---	---
10	770	---	---	770
15	---	---	---	---
20	---	---	---	---
25	---	---	---	---
30	---	---	---	---
35	970	1060	90	1015
40	980	1060	80	1020
45	1010	1060	50	1035
50	1000	1050	50	1025
55	---	1180?	---	1180?
60	---	---	---	---
65	1100	1130	30	1115
^a Velocity from near to far receiver.				

Table 4. Compressional (P-) wave cross-hole velocity data comparison of forward (Z02) and reverse (Z03) direction results

Depth	P-wave velocities (ft/sec)			
	Energy source		Difference	Mean
	Z02	Z03		
5	---	---		
10	---	---		
15	---	---		
20	---	---		
25	5200	---	---	5200
30	5310	5370	60	5340
35	5640	5630	10	5635
40	5140	5470	330	5305
45	5100	5200	100	5150
50	5540	5460	80	5500
55	5120	5630	510	5375
60	5210	5860	650	5535
65	5250	5270	20	<u>5260</u> Mean 5367 Range $\pm$ ~ 250

Figure 1.1 Forward and reverse S- and P-wave velocities at Site 1.

APPENDIX 2

SITE 2

**Table 1. Shear (S-) wave cross-hole velocity data (ft/sec)
(energy source - Z05, near receiver - Z06, far receiver - Z07)**

[illegible]

Table 1. (Continued)

				Reasons for rejection or revision ^a									
				Signal				Inconsistencies					
				Noise (receiver)		Weak (receiver)		Wave form			Results		
Depth (ft)	Velocity between near and far receivers (ft/sec)	Rejected (yes, no, or blank [not applicable])	Revised ^a (ft/sec, no, or blank [not applicable])	Near	Far	Near	Far	Polarity	Sharpness	Character	Z05 (source to near receiver)	Z07 (near to far receiver)	
80	1120	No	1150										
85	1490	Yes				X	X	X		X		X	
90	1580	No	1340			X	X	X	X	X	X		
95	1380	No	1320					X			X		
100	1340	No	1360										
105	1230	No	1250										
110	1370	No	1180				X				X		
115	1480	No	No										
120	1860	Yes					X	X			X	X	
125	1220	No	1200				X	X	X	X			
130	1020	Yes				X	X				X		
135	1310	No	1200			X					X		

^aMinor revisions are based primarily on recalculated hole deviations.^bNo results or rejected in the first draft data package.

Table 2. Shear (S-) wave cross-hole velocity data (ft/sec)
(energy source - Z07, near receiver - Z06, far receiver - Z05)

Depth (ft)	Velocity between near and far receivers (ft/sec)	Rejected (yes, no, or blank [not applicable])	Revised* (ft/sec, no, or blank [not applicable])	Reasons for rejection or revision*									
				Signal				Inconsistencies					
				Noise (receiver)		Weak (receiver)		Wave form			Results		
				Near	Far	Near	Far	Polarity	Sharpness	Character	Z07 (source to near receiver)	Z05 (near to far receiver)	
5	600	Yes				X	X	X					
10	680	No	620					X	X				
15	630	No	640										
20	730	No	No										
25	1070	No?	No										
30	--- ^b					X	X						
35	1320	Yes						X		X		X	
40	1190	No	1180										
45	980	No	1280			X					X		
50	---			X				X	X	X			
55	---			X				X	X	X			
60	1120	No	1080										
65	1080	No	1030										
70	1080	No	1030										
75	1370	Yes					X	X	X		X		

Table 2. (Continued)

			Reasons for rejection or revision ^a									
			Signal			Inconsistencies				Results		
			Noise (receiver)		Weak (receiver)		Wave form			Energy source		
Depth (ft)	Velocity between near and far receivers (ft/sec)	Rejected (yes, no, or blank [not applicable])	Revised ^a (ft/sec, no, or blank [not applicable])	Near	Far	Near	Far	Polarity	Sharpness	Character	Z07 (source to near receiver)	Z05 (near to far receiver)
80	---	No	1300					X				
85	1770	Yes				X	X	X	X	X	X	X
90	1360	No	1280									
95	1260	No	1200									
100	1230	Yes				X						
105	1280	No	1240									
110	---											
115	1790	No	1550					X			X	X
120	1970	No	1470			X					X	X
125	1120	Yes				X	X					
130	---											
135	---											

^aMinor revisions are based primarily on recalculated hole deviations.^bNo results or rejected in the first draft data package.

