APPENDIX K
UPDATED DESIGN SEISMIC GROUND MOTIONS & SEISMIC IMPACT EVALUATION

MEMORANDUM

Date: April 1, 2011

Project No.: 063-7079-200

To: Rick Kiel, P.E.

Company: Golder Associates Inc.

From: Ken Haskell, P.E. (California)
Nagesh Koragappa, P.E., G.E. (California)

RE: UPDATED DESIGN SEISMIC GROUND MOTIONS AND SEISMIC IMPACT EVALUATION FOR THE PROPOSED JUNGO DISPOSAL SITE, HUMBOLDT COUNTY, NEVADA

This memorandum summarizes the updated design seismic ground motions and seismic impact evaluations for the proposed Jungo Disposal Site (JDS). An updated seismic hazards assessment was completed to reflect the latest predicted seismic ground motions that were developed after Golder Associates Inc. (Golder) completed the initial seismic characterization for the JDS.

In addition, this memorandum summarizes the results of updated permanent seismic displacement calculations and the results of our initial liquefaction evaluation. These analyses were completed to address the Nevada Division of Environmental Protection's (NDEP's) comments dated February 2, 2011.

1.0 UPDATED SEISMIC HAZARD CHARACTERIZATION

The Jungo Disposal Site is located within a seismic impact zone, which is defined as a location that has a 10 percent or greater probability of experiencing a seismically induced peak ground acceleration (PGA) in bedrock of 0.1g or greater in a 250-year period.

Using the 2002 United States Geological Survey (USGS) database for an earthquake event with a 10 percent probability of exceedance in a 250-year period, Golder initially estimated that the design bedrock PGA was 0.28g at the JDS. This design event, which is specified by Federal Subtitle D regulations and the Nevada Administrative Code, has an associated return period of 2,475 years.

In 2008, the USGS seismic ground motion database was updated to include the latest, state-of-the-art relationships between earthquake magnitude, distance from the epicenter, and peak bedrock accelerations. Using the 2008 USGS seismic hazard mapping, the revised estimated design bedrock PGA for this site is 0.25g, which is approximately 10 percent lower than that originally estimated by Golder and previously used to assess the seismic impacts on the liner system.

2.0 UPDATED PERMANENT SEISMIC DISPLACEMENT ESTIMATES

2.1 Review of Previous Analyses

The previous versions of the Report of Design included estimated permanent seismic displacements along the base liner using a PGA of 0.28g. Potential attenuation of ground motions within the thick soil profile below the JDS were conservatively ignored. Using the simplified approach by Bray et. al. (1998), Golder estimated that the permanent seismically induced displacements would be less than 1 inch (0.8

inch) along the base liner. The currently accepted practice for landfill liner design generally limit permanent displacements to 6 to 12 inches along landfill base liners. Permanent displacements within 6 to 12 inches are not expected to adversely compromise the liner integrity, leachate collection and removal system, or other environmental controls. The estimated permanent displacement of 0.8 inch is well below the more stringent displacement criterion on 6-inches.

2.2 Updated Analyses

Following the completion of the updated seismic ground motion estimates, more rigorous seismic slope stability analyses were performed to confirm that predicted seismic deformations would be well within the accepted criterion of 6 to 12 inches or less. These procedures consisted of the following:

- Selecting of three spectrum-compatible acceleration time histories for site response analyses and considered the revised design PGA of 0.25g. Attachment A includes a more detailed description of the development of these acceleration time histories.
- Applying a yield acceleration of 0.14g as determined from the previous pseudo-static slope stability analyses. Yield accelerations are primarily a function of the landfill geometry and liner shear strengths and are not affected by the seismic ground motions.
- Performing seismic response analyses using the SHAKE91 computer program (Idriss and Sun, 1992) to estimate the average horizontal equivalent acceleration (HEA) time histories within the critical failure surfaces associated with the critical yield acceleration value.
- Performing Newmark-type displacement analyses using the computer program DISPLMT (Houston et al., 1987), which involves the double-integration of the average HEA values that exceed the yield acceleration value, to estimate the potential magnitude of seismically induced permanent displacement along the liner system.

Figures 1 through 3 show the results of seismic displacements for each of the three representative time histories that were analyzed. On each figure there are four graphical plots as follows:

- The first plot (uppermost) is the spectrally matched input acceleration time history.
- The second plot is the computed horizontal equivalent acceleration (HEA) with time. Permanent displacements only occur if the HEA exceeds the yield acceleration, which is also shown on this plot. The magnitude of the computed displacement depends on the relative amount that the HEA exceeds the yield acceleration with respect to magnitude, time, and number of cycles.
- The third plot shows the relative velocity with time.
- The final plot is the computed displacement as a function of time.

As shown in these figures, the computed HEA does not exceed the yield acceleration in Figure 2, and therefore, the estimated permanent seismic displacement is zero. For Figures 1 and 3, the computed HEA slightly exceeds the yield acceleration for one to 4 cycles, and therefore results in very small displacements of 0.4 to 0.6-inches.

Attachment A includes additional technical discussion of the SHAKE91 computer program and the computation of the permanent displacements. The results of SHAKE91 and displacement analysis are included in Attachment B.

2.3 Base Liner Seismic Impact Evaluations

Permanent seismically induced displacements computed using the more rigorous seismic analyses described in Sections 2.2 provided similar results to previously estimated by Golder. In both cases, the computed permanent seismic displacements are relatively small (less than one inch). The computed displacements using the updated design PGA of 0.25g and more rigorous analyses resulted in estimated permanent seismically-induced displacements ranging from 0 to 0.6 inches for the various representative acceleration time histories, which is more than a factor of 10 times lower than the maximum allowable permanent seismically-induced displacement of 6 to 12 inches.

Golder considers the estimated permanent seismically-induced displacements of 0.6-inch or less to be negligible for the JDS.

NDEP (February 2, 2011 comments) stated that the seismic impact evaluation should consider the maximum seismically-induced displacement and not just the permanent seismically-induced displacement. In terms of assessing impacts on the landfill liner systems, it is the permanent seismically-induced displacements that are of concern and critical to the performance of the liner system. Therefore, the accepted performance criteria for landfill liners are based on permanent seismically-induced displacements.

2.4 Other Considerations

NDEP (February 2, 2011 comments) asked that the seismic impact evaluation include the addition of seismically-induced strains to settlement induced strains.

Accepted industry standards for textured high-density polyethylene geomembranes (GRI-GM13) specifies that these materials include a minimum elongation at yield of 12 percent and elongation at break of 120 percent. Elongation at yield represents the maximum strain under which the liner performs elastically. Prudent design standards limits strains below the yield strains.

Golder's previous analyses computed maximum strains are less than 2.3 percent, which is more than 5 times lower than the yield strain specified by GRI-GM13. The addition of negligible strains due to seismically-induced permanent displacements to the above relatively low settlement induced strains will result in overall strains that are well below the maximum yield strain for textured HDPE geomembranes.

3.0 LIQUEFACTION POTENTIAL

3.1 Preliminary Liquefaction Evaluation

Liquefaction is a condition where seismic ground motions cause excessive pore pressures in soils that result in a loss in shear strength. Liquefaction can result in slope instability and/or settlement. Liquefaction is most likely to occur for (1) loose sands/silts, (2) shallow groundwater conditions, and (3) strong ground motions. At the JDS, groundwater is relatively deep at 60 feet below the ground surface and the sands and silts below the liner are considered dense base on the standard penetration test blow counts measured during the subsurface explorations.

Golder previously indicated that liquefaction was unlikely due to depth of groundwater at the JDS. In addition, the relatively high density of the sand/silts relative to the design ground motions were unlikely to result in a significant liquefaction potential.

As requested by NDEP (February 2, 2011 comments), Golder has performed a preliminary liquefaction analysis using the standard penetration (N) values recoded on the logs for the existing testing boring EB and monitoring wells MW-1 through MW-4. The liquefaction analysis has been performed for N values recorded in the upper 100 feet although the “RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities” (U.S.EPA, 1995) states that liquefaction is generally not likely to occur more than 50 feet below the ground surface. Because clayey soils are generally considered non-liquefiable, the analysis has been limited to clean and low plasticity sandy and silty soils.

The liquefaction analysis has been performed using the latest procedure developed at the University of California, Berkeley ("Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential" by Cetin et al., 2004). The deterministic approach presented in Cetin et al (2004) has been used to compute factors of safety against liquefaction potential with depth using the cyclic resistance of the soil.

Although liquefaction is a phenomenon associated with saturated or nearly-saturated (> 85% saturation) granular soils, factors of safety were computed for N values measured both above and below the ground water table. To be conservative, it is assumed that the landfill base is 15 feet below existing ground surface and no waste is present above the base line. The free-field peak ground acceleration (PGA) 0.312g was used (which is higher than the peak acceleration 0.25g in bedrock), which was estimated based on SHAKE91 analysis performed using the three acceleration time histories and a conservative soil column height of 200 feet. The fines contents (percent by weight of particles passing the No. 200 sieve) were estimated based on the available laboratory grain-size analysis test results and soil descriptions in the boring logs.

The results of the liquefaction analysis are presented in Appendix C. The analysis shows that liquefaction is unlikely during the design PGA having a 10 percent probability of exceedance in 250 years (i.e., a return period of 2,475 years).

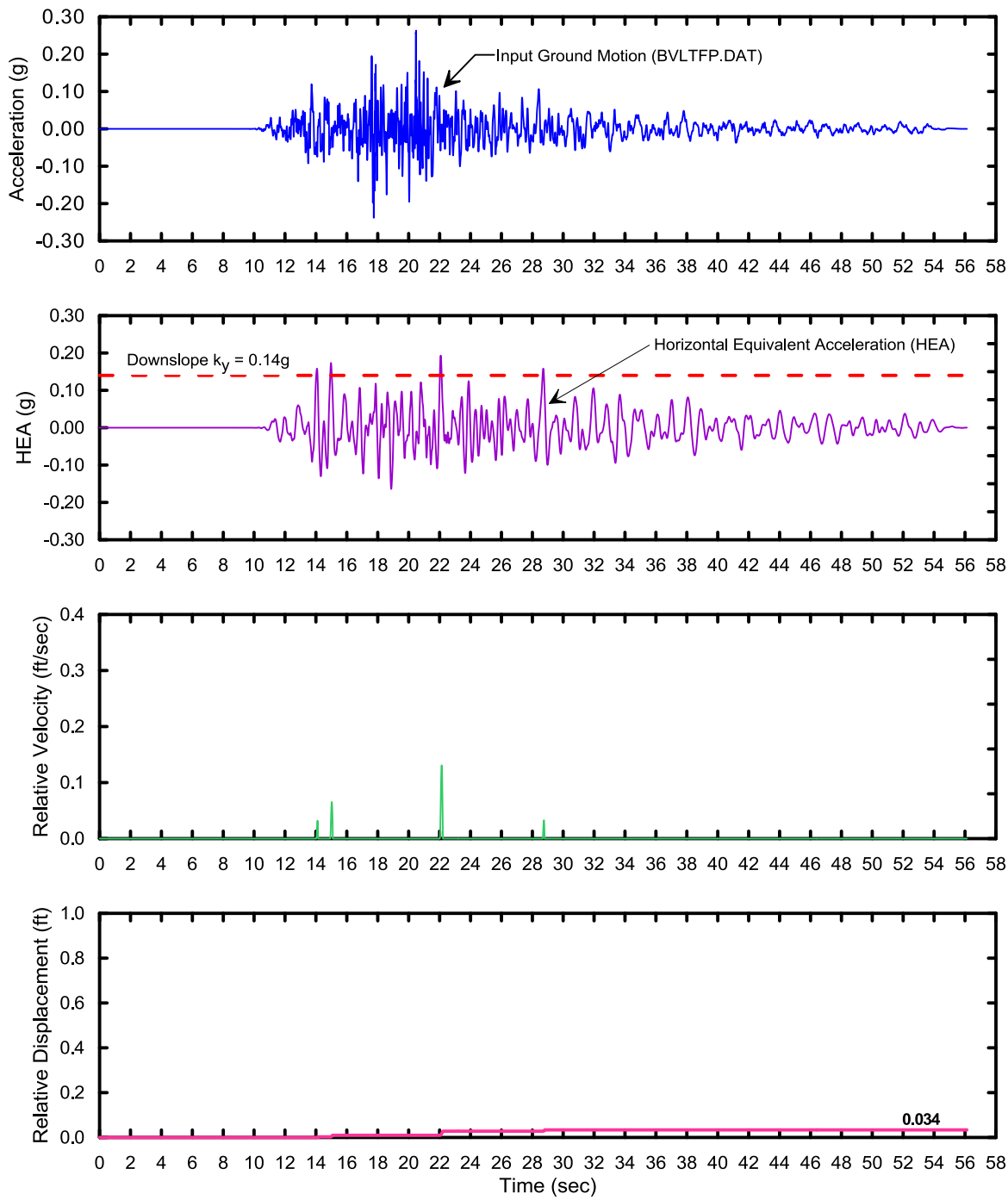
It should be noted that the liquefaction analysis discussed above should be considered preliminary and conservative because the afore-mentioned test boring EB and monitoring wells MW-1 through MW-4 were drilled using a hollow stem auger (HSA). Typically, N values measured within HSA borings below the ground water table are typical lower because the soil at the bottom of the drill hole tend to loosen or flow up because of the unbalanced pore pressure (i.e., the pore pressure inside the borehole would be lower than that outside creating a hydraulic gradient). Therefore, N values measured for liquefaction analyses are typically measured using mud rotary drilling where the hydraulic head inside the drill hole is maintained by filling the bore hole with bentonite slurry. During the design of the various operational modules of the Jungo Landfill, additional test borings will be performed using the mud-rotary technique to conduct more detailed liquefaction analysis in the future.