**Table 3. Shear (S-) wave cross-hole velocity data
[comparison of forward (Z05) and reverse (Z07) direction results]**

Depth	Energy source		Difference	Mean
	Z05	Z07		
5	---	---	---	---
10	580	620	40	600
15	620	640	20	630
20	740	730	10	735
25	---	1070	---	1070
30	---	---	---	---
35	---	---	---	---
40	1180	1180	0	1180
45	--	1280	---	1280
50	---	---	---	---
55	---	---	---	---
60	1170	1080	90	1125
65	1180	1030	150	1105
70	1100	1030	70	1065
75	---	---	---	---
80	1150	1300	150	1225
85	---	---	---	---
90	1340	1280	60	1310
95	1320	1200	120	1260
100	1360	---	---	1360
105	1250	1240	10	1245
110	1180	---	---	1180
115	1480	1550	70	1515
120	---	1470	---	1470
125	1290	---	---	1290
130	---	---	---	---
135	1200	---	---	1200

Table 4. Compressional (P-) wave cross-hole velocity comparison of forward (Z05) and reverse (Z07) direction results

Depth	Energy source		Difference	Mean
	Z05	Z07		
5 ^a	---	---	---	---
10	---	---	---	---
15	1920	1800	120	1860
20	2570	2170	400	2370
25	3200	2830	370	3015
30	3650	3110	540	3380
35	4940	4560	380	4750
40	4620	4360	260	4490
45	6730	4530	1000	5630
50	---	---	---	---
55	5800	3730	2070	4775
60	5830	5450	380	5640
65 ^a	5910	---	---	5910
70 ^b	---	---	---	---
75	4920	4800	120	4860
80	6190	---	---	6190
85	6570	6300	270	6435
90	7370	6150	1220	6770
95	6500	6040	460	6270
100	6330	6320	10	6315
105	6650	5980	670	6315
110	6330	6080	250	6205
115	6910	---	---	6910
120	---	---	---	---
125	5610	6160	550	5835
130	5230	5540	310	5385
135 ^b	5570	---	---	5570

^aP-wave velocities based on sources to near-receiver arrival times (no P-waves recorded by far receiver from 5 to 65 ft).
^bP-wave velocities based on differences in arrival times between near- and far-receivers, from 70 to 135 ft.

Figure 2.1 Forward and reverse S- and P-wave velocities at Site 2.

APPENDIX 3

SITE 3

Table 1. Shear wave cross-hole velocity data (ft/sec)
(energy source - Z09, near receiver - Z10, far receiver - Z11)

Depth (ft)	Velocity between near and far receivers (ft/sec)	Rejected (yes, no, or blank [not applicable])	Revised ^a (ft/sec, no, or blank [not applicable])	Reasons for rejection or revision ^a									
				Signal				Inconsistencies					
				Noise (receiver)		Weak (receiver)		Wave form			Results		
				Near	Far	Near	Far	Polarity	Sharpness	Character	Z09 (source to near receiver)	Z11 (near to far receiver)	
5	700 ^b	No	620					X	X		X	X	
10	700	No	620					X	X		X	X	
15	760	No	770										
20	790	No	No										
25	870	No	880										
30	950	No	No										
35	940	No	No										
40	940	No	No										
45	990	No	No										
50	980	Yes					X				X		
55	900	No	No										
60	880	Yes					X						
65	900	No	1010			X	X				X	X	

Table 1. (Continued)

Depth (ft)	Velocity between near and far receivers (ft/sec)	Rejected (yes, no, or blank [not applicable])	Revised ^a (ft/sec, no, or blank [not applicable])	Reasons for rejection or revision ^a							
				Signal			Inconsistencies				Results
				Noise (receiver)		Weak (receiver)		Wave form			
				Near	Far	Near	Far	Polarity	Sharpness	Character	Z09 (source to near receiver)
70	1220	Yes		X	X						
75	1180	No	1230								X
80	1270	No	1180					X	X		X
85	---				X						
90	1180	No	1210								X
95	---					X			X		
100	1000	Yes							X	X	X
105	---				X					X	
110	970	No	1040								
115	1050	No	1110							X	X

^aRevised data are based on corrected hole deviation calculations. Original hole deviations were calculated in error. Several revisions were also based on reinterpretation of seismograms.

^bNo results or rejected in the first draft data package.

^aRevised data are based on corrected hole deviation calculations. Original hole deviations were calculated in error. Several revisions were also based on reinterpretation of seismograms.

^bNo results or rejected in the first draft data package.

Table 2. Shear wave cross-hole velocity data
(energy source - Z11, near receiver - Z10, far receiver - Z09)

		Reasons for rejection or revision ^a									
		Velocity between near and far receivers (ft/sec)	Rejected (yes, no, or blank [not applicable])	Revised ^a (ft/sec, no, or blank [not applicable])	Signal				Inconsistencies		
					Noise (receiver)		Weak (receiver)		Wave form		
					Near	Far	Near	Far	Polarity	Sharpness	Character
Depth (ft)											Results Z11 (source to near receiver) Z09 (near to far receiver)
5		620	No	No							
10		640	No	630							
15		870	No	860							
20		930	No	920							
25		920	No	900							
30		1030	No	1000							
35		1060	No	1010							
40		950	No	890							
45		990	Yes		X						
50		1050	Yes		X	X					X
55		1180	No	1060							X
60		910	Yes		X	X					X
65		1130	No	970							

Table 2. (Continued)

		Reasons for rejection or revision ^a										
		Signal				Inconsistencies						
		Noise (receiver)		Weak (receiver)		Wave form			Results			
Depth (ft)	Velocity between near and far receivers (ft/sec)	Rejected (yes, no, or blank [not applicable])	Revised ^a (ft/sec, no, or blank [not applicable])	Near	Far	Near	Far	Polarity	Sharpness	Character	Z11 (source to near receiver)	Z09 (near to far receiver)
70	---					X	X					
75	1370	No	1140			X						
80	1800	No	1230	X	X						X	X
85	---				X							
90	1640	No	1310	X	X						X	X
95	---				X		X					
100	1430	No	1210								X	X
105	1610	Yes		X	X	X						
110	1430	No	1170								X	X
115	1510	No	1210								X	X

^aRevised data are based on corrected hole deviation calculations. Original hole deviations were in error. One revision (@ 80 ft) was also based on reinterpretation of the seismogram.

^bNo results or rejected in the first draft data package.

*Revised data are based on corrected hole deviation calculations. Original hole deviations were in error. One revision (@ 80 ft) was also based on reinterpretation of the seismogram.

^bNo results or rejected in the first draft data package.

**Table 3. Shear (S-) wave cross-hole velocity (ft/sec) summary
[comparison of forward (Z09) and reverse (Z11) direction results]**

Depth (ft)	S-wave velocities (ft/sec)			
	Energy source ^a		Difference	Mean
	Z09	Z11		
5	620	620	0	620
10	620	630	10	625
15	770	860	90	815
20	790	920	130	855
25	880	900	20	890
30	950	1000	50	975
35	940	1010	70	975
40	940	890	50	915
45	990	---	---	990
50	---	---	---	---
55	900	1060	160	980
60	---	---	---	---
65	1010	970	40	990
70	---	---	---	---
75	1230	1140	90	1185
80	1180	1230	50	1205
85	---	---	---	---
90	1210	1310	100	1250
95	---	---	---	---
100	---	1210	---	1210
105	---	---	---	---
110	1040	1170	130	1105
115	1110	1210	100	1160
^a Velocity from near to far receiver.				

**Table 4. Compressional P-wave cross-hole velocity (ft/sec) data
[comparison of forward (Z09) and reverse (Z11) direction results]**

Depth (ft)	P-wave velocities (ft/sec)			
	Energy source*		Difference	Mean
	Z09	Z11		
5	---	---	---	
10	---	---	---	
15	---	1950	---	1950
20	1520	2830	1310	2175
25	5690	---	---	5690
30	4060	3390	670	3725
35	5070	---	---	5070
40	3780	2790	990	3285
45	3930	5720	1790	4825
50	3630	5310	1680	4470
55	5240	6690	1450	5965
60	5810	5390	420	5600
65	5410	6130	720	5770
70	5540	6390	850	5965
75	6010	6310	300	6160
80	6470	6860	390	6665
85	7030	7160	130	7095
90	6590	8030	1440	7310
95	5750	6980	1230	6365
100	5970	6040	70	6005
105	5570	5690	120	5630
110	5180	5670	490	5425
115	5340	6010	670	5675
*Velocity from near to far receiver.				

Table 5. Measured down-hole shear (S-) wave velocities and range of calculated down-hole compressional (P-) wave velocities for selected depth intervals in Hole Z12

Depth interval (ft)	V_s (ft/s) ^a	V_p (ft/s) ^b		
		$\sigma - 1SD$	σ	$\sigma + 1SD$
130-195	1290	5420	6375	8215
195-265	1545	6490	7635	9840
265-334	1155	4850	5710	7355
<p>^aMeasured V_s estimates, based on linear least-squares analyses of S-wave arrival times as functions of depth.</p> <p>^bRange of calculated downhole V_p values, based on mean values (σ) and one standard deviation (1SD) above and below mean values of Poisson's ratio. Poisson's ratios are based on measured cross-hole velocities (V_s and V_p) at 5 ft intervals from the water table to the bottom of the holes.</p>

Figure 3.1 Forward and reverse S- and P-wave velocities at Site 3.

APPENDIX 4

SITE 4

Table 1. Shear (S-) wave cross-hole velocity data (ft/sec)
[energy source - Z13, near receiver - Z14, far receiver - Z15 (Z15 hole blocked below 55 ft)]

Depth (ft)	S-wave velocity between near and far receivers (5' to 50') source and near receiver (55'-120')	Rejected (yes, no, or blank [not applicable])	Revised (ft/sec, no, or blank [not applicable])	Reasons for rejection or revision								
				Signal				Inconsistencies				
				Noise (receiver)		Weak (receiver)		Wave form				
				Near	Far	Near	Far	Polarity	Sharpness	Character		
5	480	No	490									
10	---											
15	---											
20	---											
25	1180	No	1220									
30	1240	No	1300									
35	---											
40	1240	No	1330									
45	---											
50	2020	Yes						X		X		X
55	---											
60	---											
65	2100	Yes						X		X		X

Table 1. (Continued)