3.2 References

Cetin, K.O, Seed, R.B., Kiureghian, A.D., Tokimatsu, K., Harder, L.F., Kayen, R.E., and Moss, R.E.S. (2004). “Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential,” *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 130, No. 12, December 2004.

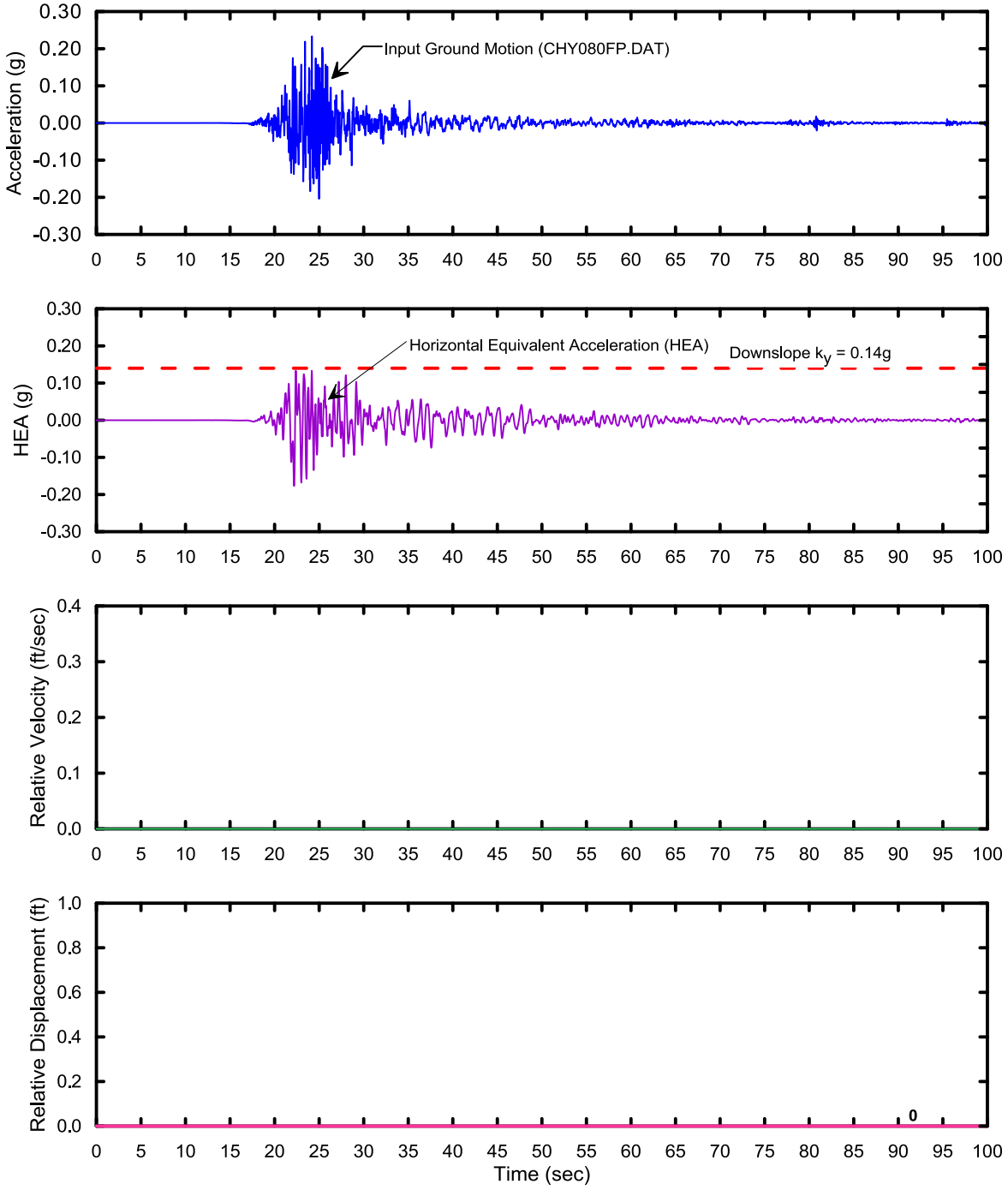
U.S.EPA (1995). “RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities”, dated April.

Attachments: Figures 1 through 3
Attachment A – Technical Summary of Seismic Analyses
Attachment B – SHAKE91 and DSIPLMT Results
Attachment C – Liquefaction Calculation Summary



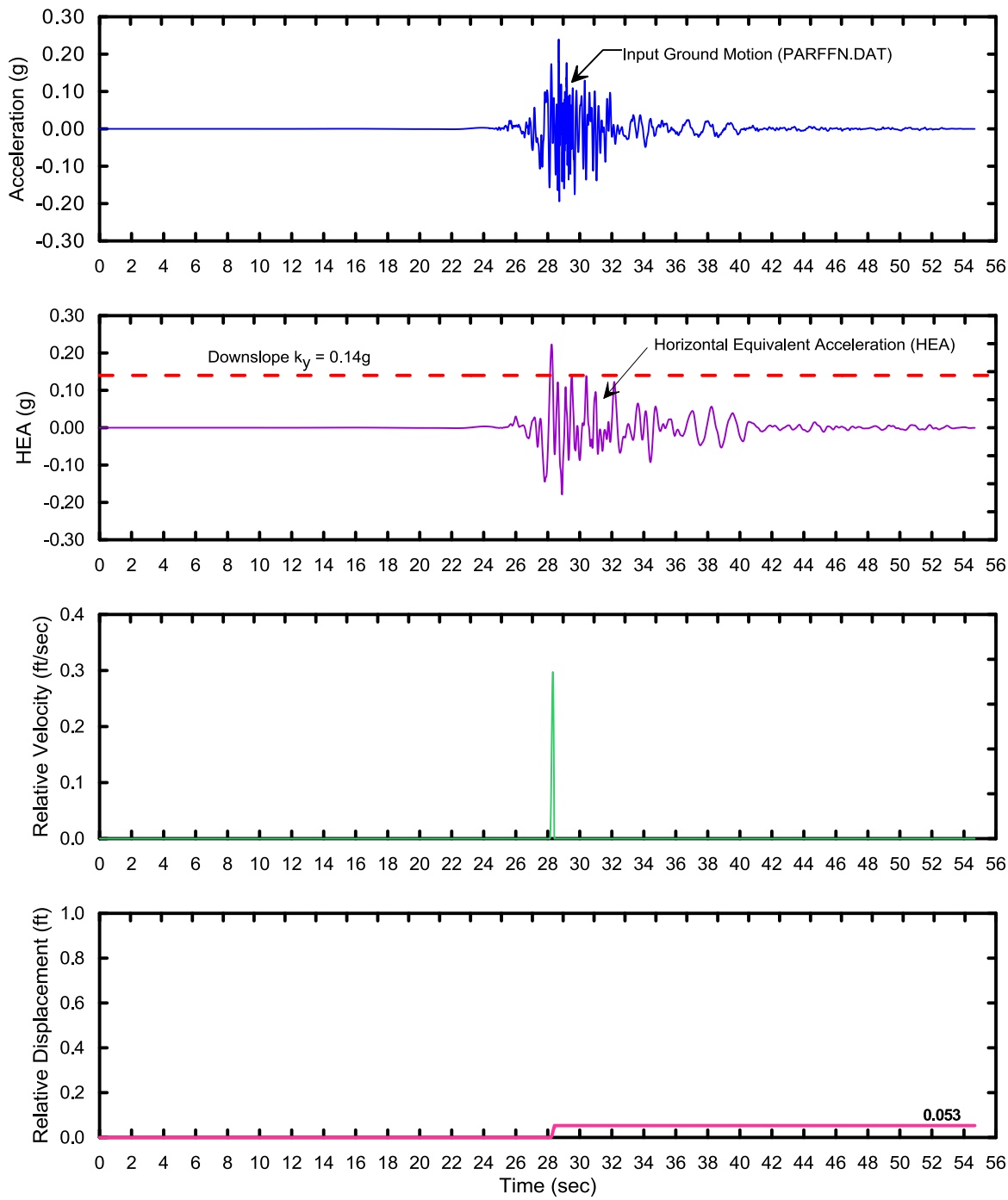
Jungo Landfill
Seismic Slope Stability
Permanent Displacement Analysis
Time History = BVLTFP.DAT

Design: **NK**	Check:	Date: **March 2011**	Figure: **1**



Jungo Landfill
Seismic Slope Stability
Permanent Displacement Analysis
Time History = CHY080FP.DAT

Design: **NK**	Check:	Date: **March 2011**	Figure: **2**



Jungo Landfill
Seismic Slope Stability
Permanent Displacement Analysis
Time History = PARFFN.DAT

Design: **NK**	Check:	Date: **March 2011**	Figure: **3**

ATTACHMENT A

TECHNICAL SUMMARY OF SEISMIC ANALYSES

The methods used to complete the seismic evaluations were briefly reviewed in Section 2.0 of the Technical Memorandum. The following sections include a more detailed discussion of the methods and assumptions used in these analyses.

1.0 SPECTRAL ACCELERATION MATCHING

The U.S. Geological Survey (1996 updated in 2008) has developed a probabilistic seismic hazard model for the United States. The U.S. Geological Survey model, and interactive ground motion disaggregation, allow for the listing of peak ground acceleration (PGA) for various probabilities of being exceeded, or return periods, and the associated earthquake modal magnitude and distance from the site. Table 1 provides a list of the PGAs on weak rock ($V_{S,30}$ = 760m/s) and associated mean earthquake magnitudes derived from the interactive disaggregation of PGAs at the Jungo Landfill site.

TABLE 1

PROBABILISTIC SEISMIC HAZARD ANALYSIS RESULTS FOR PEAK GROUND ACCELERATION (PGA) AT THE JDS (U.S. GEOLOGICAL SURVEY, 2008)

Probability of Being Exceeded (Return Period)	PGA (g)	Mean Earthquake Magnitude
2% in 50 Years (2,475 yrs)	0.25	6.2
5% in 50 Years (975 yrs)	0.16	6.2
10% in 50 Years (475 yrs)	0.10	6.2
25% in 50 Years (224 yrs)	0.07	6.2
50% in 75 Years (108 yrs)	0.03	6.2

The specific steps performed in the selection of representative in acceleration time histories and spectral matching are summarized below.

1.1 Disaggregation of PSHA

The first step to develop spectrally matched acceleration time histories is to disaggregate the PSHA model to identify the earthquake magnitude-distance pairs (scenario events) that contribute to the seismic hazard for the chosen return period and frequency. The mean magnitude earthquake event with a return period of 2,475-years is a moment magnitude (M) 6.2 earthquake located at a distance of 12 km (USGS, 2008).

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1.2 Selection of Acceleration Time Histories

We reviewed available acceleration time history records from strike-slip, reverse, and oblique-reverse mechanism earthquakes that met the magnitude-distance criteria listed in above. These earthquake mechanisms were selected because of the need to have records from a range of moderate earthquakes at relatively close source-to-site distances, the selected acceleration time history records are shown in Table 2.

TABLE 2

SELECTED TIME HISTORY FOR M 6.2 EARTHQUAKE

Motion No.	Earthquake Name (Date)	Magnitude (M)	PGA (g)	Station	Distance (km)	Vs (m/sec)
EQ1	Irpinia Italy (1980)	6.2	0.11	Rinero in Vulture	25	665
EQ2	Chi Chi Taiwan – 04 (1999)	6.2	0.12	CHY080	12.5	680
EQ3	Parkfield (1966)	6.2	0.30	Temblor	16	530

1.3 Spectral Matching

Spectral matching is a procedure used to develop an acceleration time history that closely matches a smooth design response spectrum (target spectrum). The spectral matching procedure begins with selection of a recorded acceleration time history (seed) from an earthquake whose characteristics reasonably represent the earthquake expected at the site. The objective of the spectral matching procedure is to reduce the individual spectral peaks and valleys of the seed acceleration time history while preserving the non-stationary characteristics of the seed time history as much as possible Abrahamson (1992).

The matching procedure is involves adding and subtracting elementary wavelets to and from the seed acceleration time history. Each wavelet is intended to match the design response spectrum at one period. Matching is done either period by period or in groups of periods. Several iterations are required to get reasonable convergence between the spectrally-matched acceleration time history and the design response spectrum. Spectral matching can be undertaken in either the time-domain or frequency domain. Full details of the method are presented in Lilhanand and Tseng (1988) and Abrahamson (1992).

For this study, spectral matching was accomplished using the computer program RSPMATCH which has been incorporated into the EZ-FRISK 7.51 software developed by Risk Engineering Inc. RSPMATCH is based on the on the time-domain matching method developed by Lilhanand and Tseng (1988) and

modified by Abrahamson (1992). In this study, the spectral matching was conducted in groups of periods. The goal of the spectral matching was to produce an acceleration time history with an acceleration response spectrum within about 10% (or less) of the target acceleration response spectrum. The computer program is run iteratively until the computed acceleration response spectrum is within a user specified percentage of the target acceleration response spectrum. Because the solution is not unique (i.e., there are an infinite number of motions that will produce the target spectrum), the motion was integrated to calculate the velocity and displacement time histories. The acceleration, velocity, and displacement time histories were checked to ensure that the solution is reasonable. This check was made to verify that the spectrally matched motion had a reasonable duration and there was no residual displacement.

Because the design acceleration response spectrum was developed for a bedrock site ($V_{S,30}$ = 760 m/sec), the spectrally matched motions can be considered “rock” motions.

1.4 Discussion of Spectral Matching

The seed motions used for spectral matching include actual recorded and synthetic acceleration time histories that are available from readily available worldwide databases. There are a number of parameters that must be considered when selecting recorded acceleration time histories for spectral matching. These include earthquake magnitude, sense of earthquake motions (normal, reverse, and strike-slip), site-to-source distance, shear wave velocity at the recording station, and PGA of the recorded motion. Ideally, recorded time histories that closely match each of these parameters at the site would be selected for spectral matching. However, because of the limited database of world-wide recorded acceleration time histories some of these parameters may have to be relaxed. By far, the most important parameter in spectral matching is the earthquake magnitude because the magnitude is directly related to the duration of strong shaking. This is consistent with the recommendations of Bommer and Acevedo (2004) who show that distance has little influence on spectral shape. They recommend a small window in terms of magnitude but broad limits in terms of distance. Similarly, Watson-Lamprey and Abrahamson (2006) found that spectrally matched acceleration time histories with scale factors of over 10 on PGA are acceptable. The sense of earthquake movement can affect the peak ground acceleration and the spectral accelerations, but this is accounted for in the attenuation relationships used in the probabilistic seismic hazard analysis (PSHA).

Because the spectral matching solution is not unique, the acceleration, velocity and displacement time histories were checked for the spectrally matched motions to verify that the duration of strong shaking was adequate and that residual displacement was zero. If the displacement or acceleration time history was not adequate, the spectral matching was repeated until adequate results were achieved. For each spectrally matched motion, the residual displacement was less than 0.1 centimeters (cm).

2.0 ESTIMATES OF THE PERMANENT DISPLACEMENTS

2.1 Seismic Response Analysis

SHAKE91 analyzes the seismic response of a 1-dimensional soil column; therefore, its use is ideal where the ground surfaces are relatively flat. For sloping ground surfaces, the state of practice is to use an approximation to estimate the average response of the 2-D slope failure mass. This approximation involves performing SHAKE91 analysis on one or more soil/waste columns taken across the critical failure mass identified by the pseudo-static slope stability analysis. It should be noted that the computed HEA time history based on just one waste column is conservative. In other words, averaging of HEA values from more than one waste column taken across the critical failure mass typically results in lower HEA values because of averaging of the spatial incoherence (i.e., at any instant of time, the acceleration values at different points within the critical failure surface have different magnitudes). Also, HEA values estimated based on SHAKE91 are typically conservative compared to those obtained from a 2-D site-response analysis (e.g., QUAD4M).

To be conservative, only one SHAKE column was used along each cross section analyzed. The shear stress time history output files from the SHAKE91 analyses is used to compute the time history of the horizontal equivalent acceleration (HEA) within the failure mass using the following equation (Bray et al., 1998):

$$\mathrm{HEA}\ (t) = \left[\frac{\tau(t)}{\sigma_v}\right] g$$

where, $\tau(t)$ = shear stress at the elevation of the failure plane at time t
σv = total vertical stress at the elevation of the failure plane
g = acceleration due to gravity

The various waste parameters used in SHAKE91 analyses were obtained from the following references:

- Unit weight with depth -- Zekkos et. al (2006a)
- Shear wave velocity with depth -- Kavazanjian et al. (1996)
- Modulus reduction and damping curves -- Zekkos et al. (2006b)

The shear strain dependent modulus reduction and damping values used for waste are summarized in Tables 3 and 4, respectively.

TABLE 3

SHEAR MODULUS REDUCTION AND DAMPING CURVES FOR WASTE

Shear Strain, γ (%)	G/G_{max} Matasovic and Kavazanjian (1998)	G/G_{max} Zekkos et al. (2006b)
0.0001	1.000	0.998
0.0003	1.000	0.996
0.001	1.000	0.990
0.003	0.990	0.975
0.01	0.980	0.936
0.03	0.950	0.856
0.1	0.850	0.690
0.3	0.675	0.475
1	0.330	0.252
3	0.128	0.121
8	0.050	0.058

TABLE 4

DAMPING CURVES FOR WASTE

Shear Strain, γ (%)	Damping Matasovic and Kavazanjian (1998)	Damping Zekkos et al. (2006b)
0.0001	1.8	4.0
0.0003	2.0	4.1
0.001	3.0	4.1
0.003	4.0	4.2
0.01	6.0	4.5
0.03	8.8	5.2
0.1	13.0	7.2
0.3	17.2	10.5
1	21.8	14.0
3	24.8	23.5
8	27.0	28.0

The time history of the horizontal shear stress corresponding to the elevation of the failure surface is first computed using the SHAKE program and saved in to a computer file. This file was then imported to a spreadsheet and the shear stress at each time step was divided by the weight (which is the same as the vertical stress in a 1-dimensional analysis) above the failure surface to obtain the time history of the HEA of the failure block overlying the failure plane within the waste column. As noted in Bray et al. (1998), this method of computing average acceleration of 1-dimensional soil columns was originally conceived by Seed and Martin in 1966.

Separate seismic response analyses were performed using each of the three acceleration time histories.

2.2 Permanent Displacement Analysis

The computer program DISPLMT developed by Houston et al. (1987) was used to predict the likely magnitude of seismically-induced permanent displacements. DISPLMT performs numerical double integration of the HEA values that are in excess of the yield acceleration values.

The results of the permanent displacement analyses using DISPLMT are presented graphically in Figures 1 through 3 included in the Technical Memorandum. Each of these figures indicate that the HEA values only exceed the corresponding yield acceleration values in a few brief instances in time. Therefore, the estimated permanent displacements are relatively small and range from 0 to 0.05 feet (0 to 0.6 inches).

3.0 REFERENCES

Abrahamson, N.A., (1992), Non-stationary spectral matching. Seismological Research Letters 63. Bommer, J. and Acevedo, A.B., 2004, The use of Real Accelerograms as Input to Dynamic Analysis, Journal of Earthquake Engineering, Vol. 8 (Special Issue 1), pp 43-91.

Bray, J.D., E.M. Rathje, A.J. Augello and S.M. Merry, *Simplified Seismic Design Procedure for Geosynthetic-Lined, Solid-Waste Landfills*. Geosynthetics International, 1998, Vol.5, NOS. 1-2.

Frankel, Arthur, Mueller, Charles, Barnhard, Theodore, Perkins, David, Leyendecker, E. V., Dickman, Nancy, Hanson, Stanley, and Hopper, Margaret, (1997). National 1996 Seismic Hazard Maps: U.S. Geological Survey, Open-File Report 97-131.

Houston, S.L., Houston, W.N., and Padilla, J.M. (1987). "Microcomputer-Aided Evaluation of Embankment-Induced Permanent Slope Displacements." *Microcomputers in Civil Engineering*, 2, 207-222.

Idriss, I.M. and Sun., J.I. (1992). SHAKE91: "A computer program for conducting equivalent linear seismic response analyses of horizontally layered soil deposits," Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis.

Kavazanjian, Jr., E., Matasovic, N., Bonaparte, R., and Schmertmann, G.R. (1995). "Evaluation of MSW Properties for Seismic Analysis." Geoenvironment 2000, *Geotechnical Special Publication No. 46*, pp. 1126-1141.

Kavazanjian, E., Jr., Matasovic, N., Stokoe, K.H., and Bray, J.D. (1996). "In Situ Shear Wave Velocity of Solid Waste from Surface Wave Measurements," *Proceedings of the Second International Congress on Environmental Geotechnics*, Balkema, Vol1. 1, Osaka, Japan, November 1996, pp. 97-102.

Lilhanand, K. and W. S. Tseng. (1988), Development and Application of Realistic Earthquake Time Histories Comparable with Multiple Damping Design Spectra. Proceedings of the Ninth World Conference on Earthquake Engineering, Tokyo-Kyoto, Japan, Vol. 2.

Makdisi, F.I. and Seed, H.B. (1978). “Simplified Procedure for Estimating Dam and Embankment Earthquake-Induced Deformations." *Journal of the Geotechnical Engineering Division*, ASCE, Vol. 104, No. GT7.

Matasovic, N. and Kavazanjian, E. Jr. (1998). “Cyclic Characteristics if OII Landfill Solid Waste,” *Journal of Geotechnical and Geoenvironmental Engineering*, March 1998, 124 (3), pp. 197-210.

Newmark, N.M. (1965). “Effects of Earthquakes on Dams and Embankments." *Geotechnique*, Volume 5, Number 2.

Petersen, Mark D., Frankel, Arthur D., Harmsen, Stephen C., Mueller, Charles S., Haller, Kathleen M., Wheeler, Russell L., Wesson, Robert L., Zeng, Yuehua, Boyd, Oliver S., Perkins, David M., Luco, Nicolas, Field, Edward H., Wills, Chris J., and Rukstales, Kenneth S., 2008, Documentation for the 2008 Update of the United States National Seismic Hazard Maps: U.S. Geological Survey Open-File Report 2008–1128, 61 p.

Risk Engineering, 2008, User’s Manual for EZ-FRISK Version 7.26, Software for Earthquake Ground Motion Estimation.

Schnabel, P.B., J. Lysmer, and Seed, H.B. (1972). “SHAKE: A computer program for Earthquake Response Analysis of Horizontally Layered Sites.” Report EERC-72/12, Earthquake Engineering Research Center, University of California, Berkeley.

Seed, H.B., and Martin, G.R. (1966). "The Seismic Coefficient in Earth Dam Design." *Journal of Soil Mechanics and Foundation Division*, ASCE, Vol. 92, No. SM6.

Seed, R.B., and Bonaparte, R. (1992). “Seismic Analysis and Design of Lined Waste Fills: Current Practice,” in *Proceedings of Stability and Performance of Slopes and Embankments. II. A 25-Year Perspective, Volume 2, Geotechnical Special Publication No. 31*, R.B. Seed and R.W. Boulanger, editors, American Society of Civil Engineers, New York.

U.S. Environmental Protection Agency. (1995). “RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities” prepared by Gregory N. Richardson, Edward Kavazanjian, Jr., and Neven Matasovic, Report No. EPA 600/R-95/051.

Watson-Lamprey, J. and Abrahamson, N., 2006, Selection of Ground Motion Time Series and Limits on Scaling, Soil Dynamics and Earthquake Engineering, Vol. 26, No. 5, pp 477-482.

Zekkos, D.P., Bray, J.D., Kavazanjian, Jr. E., Matasovic, N., Rathje, E.M., Riemer, M.F., Stokoe, K.H. (2006a). "Unit Weight of Municipal Solid Waste," *Journal of Geotechnical and Geoenvironmental Engineering*, Vol. 132, No. 10, pp. 1250-1261.

Zekkos, D.P., Bray, J.D., and Riemer, M.F. (2006b). "Shear Modulus and Material Damping Relations for Municipal Solid Waste," *Proceedings of the 8th National Conference on Earthquake Engineering*, April 18-22, San Francisco, California, USA, Paper No. 1324.