Depth (ft)	S-wave velocity between near and far receivers (5' to 50') source and near receiver (55'-120')	Rejected (yes, no, or blank [not applicable])	Revised (ft/sec, no, or blank [not applicable])	Reasons for rejection or revision					
				Signal			Inconsistencies		
				Noise (receiver)			Wave form		
				Near	Far	Near	Far	Polarity	Sharpness Character
70	1650	No	1470						
75	1510	No	1330						
80	2030	No	1500					X	X
85	1530	No	1320						
90	1250	No	1070						
95	1410	No	1190						
100	2270	No	1510					X	X
105	---								
110	1330	No	1100						
115	1330	No	1090						
120	1520	No							

Table 2. Compressional (P-) wave cross-hole velocity (ft/sec) data
 [energy source - Z13, near receiver - Z14, far receiver - Z15 (hole Z15 blocked below 55 ft)]

Depth (ft)	P-wave velocities (ft/sec) ^a			
	Energy source ^a		Difference	Mean
	Z13	Z15		
5	---	---		
10	---	---		
15	---	---		
20	4125	---		
25	2140	---		
30	3300	---		
35	---	1940		
40	3610	---		
45	---	4400		
50	4020	3340	680	3680
55	---	2010		
60	---	---		
65	4255	---		
70	7680	---		
75	7360			
80	11,040			
85	8190			
90	7360			
95	6615			
100	6830			
105	5600			
110	5330			
115	5410			
^a Velocity from near to far receiver (5 to 50 ft), velocity from source to near receiver (55 to 115 ft).				

Table 3. Measured down-hole shear (S-) wave velocity and range of calculated compressional (P-) wave velocities from 123 to 322 ft below the surface in Hole Z16

V_s (ft/s) ^a	V_p (ft/s) ^b		
	$\sigma - 1SD$	σ	$\sigma + 1SD$
1550	7190	7605	8115
<p>^aMeasured V_s estimates, based on linear least-squares analyses of S-wave arrival times as functions of depth.</p> <p>^bRange of calculated downhole V_p values, based on mean values (σ) and one standard deviation (1SD) above and below mean values of Poisson's ratio. Poisson's ratios are based on measured cross-hole velocities (V_s and V_p) at 5 ft intervals from the water table to the bottom of the holes.</p>			

APPENDIX 5

SUMMARY OF S- AND P-WAVE VELOCITY ESTIMATES

Table 1. Data summary, cross-hole S-wave velocities (ft./sec)

Depth (ft)	Site			
	1	2	3	4
5	---	---	620	490
10	770	600	625	---
15	---	630	815	---
20	---	735	855	---
25	---	1070	890	1220
30	---	---	975	1300
35	1015	---	975	---
40	1020	1180	915	1330
45	1035	1280	990	---
50	1025	---	---	---
55	1180?	---	980	---
60	---	1125	---	---
65	1115	1105	990	---
70		1065	---	1470
75		---	1185	1330
80		1225	1205	1500
85		---	---	1320
90		1310	1250	1070
95		1260	---	1190
100		1360	1210	1510
105		1245	---	---
110		1180	1105	1100
115		1515	1160	1090
120		1470		
125		1290		
130		---		
135		1200		

Table 2. Data summary, measured down-hole S-wave velocities and calculated down-hole P-wave velocities (ft/s)

Site	Depth interval (ft)	V_s	V_p^*
3	130-195	1290	6375
	195-265	1545	7635
	265-334	1155	5710
1, 2, 4	123-322	1550	7605
*Calculated V_p , based on mean value Poisson's ratio.			

Table 3. Data summary, cross-hole P-wave velocities (ft/sec)

Depth (ft)	Site			
	1	2	3	4
5	---	---	---	---
10	---	---	---	---
15	---	1860	1950	---
20	---	2370	2175	4125
25	5200	3015	5690	2140
30	5340	3380	3725	3300
35	5635	4750	5070	---
40	5305	4490	3285	3610
45	5150	5630	4825	---
50	5500	---	4470	4020
55	5375	4775	5965	---
60	5535	5640	5600	---
65	5260	5910	5770	4255
70	---	---	5965	7680
75	---	4860	6160	7360
80	---	6190	6665	11,040
85	---	6435	7095	8190
90	---	6770	7310	7360
95	---	6270	6365	6615
100	---	6315	6005	6830
105	---	6315	5630	5600
110	---	6205	5425	5330
115	---	6910	5675	5410
120	---	---	---	---
125	---	5835	---	---
130	---	5385	---	---
135	---	5570	---	---

Table 5. Revised P-wave velocity (V_p in ft/s) estimates for inclusion in soil columns

Site						
1		2		3		4
Depth (ft)	V _p	Depth (ft)	V _p	Depth (ft)	V _p	Depth (ft)
0-15	1000	0-11	1000	0-12	1000	0-9
15-18	2000	11-20	2115	12-21	2070	9-58
18-123	5365	20-30	3200	21-53	4510	
"		30-58	4910			
		58-75	5470	53-75	5890	58-78
		75-120	6425	75-95 95-130	6860 5660	78-88 88-98 98-103 103-123
		120-138	5600	130-195	6375	
123-322 ^b	7605	138-322 ^b	7605	195-265 265-334 ^c	7635 5710	123-322 ^c

^aSpaces left blank to place similar depth intervals among sites side-by-side for ease of comparison.
^bTop of rock assumed to be at same depth as at Site 4.
^cTop of rock at given depth.