ATTACHMENT B

SHAKE91 AND DISPLACMENT RESULTS

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 ******************************************************
 * SHAKE  --   A COMPUTER PROGRAM FOR EARTHQUAKE RESPONSE  *
 *             ANALYSIS OF HORIZONTALLY LAYERED SITES      *
 *             by: Per B. Schnabel & John Lysmer -- 1970   *
 * ---------------------------------------------------------*
 * shake85     IBM-PC version of SHAKE                     *
 *             by: S.S. (Willie) Lai, January 1985         *
 * ---------------------------------------------------------*
 * shake88   : New modulus reduction curves for clays added*
 *             using results from Sun et al (1988)         *
 *             by: J. I. Sun & Ramin Golesorkhi            *
 *             February 26, 1988                           *
 * ---------------------------------------------------------*
 * SHAKE90/91: Adjust last iteration; Input now is either  *
 *             Gmax or max Vs; up to 13 material types can *
 *             be specified by user; up to 50 Layers can   *
 *             be specified; object motion can be read in  *
 *             from a separate file and can have user      *
 *             specified format; Different periods for     *
 *             response spectral calculations; options     *
 *             are renumbered; and general cleanup         *
 *             by: J. I. Sun, I. M. Idriss & P. Dirrim     *
 *             June 1990 - February 1991                   *
 * ---------------------------------------------------------*
 * SHAKE91   : General cleanup and finalization of input/  *
 *             output format ... etc                       *
 *             by: I. M. Idriss                            *
 *             December 1991                               *
 ************************************************************
 MAX. NUMBER OF TERMS IN FOURIER TRANSFORM =     32768
 NECESSARY LENGTH OF BLANK COMMON X        =    204819
    Option NO.    1   is started.

1******   OPTION  1  ***  READ RELATION BETWEEN SOIL PROPERTIES AND STRAIN

 **********************
  MATERIAL TYPE NO. 1
 **********************

 CURVE NO.  1:      #1 modulus for clay (seed & sun 1989) upper range
 CURVE NO.  2:        damping for clay (Idriss 1990) -


     CURVE NO. 1             CURVE NO. 2
 ====================    ==================
   STRAIN    G/Gmax         STRAIN    DAMPING
 --------   -------        --------  --------
   0.0001     1.000         0.0001      0.24
   0.0003     1.000         0.0003      0.42
```

0.0010	1.000	0.0010	0.80
0.0030	0.981	0.0030	1.40
0.0100	0.941	0.0100	2.80
0.0300	0.847	0.0300	5.10
0.1000	0.656	0.1000	9.80
0.3000	0.438	0.3000	15.50
1.0000	0.238	1.0000	21.00
3.0000	0.144	3.1600	25.00
10.0000	0.110	10.0000	28.00

****
MATERIAL TYPE NO. 2
****

CURVE NO. 3: #2 modulus for sand (seed & idriss 1970) - upper Range
CURVE NO. 4: damping for sand (Idriss 1990) - (about LRng from SI

CURVE NO. 3 CURVE NO. 4

STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.24
0.0003	1.000	0.0003	0.42
0.0010	0.990	0.0010	0.80
0.0030	0.960	0.0030	1.40
0.0100	0.850	0.0100	2.80
0.0300	0.640	0.0300	5.10
0.1000	0.370	0.1000	9.80
0.3000	0.180	0.3000	15.50
1.0000	0.080	1.0000	21.00
3.0000	0.050	3.0000	25.00
10.0000	0.035	10.0000	28.00

****
MATERIAL TYPE NO. 3
****

CURVE NO. 5: #3 ATTENUATION OF ROCK AVERAGE
CURVE NO. 6: DAMPING IN ROCK

CURVE NO. 5 CURVE NO. 6

STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.40
0.0003	1.000	0.0010	0.80
0.0010	0.988	0.0100	1.50

0.0030	0.952	0.1000	3.00
0.0100	0.900	1.0000	4.60
0.0300	0.810	0.0000	0.00
0.1000	0.725	0.0000	0.00
1.0000	0.550	0.0000	0.00

****
MATERIAL TYPE NO. 4
****

CURVE NO. 7: #4 modulus for waste (Zekkos et al., 2006)
CURVE NO. 8: damping for waste (Zekkos et al., 2006)

CURVE NO. 7		CURVE NO. 8	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	4.00
0.0003	0.996	0.0003	4.10
0.0010	0.990	0.0010	4.10
0.0030	0.975	0.0030	4.20
0.0100	0.936	0.0100	4.50
0.0300	0.856	0.0300	5.20
0.1000	0.690	0.1000	7.20
0.3000	0.475	0.3000	10.50
1.0000	0.252	1.0000	14.00
3.0000	0.121	3.0000	23.50
8.0000	0.058	10.0000	28.00

****
MATERIAL TYPE NO. 7
****

CURVE NO. 13: #7 modulus for clay PI=1-10 (Sun et al., 1988)
CURVE NO. 14: damping for clay (Dobry & Vucetic Curve, 4/9/91)

CURVE NO.13		CURVE NO.14	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	1.75
0.0010	0.974	0.0010	1.75
0.0032	0.915	0.0032	2.80
0.0100	0.786	0.0100	4.90
0.0316	0.574	0.0316	9.01
0.1000	0.312	0.1000	3.45
0.3000	0.160	0.3160	18.10

```
    1.0000     0.060         1.0000     22.00
    3.1600     0.020         3.1600     24.55
   10.0000     0.006        10.0000     26.50
     Option NO.    1   has been concluded.
     Option NO.    2   is started.

1******   OPTION  2  ***  READ SOIL PROFILE
 NEW SOIL PROFILE NO.   1      IDENTIFICATION  Jungo Landfill; BVLTFP.DAT
 NUMBER OF LAYERS                  18          DEPTH TO BEDROCK        260.00

  NO. TYPE  THICKNESS   DEPTH  Tot. PRESS.  MODULUS  DAMPING   UNIT WT.  SHEAR VEL
             (ft)       (ft)      (ksf)       (ksf)             (kcf)    (fps)
   1    4     10.00      5.00      0.34        657.   0.050    0.067     562.0
   2    4     10.00     15.00      1.02        755.   0.050    0.071     585.0
   3    4     10.00     25.00      1.75        850.   0.050    0.074     608.0
   4    4     10.00     35.00      2.51        955.   0.050    0.077     632.0
   5    4     10.00     45.00      3.29       1053.   0.050    0.079     655.0
   6    4     10.00     55.00      4.08       1142.   0.050    0.080     678.0
   7    2     10.00     65.00      5.08       3019.   0.050    0.120     900.0
   8    2     15.00     77.50      6.58       3363.   0.050    0.120     950.0
   9    7     15.00     92.50      8.38       3727.   0.050    0.120    1000.0
  10    2     15.00    107.50     10.22       3144.   0.050    0.125     900.0
  11    2     15.00    122.50     12.09       3882.   0.050    0.125    1000.0
  12    1     20.00    140.00     14.28       5590.   0.050    0.125    1200.0
  13    2     20.00    160.00     16.78       4697.   0.050    0.125    1100.0
  14    2     20.00    180.00     19.33       5814.   0.050    0.130    1200.0
  15    2     20.00    200.00     21.93       6308.   0.050    0.130    1250.0
  16    2     20.00    220.00     24.53       6823.   0.050    0.130    1300.0
  17    2     30.00    245.00     27.78       6823.   0.050    0.130    1300.0
  18   BASE                                  36335.   0.050    0.130    3000.0

  PERIOD = 1.02 FROM AVERAGE SHEAR VELOCITY =   1015.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  15.72
 FOR FREQUENCY         =   1.24 C/SEC.
     PERIOD            =   0.81 SEC.
     Option NO.    2   has been concluded.
     Option NO.    3   is started.

1******   OPTION  3  ***  READ INPUT MOTION

  FILE NAME FOR INPUT MOTION = BVLTFP.DAT
    NO. OF INPUT ACC. POINTS = 19355
   NO. OF POINTS USED IN FFT = 32768
        NO. OF HEADING LINES =     5
      NO. OF POINTS PER LINE =     8
  TIME STEP FOR INPUT MOTION = 0.0029
```

```
  FORMAT FOR OF TIME HISTORY = (8F9.6)


  READING INPUT MOTION FROM ----> BVLTFP.DAT
  FORMAT OF INPUT MOTION USED --> (8F9.6)

 ***** H E A D E R
PEER NGA Rotated Accelerogram (November 1, 2007)
#Misfit: 0.0837993
File Type: Accelerations (g)
File Type: Accelerations (g)
NPTS= 19355 , DT= 0.0029 SEC
 **  FIRST & LAST 5 LINES OF INPUT MOTION *****

     1  0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
     2  0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
     3  0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
     4  0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
     5  0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
   ........ INPUT MOTION READ NOT ECHOED...........
  2416  0.000010 0.000011 0.000012 0.000013 0.000013 0.000014 0.000015 0.000016
  2417  0.000017 0.000018 0.000019 0.000020 0.000021 0.000022 0.000023 0.000023
  2418  0.000024 0.000025 0.000026 0.000027 0.000028 0.000029 0.000030 0.000031
  2419  0.000032 0.000033 0.000034 0.000035 0.000036 0.000037 0.000038 0.000039
  2420  0.000040 0.000041 0.000042 0.000000 0.000000 0.000000 0.000000 0.000000

 MAXIMUM ACCELERATION =  0.26326
 AT TIME              = 20.47 SEC
 THE VALUES WILL BE MULTIPLIED BY A FACTOR =  0.950
 TO GIVE NEW MAXIMUM ACCELERATION          =  0.25000
 MEAN SQUARE FREQUENCY =       4.57 C/SEC.
  MAX ACCELERATION =    0.25956 FOR FREQUENCIES REMOVED ABOVE     100.00 C/SEC.
     Option NO.    3   has been concluded.
     Option NO.    4   is started.
1******   OPTION  4  ***  READ WHERE OBJECT MOTION IS GIVEN
   OBJECT MOTION IN LAYER NUMBER  18 OUTCROPPING
     Option NO.    4   has been concluded.
     Option NO.    5   is started.

1******   OPTION  5  ***  OBTAIN STRAIN COMPATIBLE SOIL PROPERTIES
  MAXIMUM NUMBER OF ITERATIONS                =     6
  FACTOR FOR UNIFORM STRAIN IN TIME DOMAIN    =   0.65



+              ITERATION NUMBER  1
     EARTHQUAKE   - BVLTFP.DAT
     SOIL PROFILE - Jungo Landfill; BVLTFP.DAT
```

ITERATION NUMBER 1

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01291	0.047	0.050	-7.2	602.9	657.2	-9.0	1.000
2	4	15.0	0.02965	0.052	0.050	3.7	646.6	754.6	-16.7	1.000
3	4	25.0	0.04168	0.057	0.050	13.0	688.7	849.5	-23.4	1.000
4	4	35.0	0.05205	0.061	0.050	18.2	745.0	955.1	-28.2	1.000
5	4	45.0	0.05536	0.062	0.050	19.6	812.1	1052.6	-29.6	1.000
6	4	55.0	0.05233	0.061	0.050	18.4	890.0	1142.1	-28.3	1.000
7	2	65.0	0.02063	0.043	0.050	-15.8	2148.0	3018.6	-40.5	1.000
8	2	77.5	0.02148	0.044	0.050	-13.6	2367.5	3363.4	-42.1	1.000
9	7	92.5	0.02152	0.076	0.050	34.5	2402.8	3726.7	-55.1	1.000
10	2	107.5	0.02657	0.048	0.050	-3.2	2085.3	3144.4	-50.8	1.000
11	2	122.5	0.02295	0.045	0.050	-10.1	2683.2	3882.0	-44.7	1.000
12	1	140.0	0.01801	0.040	0.050	-24.0	4978.9	5590.1	-12.3	1.000
13	2	160.0	0.02411	0.046	0.050	-7.7	3202.6	4697.2	-46.7	1.000
14	2	180.0	0.02112	0.044	0.050	-14.5	4110.6	5813.7	-41.4	1.000
15	2	200.0	0.02058	0.043	0.050	-16.0	4491.7	6308.2	-40.4	1.000
16	2	220.0	0.01986	0.042	0.050	-18.0	4904.5	6823.0	-39.1	1.000
17	2	245.0	0.02071	0.043	0.050	-15.6	4850.1	6823.0	-40.7	1.000

+ ITERATION NUMBER 2
1

EARTHQUAKE - BVLTFP.DAT
SOIL PROFILE - Jungo Landfill; BVLTFP.DAT

ITERATION NUMBER 2

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01244	0.046	0.047	-0.5	604.7	602.9	0.3	0.917
2	4	15.0	0.03259	0.053	0.052	2.7	637.3	646.6	-1.5	0.857
3	4	25.0	0.04586	0.059	0.057	2.7	677.5	688.7	-1.7	0.811
4	4	35.0	0.05726	0.063	0.061	2.5	732.5	745.0	-1.7	0.780
5	4	45.0	0.06219	0.064	0.062	3.0	795.2	812.1	-2.1	0.772
6	4	55.0	0.06402	0.065	0.061	5.2	858.3	890.0	-3.7	0.779
7	2	65.0	0.02900	0.050	0.043	14.2	1951.4	2148.0	-10.1	0.712
8	2	77.5	0.02842	0.050	0.044	11.8	2187.3	2367.5	-8.2	0.704
9	7	92.5	0.03068	0.089	0.076	14.2	2159.5	2402.8	-11.3	0.645
10	2	107.5	0.04054	0.063	0.048	22.8	1800.2	2085.3	-15.8	0.663
11	2	122.5	0.03509	0.057	0.045	20.5	2347.9	2683.2	-14.3	0.691
12	1	140.0	0.02078	0.043	0.040	6.9	4910.5	4978.9	-1.4	0.891
13	2	160.0	0.03479	0.057	0.046	18.2	2850.3	3202.6	-12.4	0.682

```
 14  2  180.0 0.02806 0.050  0.044     12.0    3795.2    4110.6     -8.3   0.707
 15  2  200.0 0.02599 0.048  0.043     10.2    4210.1    4491.7     -6.7   0.712
 16  2  220.0 0.02371 0.046  0.042      8.0    4673.6    4904.5     -4.9   0.719
 17  2  245.0 0.02409 0.046  0.043      6.8    4652.6    4850.1     -4.2   0.711
+              ITERATION NUMBER  3
1
     EARTHQUAKE   - BVLTFP.DAT
     SOIL PROFILE - Jungo Landfill; BVLTFP.DAT

  ITERATION NUMBER  3

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------  ------   -----
  1  4    5.0 0.01175 0.046  0.046     -0.8     607.4     604.7      0.5   0.920
  2  4   15.0 0.03140 0.053  0.053     -1.2     641.2     637.3      0.6   0.845
  3  4   25.0 0.04421 0.058  0.059     -1.0     681.8     677.5      0.6   0.797
  4  4   35.0 0.05471 0.062  0.063     -1.2     738.5     732.5      0.8   0.767
  5  4   45.0 0.06001 0.064  0.064     -0.9     800.4     795.2      0.6   0.755
  6  4   55.0 0.06307 0.064  0.065     -0.4     860.6     858.3      0.3   0.751
  7  2   65.0 0.03065 0.052  0.050      3.0    1917.5    1951.4     -1.8   0.646
  8  2   77.5 0.03009 0.051  0.050      2.5    2150.2    2187.3     -1.7   0.650
  9  7   92.5 0.03337 0.087  0.089     -1.8    2092.9    2159.5     -3.2   0.579
 10  2  107.5 0.04522 0.067  0.063      6.4    1723.0    1800.2     -4.5   0.572
 11  2  122.5 0.03823 0.060  0.057      5.5    2273.4    2347.9     -3.3   0.605
 12  1  140.0 0.01988 0.042  0.043     -2.2    4931.6    4910.5      0.4   0.878
 13  2  160.0 0.03646 0.059  0.057      3.1    2800.7    2850.3     -1.8   0.607
 14  2  180.0 0.02816 0.050  0.050      0.2    3791.2    3795.2     -0.1   0.653
 15  2  200.0 0.02548 0.048  0.048     -0.9    4234.3    4210.1      0.6   0.667
 16  2  220.0 0.02276 0.045  0.046     -1.9    4726.8    4673.6      1.1   0.685
 17  2  245.0 0.02646 0.048  0.046      4.1    4530.5    4652.6     -2.7   0.682
+              ITERATION NUMBER  4
1
     EARTHQUAKE   - BVLTFP.DAT
     SOIL PROFILE - Jungo Landfill; BVLTFP.DAT

  ITERATION NUMBER  4

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------  ------   -----
  1  4    5.0 0.01157 0.046  0.046     -0.2     608.2     607.4      0.1   0.924
  2  4   15.0 0.03090 0.052  0.053     -0.5     642.9     641.2      0.3   0.850
  3  4   25.0 0.04360 0.058  0.058     -0.4     683.4     681.8      0.2   0.803
  4  4   35.0 0.05384 0.062  0.062     -0.4     740.6     738.5      0.3   0.773
```

5	4	45.0	0.05897	0.063	0.064	-0.5	802.9	800.4	0.3	0.760
6	4	55.0	0.06241	0.064	0.064	-0.3	862.3	860.6	0.2	0.754
7	2	65.0	0.03106	0.052	0.052	1.0	1908.4	1917.5	-0.5	0.635
8	2	77.5	0.03064	0.052	0.051	1.3	2136.7	2150.2	-0.6	0.639
9	7	92.5	0.03444	0.086	0.087	-1.8	2066.1	2092.9	-1.3	0.562
10	2	107.5	0.04690	0.068	0.067	2.1	1697.3	1723.0	-1.5	0.548
11	2	122.5	0.03908	0.061	0.060	1.4	2254.3	2273.4	-0.8	0.586
12	1	140.0	0.01956	0.042	0.042	-0.8	4939.3	4931.6	0.2	0.882
13	2	160.0	0.03659	0.059	0.059	0.2	2797.0	2800.7	-0.1	0.596
14	2	180.0	0.02779	0.049	0.050	-0.6	3805.8	3791.2	0.4	0.652
15	2	200.0	0.02498	0.047	0.048	-0.9	4258.1	4234.3	0.6	0.671
16	2	220.0	0.02222	0.045	0.045	-1.1	4758.4	4726.8	0.7	0.693
17	2	245.0	0.02740	0.049	0.048	1.5	4485.0	4530.5	-1.0	0.664

+ ITERATION NUMBER 5
1

EARTHQUAKE - BVLTFP.DAT
SOIL PROFILE - Jungo Landfill; BVLTFP.DAT

ITERATION NUMBER 5

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01153	0.046	0.046	-0.1	608.3	608.2	0.0	0.925
2	4	15.0	0.03075	0.052	0.052	-0.2	643.4	642.9	0.1	0.852
3	4	25.0	0.04343	0.058	0.058	-0.1	683.9	683.4	0.1	0.804
4	4	35.0	0.05363	0.062	0.062	-0.1	741.1	740.6	0.1	0.775
5	4	45.0	0.05862	0.063	0.063	-0.2	803.8	802.9	0.1	0.763
6	4	55.0	0.06217	0.064	0.064	-0.1	862.9	862.3	0.1	0.755
7	2	65.0	0.03118	0.053	0.052	0.3	1905.7	1908.4	-0.1	0.632
8	2	77.5	0.03085	0.052	0.052	0.5	2131.6	2136.7	-0.2	0.635
9	7	92.5	0.03490	0.085	0.086	-0.8	2054.8	2066.1	-0.6	0.554
10	2	107.5	0.04754	0.069	0.068	0.8	1687.7	1697.3	-0.6	0.540
11	2	122.5	0.03932	0.062	0.061	0.4	2249.0	2254.3	-0.2	0.581
12	1	140.0	0.01947	0.042	0.042	-0.2	4941.5	4939.3	0.0	0.884
13	2	160.0	0.03652	0.059	0.059	-0.1	2799.2	2797.0	0.1	0.595
14	2	180.0	0.02760	0.049	0.049	-0.3	3813.6	3805.8	0.2	0.655
15	2	200.0	0.02477	0.047	0.047	-0.4	4268.2	4258.1	0.2	0.675
16	2	220.0	0.02210	0.045	0.045	-0.2	4765.1	4758.4	0.1	0.697
17	2	245.0	0.02776	0.049	0.049	0.6	4467.7	4485.0	-0.4	0.657

+ ITERATION NUMBER 6
1

EARTHQUAKE - BVLTFP.DAT
SOIL PROFILE - Jungo Landfill; BVLTFP.DAT

ITERATION NUMBER 6

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01151	0.046	0.046	0.0	608.4	608.3	0.0	0.926
2	4	15.0	0.03070	0.052	0.052	0.0	643.5	643.4	0.0	0.853
3	4	25.0	0.04338	0.058	0.058	0.0	684.0	683.9	0.0	0.805
4	4	35.0	0.05358	0.062	0.062	0.0	741.2	741.1	0.0	0.776
5	4	45.0	0.05850	0.063	0.063	-0.1	804.1	803.8	0.0	0.764
6	4	55.0	0.06208	0.064	0.064	0.0	863.1	862.9	0.0	0.756
7	2	65.0	0.03122	0.053	0.053	0.1	1905.0	1905.7	0.0	0.631
8	2	77.5	0.03092	0.052	0.052	0.2	2129.7	2131.6	-0.1	0.634
9	7	92.5	0.03511	0.085	0.085	-0.3	2049.9	2054.8	-0.2	0.551
10	2	107.5	0.04779	0.069	0.069	0.3	1684.0	1687.7	-0.2	0.537
11	2	122.5	0.03938	0.062	0.062	0.1	2247.7	2249.0	-0.1	0.579
12	1	140.0	0.01945	0.042	0.042	-0.1	4942.2	4941.5	0.0	0.884
13	2	160.0	0.03645	0.059	0.059	-0.1	2801.2	2799.2	0.1	0.596
14	2	180.0	0.02751	0.049	0.049	-0.1	3817.0	3813.6	0.1	0.656
15	2	200.0	0.02469	0.047	0.047	-0.1	4272.1	4268.2	0.1	0.677
16	2	220.0	0.02209	0.045	0.045	0.0	4765.9	4765.1	0.0	0.698
17	2	245.0	0.02791	0.049	0.049	0.2	4461.0	4467.7	-0.2	0.655

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	4	10.0	5.0	0.01771	107.76	18.90
2	4	10.0	15.0	0.04723	303.87	18.90
3	4	10.0	25.0	0.06673	456.37	18.07
4	4	10.0	35.0	0.08242	610.84	18.06
5	4	10.0	45.0	0.09000	723.38	22.08
6	4	10.0	55.0	0.09551	824.13	22.08
7	2	10.0	65.0	0.04803	915.23	22.07
8	2	15.0	77.5	0.04757	1014.06	22.06
9	7	15.0	92.5	0.05401	1109.90	15.01
10	2	15.0	107.5	0.07353	1240.95	28.66
11	2	15.0	122.5	0.06058	1362.42	28.64
12	1	20.0	140.0	0.02992	1478.30	28.62
13	2	20.0	160.0	0.05607	1569.49	28.61
14	2	20.0	180.0	0.04232	1614.07	28.59
15	2	20.0	200.0	0.03799	1621.38	28.58
16	2	20.0	220.0	0.03398	1619.38	14.51
17	2	30.0	245.0	0.04294	1918.24	14.53

PERIOD = 1.24 FROM AVERAGE SHEAR VELOCITY = 835.

```
  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  14.00
 FOR FREQUENCY         =   1.00 C/SEC.
     PERIOD            =   1.00 SEC.
     Option NO.    5   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -BVLTFP.DAT
  SOIL DEPOSIT - Jungo Landfill; BVLTFP.DAT
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH SAVED
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC. RECORD
     WITHIN            0.0        0.32169          20.79           2.61               0.000                  0
     WITHIN           10.0        0.28528          18.89           2.31               0.000                  0
     WITHIN           20.0        0.26925          18.05           2.03               0.000                  0
     WITHIN           30.0        0.22545          22.08           2.07               0.000                  0
     WITHIN           40.0        0.19054          14.98           2.19               0.000                  0
     WITHIN           50.0        0.17718          17.85           2.38               0.000                  0
     WITHIN           60.0        0.21215          20.91           2.52               0.000                  0
     WITHIN           70.0        0.18833          20.90           2.40               0.000                  0
     WITHIN           85.0        0.16550          21.33           2.28               0.000                  0
     WITHIN          100.0        0.14786          20.63           2.55               0.000                  0
     WITHIN          115.0        0.16059          17.76           2.98               0.000                  0
     WITHIN          130.0        0.15903          17.74           3.15               0.000                  0
     WITHIN          150.0        0.14897          17.73           2.93               0.000                  0
     WITHIN          170.0        0.14701          21.05           3.56               0.000                  0
     Option NO.    6   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -BVLTFP.DAT
  SOIL DEPOSIT - Jungo Landfill; BVLTFP.DAT
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH SAVED
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC. RECORD
     WITHIN          190.0        0.17191          20.53           3.66               0.000                  0
     WITHIN          210.0        0.17177          20.51           3.92               0.000                  0
     WITHIN          230.0        0.17208          20.49           4.18               0.000                  0
     WITHIN          260.0        0.19518          20.47           4.54               0.000                  0
     OUTCR.          260.0        0.25956          20.47           4.57               0.000                  0
     Option NO.    6   has been concluded.
     Option NO.    7   is started.