APPENDIX 6

SOIL COLUMNS AND SITE LOCATION MAP

HOLE/SAMPLE NO. L. P. USC T₉₀(PO)

S - WAVE VELOCITY (FPS) ± 10% P - WAVE VELOCITY (FPS) ± 10%

15 FEET OF LEAN CLAY I _w = 0.125 KCF SHEAR WAVE VELOCITY = 770 FPS P - WAVE VELOCITY = 1000 FPS	380
3 FEET OF SILTY SAND I _w = 0.135 KCF SHEAR WAVE VELOCITY = 1085 FPS P - WAVE VELOCITY = 2000 FPS	370
10 FEET OF SILTY SAND & GRAVEL I _w = 0.115 KCF SHEAR WAVE VELOCITY = 1085 FPS P - WAVE VELOCITY = 5365 FPS	360
	350
	340
40 FEET OF CLAYEY SILT I _w = 0.185 KCF SHEAR WAVE VELOCITY = 1085 FPS P - WAVE VELOCITY = 5365 FPS	330
	320
	310
	300
	290
56 FEET OF SILTY CLAY & CLAYEY SILT I _w = 0.185 KCF SHEAR WAVE VELOCITY = 1085 FPS P - WAVE VELOCITY = 5365 FPS	280
	270
	260
5 FEET OF SILTY SAND I _w = 0.125 KCF SHEAR WAVE VELOCITY = 1550 FPS P - WAVE VELOCITY = 7805 FPS	250
	240
35 FEET OF INTERBEDDED SAND, SILT & CLAY I _w = 0.125 KCF SHEAR WAVE VELOCITY = 1550 FPS P - WAVE VELOCITY = 7805 FPS	230
	220
10 FEET OF INTERBEDDED SAND, SILT & CLAY I _w = 0.125 KCF SHEAR WAVE VELOCITY = 1550 FPS P - WAVE VELOCITY = 7805 FPS	210
	200
21 FEET OF INTERBEDDED SAND, SILT & CLAY I _w = 0.125 KCF SHEAR WAVE VELOCITY = 1550 FPS P - WAVE VELOCITY = 7805 FPS	190
	180
	170
30 FEET OF INTERBEDDED SAND, SILT & CLAY I _w = 0.125 KCF SHEAR WAVE VELOCITY = 1550 FPS P - WAVE VELOCITY = 7805 FPS	160

ESTIMATED MSL ELEVATIONS FOR TOP & BOTTOM OF FORMATION OR UNIT IN BORINGS 2-1 & 2-18	
FORMATION OR UNIT	TOP/BOTTOM
LOESS UNIT	380.3 TO 365
UPPER AQUIFER UNIT	365 TO 353
REGIONAL AQUIFER UNIT	ABSENT
PORTERS CREEK FORMATION	345 TO 261
CLAYTON-McNAURY FORMATIONS	261 TO 49

- NOTES:
- ★ ESTIMATED VALUE
 - APPROXIMATE VALUE FROM NEARBY BORING
 - ? NATURAL MOISTURE CONTENT APPEARS TO BE TOO HIGH COMPARED TO THE LIQUID LIMIT BASED ON SPT "N" VALUES

PGDP COORDINATES FOR THESE BORINGS:
Z-1 - S 5855.57, W 4327.82
Z-16 - S 585.15, W 8436.66
• DATA SUPPLIED BY ERCE 1990

MARTIN MARIETTA ENERGY SYSTEMS, INC.
PADUCAH GASEOUS DIFFUSION PLANT
PADUCAH, KENTUCKY

**SOIL COLUMN
FOR SITE 1**

PLATE I

COMPOSITE DRAWING
2-5 & 2-16

370.9

2-5

572.0

BORING 2-3
GAMMA
(COUNTS/SECOND)
TOP OF CASING
ELEV. = 381.03

BORING 2-3
ELECTROMAGNETIC
(MILLISIEGMENTS/METER)
TOP OF CASING
ELEV. = 381.05

BORING 2-16
GUMMI
(COUNTS/SECOND)
TOP OF CASING
ELEV. = 372.74

GEOPHYSICAL
INTERPRETATION
ELEV. = 300.0

[illegible]

2-71

The diagram illustrates a vertical rock sample core with various features and labels. At the top, a horizontal line is labeled "SAMPLE NUMBER" and "HOLE ELEVATION". Below this, a vertical line represents the core, with a "100.0" mark. A horizontal line is labeled "DRIVE-SAMPLE #1 WITH 'N' VALUE (AS PER A.S.T.M. D1586) UNLESS OTHERWISE NOTED". Below this, a horizontal line is labeled "WATER FIRST ENCOUNTERED DURING DRILLING". Below this, a horizontal line is labeled "WATER LEVEL AT COMPLETION OF DRILLING". Below this, a horizontal line is labeled "WATER LEVEL ON DATE SHOWN". Below this, a horizontal line is labeled "APPROX CHARGE IN TYPE OF MATERIAL". Below this, a horizontal line is labeled "UNDISTURBED SAMPLE(S)". Below this, a horizontal line is labeled "ELEVATION CORING BEGUN". Below this, a horizontal line is labeled "PARTIAL CORE". Below this, a horizontal line is labeled "FILLED CAVITY". Below this, a horizontal line is labeled "OPEN CAVITY". Below this, a horizontal line is labeled "PARTLY FILLED CAVITY". Below this, a horizontal line is labeled "ROTATED". Below this, a horizontal line is labeled "OPEN BEDDING PLANE". Below this, a horizontal line is labeled "OPEN VERTICAL FRACTURE". Below this, a horizontal line is labeled "OPEN BEDDING FRACTURE". Below this, a horizontal line is labeled "SHALE BAND". At the bottom, a horizontal line is labeled "ROCK TYPE".

ATION, FEET (MSL)

INPUT VALUES

S - WAVE VELOCITY (FPS) $\pm 10\%$ P - WAVE VELOCITY (FPS) $\pm 10\%$

HOLE/SAMPLE	WT	LL	PI	LSC	Iw (pcf)	S - WAVE		P - WAVE	
						VELOCITY (FPS) ± 10%	VELOCITY (FPS) ± 10%	VELOCITY (FPS) ± 10%	VELOCITY (FPS) ± 10%
Z-5/1	23.3	30	8	CL	-				
Z-4/ST-1	21.5	-	-	-	120.9				
Z-5/7	18.0	30	12	CL	-				
S-7/3	17.2	35	14	CL	-				
Z-5/10	15.7	22	4	CL-M	-				
Z-4/ST-2	16.9	-	-	-	127.3				
Z-5/13	17.3	23	8	CL	-				
S-7/7	13.3	21	5	SM/SC	-				
Z-6/ST-3	19.6	-	-	-	127.4				
Z-5/15	18.3	34	18	CL	-				
Z-5/17	22.2	38	20	CL	-				
Z-6/ST-4	23.7	-	-	-	123.6				
S-7/12	18.2	22	8	SC	-				
S-7/13	22.1	22	8	SC	-				
Z-5/20	16.5	15	NP	SM	-				
Z-5/21	21.1	27	NP	SM	-				
Z-5/33	30.0	29	NP	SM	-				
S-7/27	41.6	NP	NP	ML	-				
Z-16/2	33.0	26	7	SM/SC	-				
Z-16/3	25.6	24	10	CL	-				
Z-16/6	25.3	23	NP	SM	-				
Z-16/ST-1	38.5	-	-	-	-				
Z-16/8	24.2	30	18	CL	-

GEOPHYSICAL DATA

COMPOSITE BORING
Z-9 & Z-12

PH

LEGEND

ELEVATION, FEET MSL

RECOMMENDED SHAPE INPUT VALUES

	HOLE/SAMPLE	NO.	LL	PI	USC	TW(FOOT)	S - WAVE VELOCITY (FPS) ± 10%	P - WAVE VELOCITY (FPS) ± 10%		
12 FEET OF LEAN CLAY TW = 0.125 KCF SHEAR WAVE VELOCITY = 825 FPS P - WAVE VELOCITY = 1000 FPS	2-10/ST-1	25.8	-	-	-	124.1	825	1000		340
9 FEET OF INTERBEDDED LEAN CLAY & SANDY SILT TW = 0.125 KCF SHEAR WAVE VELOCITY = 855 FPS P - WAVE VELOCITY = 2070 FPS	2-10/8	17.8	-	-	-	124.1	855	2070		340
7 FEET OF INTERBEDDED LEAN CLAY & SANDY SILT TW = 0.125 KCF SHEAR WAVE VELOCITY = 855 FPS P - WAVE VELOCITY = 4510 FPS	2-8/13	14.9	18	7	SC	-				330
	2-10/ST-3	16.9	-	-	-	132.1				320
	2-8/14	14.1	17	3	ML	-		4510		310
25 FEET OF INTERBEDDED SAND, CLAY, & SILT TW = 0.125 KCF SHEAR WAVE VELOCITY = 870 FPS P - WAVE VELOCITY = 4510 FPS	2-10/ST-4	23.3	-	-	-	116.7				310
	2-8/16	21.8	19	NP	SM	-	870			300
	2-8/17	18.6	31	9	CL	-				300
										290
16 FEET OF INTERBEDDED SAND, CLAY, & SILT TW = 0.125 KCF SHEAR WAVE VELOCITY = 870 FPS P - WAVE VELOCITY = 5890 FPS								5890		290
										280
6 FEET OF SANDY SILT TW = 0.125 KCF SHEAR WAVE VELOCITY = 870 FPS P - WAVE VELOCITY = 5890 FPS	2-8/21	18.2	16	NP	ML	-				280
										270
	2-8/23	8.1	31	7	SH/SM	-				270
										260
21 FEET OF SAND & GRAVEL TW = 0.125 KCF SHEAR WAVE VELOCITY = 1185 FPS P - WAVE VELOCITY = 6060 FPS								6060		260
										250
							1185			250
										240
20 FEET OF CLAY, SILT & SAND TW = 0.125 KCF SHEAR WAVE VELOCITY = 1185 FPS P - WAVE VELOCITY = 5660 FPS										240
								5660		230
										220
										210
24 FEET OF CLAY, SILT & SAND TW = 0.125 KCF SHEAR WAVE VELOCITY = 1290 FPS P - WAVE VELOCITY = 6375 FPS	2-12/1	30.0	35	14	CL	-				210
										200
										190
							1290	6375		190
										170
41 FEET OF INTERBEDDED CLAY, SILT, & CLAY IN LAYERS OF GRAVEL TW = 0.125 KCF SHEAR WAVE VELOCITY = 1290 FPS P - WAVE VELOCITY = 6375 FPS										170
										160
										150
	2-12/4	10.1	25	14	CL	-				150
										140