1******   OPTION  7  ***  COMPUTE STRESS/STRAIN HISTORY

  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    7
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Stress at the top of layer
```

```
  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    7
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Strain not saved
     Option NO.    7   has been concluded.
```

```
 ******************************************************
 * SHAKE  --   A COMPUTER PROGRAM FOR EARTHQUAKE RESPONSE  *
 *             ANALYSIS OF HORIZONTALLY LAYERED SITES      *
 *             by: Per B. Schnabel & John Lysmer -- 1970   *
 * ---------------------------------------------------------*
 * shake85     IBM-PC version of SHAKE                     *
 *             by: S.S. (Willie) Lai, January 1985         *
 * ---------------------------------------------------------*
 * shake88   : New modulus reduction curves for clays added*
 *             using results from Sun et al (1988)         *
 *             by: J. I. Sun & Ramin Golesorkhi            *
 *             February 26, 1988                           *
 * ---------------------------------------------------------*
 * SHAKE90/91: Adjust last iteration; Input now is either  *
 *             Gmax or max Vs; up to 13 material types can *
 *             be specified by user; up to 50 Layers can   *
 *             be specified; object motion can be read in  *
 *             from a separate file and can have user      *
 *             specified format; Different periods for     *
 *             response spectral calculations; options     *
 *             are renumbered; and general cleanup         *
 *             by: J. I. Sun, I. M. Idriss & P. Dirrim     *
 *             June 1990 - February 1991                   *
 * ---------------------------------------------------------*
 * SHAKE91   : General cleanup and finalization of input/  *
 *             output format ... etc                       *
 *             by: I. M. Idriss                            *
 *             December 1991                               *
 ************************************************************
 MAX. NUMBER OF TERMS IN FOURIER TRANSFORM =     32768
 NECESSARY LENGTH OF BLANK COMMON X        =    204819
    Option NO.    1   is started.

1******   OPTION  1  ***  READ RELATION BETWEEN SOIL PROPERTIES AND STRAIN

 **********************
  MATERIAL TYPE NO. 1
 **********************

 CURVE NO.  1:      #1 modulus for clay (seed & sun 1989) upper range
 CURVE NO.  2:        damping for clay (Idriss 1990) -


     CURVE NO. 1             CURVE NO. 2
 ====================    ==================
   STRAIN    G/Gmax         STRAIN    DAMPING
 --------   -------        --------  --------
   0.0001     1.000         0.0001      0.24
   0.0003     1.000         0.0003      0.42
```

0.0010	1.000	0.0010	0.80
0.0030	0.981	0.0030	1.40
0.0100	0.941	0.0100	2.80
0.0300	0.847	0.0300	5.10
0.1000	0.656	0.1000	9.80
0.3000	0.438	0.3000	15.50
1.0000	0.238	1.0000	21.00
3.0000	0.144	3.1600	25.00
10.0000	0.110	10.0000	28.00

****
MATERIAL TYPE NO. 2
****

CURVE NO. 3: #2 modulus for sand (seed & idriss 1970) - upper Range
CURVE NO. 4: damping for sand (Idriss 1990) - (about LRng from SI

CURVE NO. 3		CURVE NO. 4	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.24
0.0003	1.000	0.0003	0.42
0.0010	0.990	0.0010	0.80
0.0030	0.960	0.0030	1.40
0.0100	0.850	0.0100	2.80
0.0300	0.640	0.0300	5.10
0.1000	0.370	0.1000	9.80
0.3000	0.180	0.3000	15.50
1.0000	0.080	1.0000	21.00
3.0000	0.050	3.0000	25.00
10.0000	0.035	10.0000	28.00

****
MATERIAL TYPE NO. 3
****

CURVE NO. 5: #3 ATTENUATION OF ROCK AVERAGE
CURVE NO. 6: DAMPING IN ROCK

CURVE NO. 5		CURVE NO. 6	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.40
0.0003	1.000	0.0010	0.80
0.0010	0.988	0.0100	1.50

0.0030	0.952	0.1000	3.00
0.0100	0.900	1.0000	4.60
0.0300	0.810	0.0000	0.00
0.1000	0.725	0.0000	0.00
1.0000	0.550	0.0000	0.00

****
MATERIAL TYPE NO. 4
****

CURVE NO. 7: #4 modulus for waste (Zekkos et al., 2006)
CURVE NO. 8: damping for waste (Zekkos et al., 2006)

CURVE NO. 7		CURVE NO. 8	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	4.00
0.0003	0.996	0.0003	4.10
0.0010	0.990	0.0010	4.10
0.0030	0.975	0.0030	4.20
0.0100	0.936	0.0100	4.50
0.0300	0.856	0.0300	5.20
0.1000	0.690	0.1000	7.20
0.3000	0.475	0.3000	10.50
1.0000	0.252	1.0000	14.00
3.0000	0.121	3.0000	23.50
8.0000	0.058	10.0000	28.00

****
MATERIAL TYPE NO. 7
****

CURVE NO. 13: #7 modulus for clay PI=1-10 (Sun et al., 1988)
CURVE NO. 14: damping for clay (Dobry & Vucetic Curve, 4/9/91)

CURVE NO.13		CURVE NO.14	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	1.75
0.0010	0.974	0.0010	1.75
0.0032	0.915	0.0032	2.80
0.0100	0.786	0.0100	4.90
0.0316	0.574	0.0316	9.01
0.1000	0.312	0.1000	3.45
0.3000	0.160	0.3160	18.10

```
    1.0000     0.060         1.0000     22.00
    3.1600     0.020         3.1600     24.55
   10.0000     0.006        10.0000     26.50
     Option NO.    1   has been concluded.
     Option NO.    2   is started.

1******   OPTION  2  ***  READ SOIL PROFILE
 NEW SOIL PROFILE NO.   1      IDENTIFICATION  Jungo Landfill; CHY080FP.DAT
 NUMBER OF LAYERS                  18          DEPTH TO BEDROCK        260.00

  NO. TYPE  THICKNESS   DEPTH  Tot. PRESS.  MODULUS  DAMPING   UNIT WT.  SHEAR VEL
              (ft)      (ft)      (ksf)       (ksf)             (kcf)    (fps)
   1    4     10.00      5.00      0.34        657.   0.050    0.067     562.0
   2    4     10.00     15.00      1.02        755.   0.050    0.071     585.0
   3    4     10.00     25.00      1.75        850.   0.050    0.074     608.0
   4    4     10.00     35.00      2.51        955.   0.050    0.077     632.0
   5    4     10.00     45.00      3.29       1053.   0.050    0.079     655.0
   6    4     10.00     55.00      4.08       1142.   0.050    0.080     678.0
   7    2     10.00     65.00      5.08       3019.   0.050    0.120     900.0
   8    2     15.00     77.50      6.58       3363.   0.050    0.120     950.0
   9    7     15.00     92.50      8.38       3727.   0.050    0.120    1000.0
  10    2     15.00    107.50     10.22       3144.   0.050    0.125     900.0
  11    2     15.00    122.50     12.09       3882.   0.050    0.125    1000.0
  12    1     20.00    140.00     14.28       5590.   0.050    0.125    1200.0
  13    2     20.00    160.00     16.78       4697.   0.050    0.125    1100.0
  14    2     20.00    180.00     19.33       5814.   0.050    0.130    1200.0
  15    2     20.00    200.00     21.93       6308.   0.050    0.130    1250.0
  16    2     20.00    220.00     24.53       6823.   0.050    0.130    1300.0
  17    2     30.00    245.00     27.78       6823.   0.050    0.130    1300.0
  18   BASE                                  36335.   0.050    0.130    3000.0

  PERIOD = 1.02 FROM AVERAGE SHEAR VELOCITY =   1015.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  15.72
 FOR FREQUENCY         =   1.24 C/SEC.
     PERIOD            =   0.81 SEC.
     Option NO.    2   has been concluded.
     Option NO.    3   is started.

1******   OPTION  3  ***  READ INPUT MOTION

  FILE NAME FOR INPUT MOTION = CHY080FP.DAT
    NO. OF INPUT ACC. POINTS = 22080
   NO. OF POINTS USED IN FFT = 32768
        NO. OF HEADING LINES =     5
      NO. OF POINTS PER LINE =     8
  TIME STEP FOR INPUT MOTION = 0.0050
```

```
  FORMAT FOR OF TIME HISTORY = (8F9.6)


  READING INPUT MOTION FROM ----> CHY080FP.DAT
  FORMAT OF INPUT MOTION USED --> (8F9.6)

 ***** H E A D E R
PEER NGA Rotated Accelerogram (November 1, 2007)
#Misfit: 0.0706782
File Type: Accelerations (g)
File Type: Accelerations (g)
NPTS= 22081 , DT= 0.005 SEC
 **  FIRST & LAST 5 LINES OF INPUT MOTION *****

     1 -0.000001-0.000001-0.000001-0.000001-0.000001-0.000001-0.000001-0.000001
     2 -0.000001-0.000001-0.000001-0.000001-0.000001-0.000001-0.000001-0.000001
     3 -0.000001-0.000001-0.000001-0.000001-0.000001-0.000001-0.000001-0.000001
     4 -0.000001-0.000001-0.000001-0.000001-0.000001-0.000001-0.000001-0.000001
     5 -0.000001-0.000001-0.000001-0.000001-0.000001-0.000002-0.000002-0.000002
   ........ INPUT MOTION READ NOT ECHOED...........
  2756  0.000030 0.000030 0.000030 0.000030 0.000030 0.000030 0.000030 0.000031
  2757  0.000031 0.000031 0.000031 0.000031 0.000031 0.000031 0.000031 0.000031
  2758  0.000032 0.000032 0.000032 0.000032 0.000032 0.000032 0.000032 0.000032
  2759  0.000033 0.000033 0.000033 0.000033 0.000033 0.000033 0.000033 0.000033
  2760  0.000033 0.000033 0.000034 0.000034 0.000034 0.000034 0.000034 0.000034

 MAXIMUM ACCELERATION =  0.23357
 AT TIME              = 24.18 SEC
 THE VALUES WILL BE MULTIPLIED BY A FACTOR =  1.070
 TO GIVE NEW MAXIMUM ACCELERATION          =  0.25000
 MEAN SQUARE FREQUENCY =       5.68 C/SEC.
  MAX ACCELERATION =    0.25000 FOR FREQUENCIES REMOVED ABOVE     100.00 C/SEC.
     Option NO.    3   has been concluded.
     Option NO.    4   is started.
1******   OPTION  4  ***  READ WHERE OBJECT MOTION IS GIVEN
   OBJECT MOTION IN LAYER NUMBER  18 OUTCROPPING
     Option NO.    4   has been concluded.
     Option NO.    5   is started.

1******   OPTION  5  ***  OBTAIN STRAIN COMPATIBLE SOIL PROPERTIES
  MAXIMUM NUMBER OF ITERATIONS                =     6
  FACTOR FOR UNIFORM STRAIN IN TIME DOMAIN    =   0.65



+              ITERATION NUMBER  1
     EARTHQUAKE   - CHY080FP.DAT
     SOIL PROFILE - Jungo Landfill; CHY080FP.DAT
```

ITERATION NUMBER 1

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01652	0.048	0.050	-3.7	591.1	657.2	-11.2	1.000
2	4	15.0	0.04133	0.057	0.050	12.8	612.6	754.6	-23.2	1.000
3	4	25.0	0.05565	0.062	0.050	19.7	654.8	849.5	-29.7	1.000
4	4	35.0	0.06026	0.064	0.050	21.4	725.8	955.1	-31.6	1.000
5	4	45.0	0.05945	0.063	0.050	21.1	801.7	1052.6	-31.3	1.000
6	4	55.0	0.05956	0.063	0.050	21.1	869.6	1142.1	-31.3	1.000
7	2	65.0	0.02535	0.047	0.050	-5.3	2029.2	3018.6	-48.8	1.000
8	2	77.5	0.02561	0.048	0.050	-4.8	2254.2	3363.4	-49.2	1.000
9	7	92.5	0.02545	0.082	0.050	39.3	2287.8	3726.7	-62.9	1.000
10	2	107.5	0.03244	0.054	0.050	7.5	1957.4	3144.4	-60.6	1.000
11	2	122.5	0.02778	0.049	0.050	-1.2	2541.6	3882.0	-52.7	1.000
12	1	140.0	0.02045	0.043	0.050	-16.3	4918.0	5590.1	-13.7	1.000
13	2	160.0	0.02717	0.049	0.050	-2.2	3095.3	4697.2	-51.8	1.000
14	2	180.0	0.02361	0.046	0.050	-8.7	3987.0	5813.7	-45.8	1.000
15	2	200.0	0.02292	0.045	0.050	-10.2	4361.8	6308.2	-44.6	1.000
16	2	220.0	0.02306	0.045	0.050	-9.9	4709.8	6823.0	-44.9	1.000
17	2	245.0	0.02497	0.047	0.050	-6.0	4605.8	6823.0	-48.1	1.000

+ ITERATION NUMBER 2
1

EARTHQUAKE - CHY080FP.DAT
SOIL PROFILE - Jungo Landfill; CHY080FP.DAT

ITERATION NUMBER 2

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01652	0.048	0.048	0.0	591.1	591.1	0.0	0.899
2	4	15.0	0.04583	0.059	0.057	2.9	601.8	612.6	-1.8	0.812
3	4	25.0	0.06464	0.065	0.062	3.8	637.3	654.8	-2.8	0.771
4	4	35.0	0.06987	0.066	0.064	3.7	706.3	725.8	-2.8	0.760
5	4	45.0	0.06700	0.065	0.063	3.0	784.4	801.7	-2.2	0.762
6	4	55.0	0.06901	0.066	0.063	3.7	846.4	869.6	-2.7	0.761
7	2	65.0	0.03276	0.054	0.047	12.8	1872.4	2029.2	-8.4	0.672
8	2	77.5	0.03324	0.055	0.048	13.3	2075.2	2254.2	-8.6	0.670
9	7	92.5	0.03521	0.085	0.082	3.0	2047.5	2287.8	-11.7	0.614
10	2	107.5	0.04498	0.067	0.054	19.1	1726.8	1957.4	-13.4	0.622
11	2	122.5	0.03823	0.060	0.049	18.3	2273.4	2541.6	-11.8	0.655
12	1	140.0	0.02311	0.046	0.043	5.6	4859.7	4918.0	-1.2	0.880
13	2	160.0	0.04340	0.065	0.049	25.2	2617.3	3095.3	-18.3	0.659

```
 14  2  180.0 0.03838 0.061  0.046     24.1    3399.7    3987.0    -17.3   0.686
 15  2  200.0 0.03864 0.061  0.045     25.5    3679.4    4361.8    -18.5   0.691
 16  2  220.0 0.03831 0.061  0.045     24.9    3992.5    4709.8    -18.0   0.690
 17  2  245.0 0.04214 0.064  0.047     26.6    3846.9    4605.8    -19.7   0.675
+              ITERATION NUMBER  3
1
     EARTHQUAKE   - CHY080FP.DAT
     SOIL PROFILE - Jungo Landfill; CHY080FP.DAT

  ITERATION NUMBER  3

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------  ------   -----
  1  4    5.0 0.01427 0.047  0.048     -2.0     598.1     591.1      1.2   0.899
  2  4   15.0 0.04017 0.057  0.059     -3.8     615.6     601.8      2.2   0.798
  3  4   25.0 0.05679 0.063  0.065     -3.4     652.5     637.3      2.3   0.750
  4  4   35.0 0.06092 0.064  0.066     -3.6     724.3     706.3      2.5   0.739
  5  4   45.0 0.05771 0.063  0.065     -3.9     806.1     784.4      2.7   0.745
  6  4   55.0 0.06000 0.064  0.066     -3.7     868.5     846.4      2.5   0.741
  7  2   65.0 0.03003 0.051  0.054     -6.6    1931.2    1872.4      3.0   0.620
  8  2   77.5 0.03144 0.053  0.055     -4.1    2117.2    2075.2      2.0   0.617
  9  7   92.5 0.03652 0.083  0.085     -2.1    2016.5    2047.5     -1.5   0.549
 10  2  107.5 0.04922 0.070  0.067      5.0    1663.3    1726.8     -3.8   0.549
 11  2  122.5 0.04391 0.066  0.060      8.2    2152.8    2273.4     -5.6   0.586
 12  1  140.0 0.02390 0.046  0.046      1.5    4843.6    4859.7     -0.3   0.869
 13  2  160.0 0.05262 0.073  0.065     10.3    2414.3    2617.3     -8.4   0.557
 14  2  180.0 0.04552 0.067  0.061      9.9    3177.1    3399.7     -7.0   0.585
 15  2  200.0 0.04553 0.067  0.061      9.5    3447.2    3679.4     -6.7   0.583
 16  2  220.0 0.04415 0.066  0.061      8.4    3775.6    3992.5     -5.7   0.585
 17  2  245.0 0.04804 0.069  0.064      7.4    3646.3    3846.9     -5.5   0.564
+              ITERATION NUMBER  4
1
     EARTHQUAKE   - CHY080FP.DAT
     SOIL PROFILE - Jungo Landfill; CHY080FP.DAT

  ITERATION NUMBER  4

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------  ------   -----
  1  4    5.0 0.01360 0.047  0.047     -0.6     600.4     598.1      0.4   0.910
  2  4   15.0 0.03785 0.056  0.057     -1.8     621.7     615.6      1.0   0.816
  3  4   25.0 0.05353 0.062  0.063     -1.6     659.4     652.5      1.1   0.768
  4  4   35.0 0.05733 0.063  0.064     -1.6     732.3     724.3      1.1   0.758
```

5	4	45.0	0.05368	0.062	0.063	-2.0	816.6	806.1	1.3	0.766
6	4	55.0	0.05571	0.062	0.064	-2.0	880.2	868.5	1.3	0.760
7	2	65.0	0.02900	0.050	0.051	-1.5	1951.5	1931.2	1.0	0.640
8	2	77.5	0.03117	0.052	0.053	-0.6	2123.6	2117.2	0.3	0.629
9	7	92.5	0.03766	0.082	0.083	-1.8	1990.4	2016.5	-1.3	0.541
10	2	107.5	0.05149	0.072	0.070	2.4	1631.6	1663.3	-1.9	0.529
11	2	122.5	0.04638	0.068	0.066	3.1	2105.2	2152.8	-2.3	0.555
12	1	140.0	0.02391	0.046	0.046	0.0	4843.3	4843.6	0.0	0.866
13	2	160.0	0.05687	0.076	0.073	4.0	2332.5	2414.3	-3.5	0.514
14	2	180.0	0.04838	0.070	0.067	3.4	3097.6	3177.1	-2.6	0.546
15	2	200.0	0.04804	0.069	0.067	3.0	3371.1	3447.2	-2.3	0.546
16	2	220.0	0.04602	0.068	0.066	2.4	3712.1	3775.6	-1.7	0.553
17	2	245.0	0.04987	0.071	0.069	2.1	3589.0	3646.3	-1.6	0.534

+ ITERATION NUMBER 5
1

EARTHQUAKE - CHY080FP.DAT
SOIL PROFILE - Jungo Landfill; CHY080FP.DAT

ITERATION NUMBER 5

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01336	0.047	0.047	-0.2	601.3	600.4	0.1	0.914
2	4	15.0	0.03698	0.055	0.056	-0.7	624.2	621.7	0.4	0.824
3	4	25.0	0.05224	0.061	0.062	-0.7	662.2	659.4	0.4	0.776
4	4	35.0	0.05601	0.062	0.063	-0.6	735.4	732.3	0.4	0.767
5	4	45.0	0.05236	0.061	0.062	-0.7	820.2	816.6	0.4	0.776
6	4	55.0	0.05510	0.062	0.062	-0.3	881.9	880.2	0.2	0.771
7	2	65.0	0.02880	0.050	0.050	-0.3	1955.4	1951.5	0.2	0.646
8	2	77.5	0.03126	0.053	0.052	0.2	2121.4	2123.6	-0.1	0.631
9	7	92.5	0.03837	0.081	0.082	-1.1	1974.5	1990.4	-0.8	0.534
10	2	107.5	0.05263	0.073	0.072	1.2	1616.1	1631.6	-1.0	0.519
11	2	122.5	0.04743	0.069	0.068	1.3	2085.8	2105.2	-0.9	0.542
12	1	140.0	0.02388	0.046	0.046	-0.1	4843.9	4843.3	0.0	0.866
13	2	160.0	0.05878	0.077	0.076	1.7	2297.7	2332.5	-1.5	0.497
14	2	180.0	0.04946	0.071	0.070	1.2	3068.9	3097.6	-0.9	0.533
15	2	200.0	0.04886	0.070	0.069	0.9	3347.2	3371.1	-0.7	0.534
16	2	220.0	0.04653	0.068	0.068	0.6	3695.0	3712.1	-0.5	0.544
17	2	245.0	0.05034	0.071	0.071	0.5	3574.7	3589.0	-0.4	0.526

+ ITERATION NUMBER 6
1

EARTHQUAKE - CHY080FP.DAT
SOIL PROFILE - Jungo Landfill; CHY080FP.DAT

ITERATION NUMBER 6

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01328	0.047	0.047	-0.1	601.5	601.3	0.0	0.915
2	4	15.0	0.03666	0.055	0.055	-0.3	625.1	624.2	0.1	0.827
3	4	25.0	0.05176	0.061	0.061	-0.3	663.3	662.2	0.2	0.780
4	4	35.0	0.05550	0.062	0.062	-0.2	736.6	735.4	0.2	0.770
5	4	45.0	0.05192	0.061	0.061	-0.2	821.4	820.2	0.1	0.779
6	4	55.0	0.05504	0.062	0.062	0.0	882.1	881.9	0.0	0.772
7	2	65.0	0.02878	0.050	0.050	0.0	1956.0	1955.4	0.0	0.648
8	2	77.5	0.03135	0.053	0.053	0.2	2119.4	2121.4	-0.1	0.631
9	7	92.5	0.03873	0.080	0.081	-0.6	1966.7	1974.5	-0.4	0.530
10	2	107.5	0.05320	0.073	0.073	0.6	1608.4	1616.1	-0.5	0.514
11	2	122.5	0.04787	0.069	0.069	0.5	2077.7	2085.8	-0.4	0.537
12	1	140.0	0.02387	0.046	0.046	0.0	4844.0	4843.9	0.0	0.867
13	2	160.0	0.05965	0.078	0.077	0.7	2282.2	2297.7	-0.7	0.489
14	2	180.0	0.04987	0.071	0.071	0.5	3058.2	3068.9	-0.4	0.528
15	2	200.0	0.04912	0.070	0.070	0.3	3339.8	3347.2	-0.2	0.531
16	2	220.0	0.04665	0.068	0.068	0.1	3691.3	3695.0	-0.1	0.542
17	2	245.0	0.05041	0.071	0.071	0.1	3572.5	3574.7	-0.1	0.524

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	4	10.0	5.0	0.02043	122.86	22.39
2	4	10.0	15.0	0.05640	352.04	22.39
3	4	10.0	25.0	0.07964	527.37	22.39
4	4	10.0	35.0	0.08538	627.86	22.39
5	4	10.0	45.0	0.07987	655.11	22.39
6	4	10.0	55.0	0.08467	746.70	22.19
7	2	10.0	65.0	0.04427	865.64	22.18
8	2	15.0	77.5	0.04823	1023.18	22.17
9	7	15.0	92.5	0.05959	1176.53	22.16
10	2	15.0	107.5	0.08185	1322.77	22.14
11	2	15.0	122.5	0.07365	1536.10	22.11
12	1	20.0	140.0	0.03673	1779.11	22.08
13	2	20.0	160.0	0.09177	2108.56	22.07
14	2	20.0	180.0	0.07672	2354.54	22.06
15	2	20.0	200.0	0.07557	2529.33	22.04
16	2	20.0	220.0	0.07177	2651.77	22.02
17	2	30.0	245.0	0.07756	2772.52	21.99

PERIOD = 1.32 FROM AVERAGE SHEAR VELOCITY = 786.

```
  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  10.68
 FOR FREQUENCY         =   0.92 C/SEC.
     PERIOD            =   1.09 SEC.
     Option NO.    5   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -CHY080FP.DAT
  SOIL DEPOSIT - Jungo Landfill; CHY080FP.DAT
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH SAVED
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC. RECORD
     WITHIN            0.0        0.37502          22.39           2.80               0.000                  0
     WITHIN           10.0        0.34163          22.39           2.49               0.000                  0
     WITHIN           20.0        0.25297          22.39           2.08               0.000                  0
     WITHIN           30.0        0.19361          22.15           2.17               0.000                  0
     WITHIN           40.0        0.18002          22.15           2.47               0.000                  0
     WITHIN           50.0        0.17042          22.52           2.60               0.000                  0
     WITHIN           60.0        0.23194          22.51           2.70               0.000                  0
     WITHIN           70.0        0.23686          22.51           2.61               0.000                  0
     WITHIN           85.0        0.19650          22.50           2.37               0.000                  0
     WITHIN          100.0        0.17008          22.03           2.65               0.000                  0
     WITHIN          115.0        0.17249          22.59           3.15               0.000                  0
     WITHIN          130.0        0.18242          22.60           3.25               0.000                  0
     WITHIN          150.0        0.16618          23.98           3.05               0.000                  0
     WITHIN          170.0        0.17109          23.51           3.81               0.000                  0
     Option NO.    6   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -CHY080FP.DAT
  SOIL DEPOSIT - Jungo Landfill; CHY080FP.DAT
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH SAVED
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC. RECORD
     WITHIN          190.0        0.17474          23.48           4.05               0.000                  0
     WITHIN          210.0        0.18147          23.47           4.29               0.000                  0
     WITHIN          230.0        0.19367          23.44           4.67               0.000                  0
     WITHIN          260.0        0.19312          24.18           5.52               0.000                  0
     OUTCR.          260.0        0.25000          24.18           5.68               0.000                  0
     Option NO.    6   has been concluded.
     Option NO.    7   is started.