FORMATION OR UNIT	TOP/BOTTOM
LOESS UNIT	334.6 TO 343
UPPER AQUIFER UNIT	3079 TO 3039
REGIONAL AQUIFER UNIT	282 TO 250
PORTER'S CREEK FORMATION	ABSENT
CLAYTON-MCNARY FORMATIONS	250 TO 27

- NOTES:
 - * ESTIMATED VALUE
 - APPROXIMATE VALUE FROM NEAREST BORING
 - ? NATURAL MOISTURE CONTENT APPEARS TO BE TOO HIGH COMPARED TO THE LIQUID LIMIT BASED ON SPT "N" VALUES
- PGDP COORDINATES FOR THESE BORINGS:

Z-9	-	N	120733.30	N	28300.84
Z-10	-	N	120359.83	N	28300.41
Z-12	-	N	120444.52	N	28800.58
- DATA SUPPLIED BY ERCE 1990

MARTIN MARIETTA ENERGY SYSTEMS, INC.
PADUCAH GASEOUS DIFFUSION PLANT
PADUCAH, KENTUCKY

**SOIL COLUMN
FOR SITE 3**

PLATE 3

COMPOSITE BORING
Z-14 & Z-16

PHYSICAL PROPERTIES

INPUT VALUES

	HOLE/SAMPLE	MB	LL	PI	LWC	I _w (POF)	S - WAVE VELOCITY (FPS) ± 10%		P - WAVE VELOCITY (FPS) ± 10%		
	Z-14/2	12.8	27	9	CL	-					380
	Z-15/ST-1	21.7	-	-	-	124.6	500		1000		370
										9 FEET OF LEAN CLAY I _w = 0.125 KCF SHEAR WAVE VELOCITY = 500 FPS P - WAVE VELOCITY = 1000 FPS	
	Z-14/3	23.1	25	9	ML/CL	-					360
	Z-14/8	20.4	30	6	ML	-	655				360
	Z-14/9	7.3	-	-	ML/CL	-					350
	Z-14/ST-1	18.7	-	-	-	118.6					350
	Z-14/12	22.5	40	20	CL	-					340
									3800		340
	Z-14/14	16.0	28	10	SC	-					330
	Z-14/ST-2	18.8	28	9	SC	131.3	1280				330
	Z-14/15	20.0	38	13	ML	-					320
	Z-14/16	25.6	32	8	SW	-					320
	Z-13/ST-1	23.1	-	-	-	123.2					320
	Z-14/17	18.6	27	4	SW	-					310
	Z-14/18	22.27	21	NP	SW	-					310
											300
							1410		7520		300
										21 FEET OF SAND W/ GRAVEL I _w = 0.125 KCF SHEAR WAVE VELOCITY = 1410 FPS P - WAVE VELOCITY = 7520 FPS	
											290
									11,040		290
										8 FEET OF SAND W/ GRAVEL I _w = 0.125 KCF SHEAR WAVE VELOCITY = 1410 FPS P - WAVE VELOCITY = 11,040 FPS	
	Z-14/25	-	-	-	SW/CL	-	1130		7775		280
										10 FEET OF SAND W/ GRAVEL I _w = 0.125 KCF SHEAR WAVE VELOCITY = 1130 FPS P - WAVE VELOCITY = 7775 FPS	
							1510		8720		270
										5 FEET OF SAND W/ GRAVEL I _w = 0.125 KCF SHEAR WAVE VELOCITY = 1510 FPS P - WAVE VELOCITY = 8720 FPS	
	Z-14/28	-	-	-	SW/CL	-					270
	Z-14/29	30.3	43	9	ML	-	1100		5450		260
										6 FEET OF SILTY SAND I _w = 0.120 KCF SHEAR WAVE VELOCITY = 1100 FPS P - WAVE VELOCITY = 5450 FPS	
	Z-14/31	26.6	37	13	CL	-					250
										13 FEET OF SANDY SILT I _w = 0.120 KCF SHEAR WAVE VELOCITY = 1100 FPS P - WAVE VELOCITY = 5450 FPS	
											240
	Z-14/2	33.07	28	7	ML/CL	-					240
										33 FEET OF INTERBEDDED SAND, SILT & CLAY I _w = 0.125 KCF SHEAR WAVE VELOCITY = 1550 FPS P - WAVE VELOCITY = 7605 FPS	
											230
											220
	Z-14/3	25.67	24	10	CL	-					210
										10 FEET OF INTERBEDDED SAND, SILT & CLAY I _w = 0.120 KCF SHEAR WAVE VELOCITY = 1550 FPS P - WAVE VELOCITY = 7605 FPS	
	Z-14/8	25.37	23	NP	SW	-					200
	Z-14/ST-1	38.9	-	-	-	-					190
										31 FEET OF INTERBEDDED SAND, SILT & CLAY I _w = 0.125 KCF SHEAR WAVE VELOCITY = 1550 FPS P - WAVE VELOCITY = 7605 FPS	
											180
	Z-14/9	24.3	39	18	CL	-					170
											170
											160
										30 FEET OF INTERBEDDED SAND, SILT & CLAY I _w = 0.120 KCF SHEAR WAVE VELOCITY = 1550 FPS P - WAVE VELOCITY = 7605 FPS

N-10,000 +
W-12,000 +

N-8,000 +

N-6,000 +

N-4,000 +

N-2,000 +

000 +

S-2,000 +

S-4,000 +

S-6,000 +

W-8,000 +

W-6,000 +

W-4,000 +

W-2,000 +

000 +

WEST KENTUCKY
STATE WILDLIFE
MANAGEMENT AREA

Z-13/Z-16
(SITE 4)

Z-9/Z-12
(SITE 3)

EXISTING LANDFILL

ST. HWY. 358

OGDEN LANDING

Z-5/Z-7
(SITE 2)

SECURITY AREA

MCCALL

Z-1/Z-3
(SITE 1)

PLANT ACCESS
ROAD

TRANSPORT ROAD

WHITEN HORNS ROAD

OLD LANDFILL

GRACE ROAD

C-746-A
C-746-B

C-336

C-337

C-720

C-410

C-331

C-333

WEST KENTUCKY
STATE WILDLIFE
MANAGEMENT AREA

N-4,000

N-2,000

000

S-2,000

S-4,000

S-6,000

S-8,000

S-10,000

W-12,000

W-10,000

W-8,000

W-6,000

W-4,000

Z-13/Z-16
(SITE 4)

C-744-A
C-744-B

C-330

C-720

OLD LANDFILL

Z-1/Z-3
(SITE 1)

OLD KENTUCKY
ORDNANCE WORKS
(KOW)

PLANT ACCESS
ROAD

TRANSPORT ROAD

WATER WORKS ROAD

GRACE ROAD

WATER

LINE

NOTE

1. THIS BASE MAP IS ADAPTED FROM MULTIPLE DRAWINGS SUPPLIED BY MARTIN MARIETTA ENERGY SYSTEMS IN ADDITION TO THE JOPPA QUADRANGLE AND HEATH QUADRANGLE (1:24000) PUBLISHED BY THE U.S. GEOLOGICAL SURVEY AND IS INTENDED FOR GENERAL REFERENCE ONLY. FOR PRECISE LOCATION OF FEATURES REFER TO LARGER SCALE MAPS AND/OR FEATURE COORDINATES.

LEGEND

- Z-1/Z-3 (SITE 1) GEOPHYSICAL BOREHOLE CLUSTER

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 REFER TO LARGER SCALE

Z-1/Z-3
 (SITE 1)

1000

NOTE

1. THIS BASE MAP IS ADAPTED FROM MULTIPLE DRAWINGS SUPPLIED BY MARTIN MARIETTA ENERGY SYSTEMS IN ADDITION TO THE JOPPA QUADRANGLE AND HEATH QUADRANGLE (1:24000) PUBLISHED BY THE U.S. GEOLOGICAL SURVEY AND IS INTENDED FOR GENERAL REFERENCE ONLY. FOR PRECISE LOCATION OF FEATURES REFER TO LARGER SCALE MAPS AND/OR FEATURE COORDINATES

LEGEND

- ⊙ Z-1/Z-3
(SITE 1) GEOPHYSICAL BOREHOLE CLUSTER

PLATE 5

SITE LOCATION OF GEOPHYSICAL BOREHOLE CLUSTERS

MARTIN MARIETTA ENERGY SYSTEMS, INC.
PADUCAH GASEOUS DIFFUSION PLANT
PADUCAH, KENTUCKY

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