1******   OPTION  7  ***  COMPUTE STRESS/STRAIN HISTORY

  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    7
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Stress at the top of layer
```

```
  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    7
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Strain not saved
     Option NO.    7   has been concluded.
```

```
 ******************************************************
 * SHAKE  --   A COMPUTER PROGRAM FOR EARTHQUAKE RESPONSE  *
 *             ANALYSIS OF HORIZONTALLY LAYERED SITES      *
 *             by: Per B. Schnabel & John Lysmer -- 1970   *
 * ---------------------------------------------------------*
 * shake85     IBM-PC version of SHAKE                     *
 *             by: S.S. (Willie) Lai, January 1985         *
 * ---------------------------------------------------------*
 * shake88   : New modulus reduction curves for clays added*
 *             using results from Sun et al (1988)         *
 *             by: J. I. Sun & Ramin Golesorkhi            *
 *             February 26, 1988                           *
 * ---------------------------------------------------------*
 * SHAKE90/91: Adjust last iteration; Input now is either  *
 *             Gmax or max Vs; up to 13 material types can *
 *             be specified by user; up to 50 Layers can   *
 *             be specified; object motion can be read in  *
 *             from a separate file and can have user      *
 *             specified format; Different periods for     *
 *             response spectral calculations; options     *
 *             are renumbered; and general cleanup         *
 *             by: J. I. Sun, I. M. Idriss & P. Dirrim     *
 *             June 1990 - February 1991                   *
 * ---------------------------------------------------------*
 * SHAKE91   : General cleanup and finalization of input/  *
 *             output format ... etc                       *
 *             by: I. M. Idriss                            *
 *             December 1991                               *
 ************************************************************
 MAX. NUMBER OF TERMS IN FOURIER TRANSFORM =     32768
 NECESSARY LENGTH OF BLANK COMMON X        =    204819
    Option NO.    1   is started.

1******   OPTION  1  ***  READ RELATION BETWEEN SOIL PROPERTIES AND STRAIN

 **********************
  MATERIAL TYPE NO. 1
 **********************

 CURVE NO.  1:      #1 modulus for clay (seed & sun 1989) upper range
 CURVE NO.  2:        damping for clay (Idriss 1990) -


     CURVE NO. 1             CURVE NO. 2
 ====================    ==================
   STRAIN    G/Gmax         STRAIN    DAMPING
 --------   -------        --------  --------
   0.0001     1.000         0.0001      0.24
   0.0003     1.000         0.0003      0.42
```

0.0010	1.000	0.0010	0.80
0.0030	0.981	0.0030	1.40
0.0100	0.941	0.0100	2.80
0.0300	0.847	0.0300	5.10
0.1000	0.656	0.1000	9.80
0.3000	0.438	0.3000	15.50
1.0000	0.238	1.0000	21.00
3.0000	0.144	3.1600	25.00
10.0000	0.110	10.0000	28.00

****
MATERIAL TYPE NO. 2
****

CURVE NO. 3: #2 modulus for sand (seed & idriss 1970) - upper Range
CURVE NO. 4: damping for sand (Idriss 1990) - (about LRng from SI

CURVE NO. 3		CURVE NO. 4	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.24
0.0003	1.000	0.0003	0.42
0.0010	0.990	0.0010	0.80
0.0030	0.960	0.0030	1.40
0.0100	0.850	0.0100	2.80
0.0300	0.640	0.0300	5.10
0.1000	0.370	0.1000	9.80
0.3000	0.180	0.3000	15.50
1.0000	0.080	1.0000	21.00
3.0000	0.050	3.0000	25.00
10.0000	0.035	10.0000	28.00

****
MATERIAL TYPE NO. 3
****

CURVE NO. 5: #3 ATTENUATION OF ROCK AVERAGE
CURVE NO. 6: DAMPING IN ROCK

CURVE NO. 5		CURVE NO. 6	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.40
0.0003	1.000	0.0010	0.80
0.0010	0.988	0.0100	1.50

0.0030	0.952	0.1000	3.00
0.0100	0.900	1.0000	4.60
0.0300	0.810	0.0000	0.00
0.1000	0.725	0.0000	0.00
1.0000	0.550	0.0000	0.00

****
MATERIAL TYPE NO. 4
****

CURVE NO. 7: #4 modulus for waste (Zekkos et al., 2006)
CURVE NO. 8: damping for waste (Zekkos et al., 2006)

CURVE NO. 7		CURVE NO. 8	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	4.00
0.0003	0.996	0.0003	4.10
0.0010	0.990	0.0010	4.10
0.0030	0.975	0.0030	4.20
0.0100	0.936	0.0100	4.50
0.0300	0.856	0.0300	5.20
0.1000	0.690	0.1000	7.20
0.3000	0.475	0.3000	10.50
1.0000	0.252	1.0000	14.00
3.0000	0.121	3.0000	23.50
8.0000	0.058	10.0000	28.00

****
MATERIAL TYPE NO. 7
****

CURVE NO. 13: #7 modulus for clay PI=1-10 (Sun et al., 1988)
CURVE NO. 14: damping for clay (Dobry & Vucetic Curve, 4/9/91)

CURVE NO.13		CURVE NO.14	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	1.75
0.0010	0.974	0.0010	1.75
0.0032	0.915	0.0032	2.80
0.0100	0.786	0.0100	4.90
0.0316	0.574	0.0316	9.01
0.1000	0.312	0.1000	3.45
0.3000	0.160	0.3160	18.10

```
    1.0000     0.060         1.0000     22.00
    3.1600     0.020         3.1600     24.55
   10.0000     0.006        10.0000     26.50
     Option NO.    1   has been concluded.
     Option NO.    2   is started.

1******   OPTION  2  ***  READ SOIL PROFILE
 NEW SOIL PROFILE NO.   1      IDENTIFICATION  Jungo Landfill; PARFFN.DAT
 NUMBER OF LAYERS                  18          DEPTH TO BEDROCK        260.00

  NO. TYPE  THICKNESS   DEPTH  Tot. PRESS.  MODULUS  DAMPING   UNIT WT.  SHEAR VEL
              (ft)      (ft)      (ksf)       (ksf)             (kcf)    (fps)
   1    4     10.00      5.00      0.34        657.   0.050    0.067     562.0
   2    4     10.00     15.00      1.02        755.   0.050    0.071     585.0
   3    4     10.00     25.00      1.75        850.   0.050    0.074     608.0
   4    4     10.00     35.00      2.51        955.   0.050    0.077     632.0
   5    4     10.00     45.00      3.29       1053.   0.050    0.079     655.0
   6    4     10.00     55.00      4.08       1142.   0.050    0.080     678.0
   7    2     10.00     65.00      5.08       3019.   0.050    0.120     900.0
   8    2     15.00     77.50      6.58       3363.   0.050    0.120     950.0
   9    7     15.00     92.50      8.38       3727.   0.050    0.120    1000.0
  10    2     15.00    107.50     10.22       3144.   0.050    0.125     900.0
  11    2     15.00    122.50     12.09       3882.   0.050    0.125    1000.0
  12    1     20.00    140.00     14.28       5590.   0.050    0.125    1200.0
  13    2     20.00    160.00     16.78       4697.   0.050    0.125    1100.0
  14    2     20.00    180.00     19.33       5814.   0.050    0.130    1200.0
  15    2     20.00    200.00     21.93       6308.   0.050    0.130    1250.0
  16    2     20.00    220.00     24.53       6823.   0.050    0.130    1300.0
  17    2     30.00    245.00     27.78       6823.   0.050    0.130    1300.0
  18   BASE                                  36335.   0.050    0.130    3000.0

  PERIOD = 1.02 FROM AVERAGE SHEAR VELOCITY =   1015.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  15.72
 FOR FREQUENCY         =   1.24 C/SEC.
     PERIOD            =   0.81 SEC.
     Option NO.    2   has been concluded.
     Option NO.    3   is started.

1******   OPTION  3  ***  READ INPUT MOTION

  FILE NAME FOR INPUT MOTION = PARFFN.DAT
    NO. OF INPUT ACC. POINTS = 10936
   NO. OF POINTS USED IN FFT = 16384
        NO. OF HEADING LINES =     5
      NO. OF POINTS PER LINE =     8
  TIME STEP FOR INPUT MOTION = 0.0050
```

```
  FORMAT FOR OF TIME HISTORY = (8F9.6)


  READING INPUT MOTION FROM ----> PARFFN.DAT
  FORMAT OF INPUT MOTION USED --> (8F9.6)

 ***** H E A D E R
PEER NGA Rotated Accelerogram (November 1, 2007)
#Misfit: 0.0707737
File Type: Accelerations (g)
File Type: Accelerations (g)
NPTS= 10936 , DT= 0.005 SEC
 **  FIRST & LAST 5 LINES OF INPUT MOTION *****

     1  0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
     2  0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
     3  0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
     4  0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
     5  0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
   ........ INPUT MOTION READ NOT ECHOED...........
  1363 -0.000076-0.000077-0.000079-0.000080-0.000081-0.000083-0.000084-0.000086
  1364 -0.000087-0.000088-0.000089-0.000091-0.000092-0.000093-0.000094-0.000095
  1365 -0.000096-0.000097-0.000097-0.000098-0.000099-0.000099-0.000100-0.000100
  1366 -0.000101-0.000101-0.000101-0.000101-0.000101-0.000101-0.000101-0.000101
  1367 -0.000100-0.000100-0.000099-0.000099-0.000098-0.000098-0.000097-0.000096

 MAXIMUM ACCELERATION =  0.23962
 AT TIME              = 28.68 SEC
 THE VALUES WILL BE MULTIPLIED BY A FACTOR =  1.043
 TO GIVE NEW MAXIMUM ACCELERATION          =  0.25000
 MEAN SQUARE FREQUENCY =       5.88 C/SEC.
  MAX ACCELERATION =    0.25000 FOR FREQUENCIES REMOVED ABOVE     100.00 C/SEC.
     Option NO.    3   has been concluded.
     Option NO.    4   is started.
1******   OPTION  4  ***  READ WHERE OBJECT MOTION IS GIVEN
   OBJECT MOTION IN LAYER NUMBER  18 OUTCROPPING
     Option NO.    4   has been concluded.
     Option NO.    5   is started.

1******   OPTION  5  ***  OBTAIN STRAIN COMPATIBLE SOIL PROPERTIES
  MAXIMUM NUMBER OF ITERATIONS                =     6
  FACTOR FOR UNIFORM STRAIN IN TIME DOMAIN    =   0.65



+              ITERATION NUMBER  1
     EARTHQUAKE   - PARFFN.DAT
     SOIL PROFILE - Jungo Landfill; PARFFN.DAT
```

ITERATION NUMBER 1

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01349	0.047	0.050	-6.6	600.8	657.2	-9.4	1.000
2	4	15.0	0.03428	0.054	0.050	7.8	632.1	754.6	-19.4	1.000
3	4	25.0	0.04747	0.060	0.050	16.1	673.4	849.5	-26.1	1.000
4	4	35.0	0.05288	0.061	0.050	18.6	742.9	955.1	-28.6	1.000
5	4	45.0	0.05297	0.061	0.050	18.6	818.5	1052.6	-28.6	1.000
6	4	55.0	0.05700	0.063	0.050	20.2	876.5	1142.1	-30.3	1.000
7	2	65.0	0.02556	0.048	0.050	-4.9	2024.4	3018.6	-49.1	1.000
8	2	77.5	0.02775	0.049	0.050	-1.3	2202.7	3363.4	-52.7	1.000
9	7	92.5	0.02938	0.088	0.050	42.9	2189.1	3726.7	-70.2	1.000
10	2	107.5	0.03896	0.061	0.050	18.3	1828.2	3144.4	-72.0	1.000
11	2	122.5	0.03408	0.056	0.050	10.7	2373.5	3882.0	-63.6	1.000
12	1	140.0	0.02513	0.047	0.050	-5.7	4819.5	5590.1	-16.0	1.000
13	2	160.0	0.03155	0.053	0.050	5.6	2953.1	4697.2	-59.1	1.000
14	2	180.0	0.02715	0.049	0.050	-2.2	3831.8	5813.7	-51.7	1.000
15	2	200.0	0.02625	0.048	0.050	-3.7	4198.4	6308.2	-50.3	1.000
16	2	220.0	0.02447	0.047	0.050	-7.0	4632.3	6823.0	-47.3	1.000
17	2	245.0	0.02357	0.046	0.050	-8.8	4681.2	6823.0	-45.8	1.000

+ ITERATION NUMBER 2
1

EARTHQUAKE - PARFFN.DAT
SOIL PROFILE - Jungo Landfill; PARFFN.DAT

ITERATION NUMBER 2

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01184	0.046	0.047	-1.8	607.1	600.8	1.0	0.914
2	4	15.0	0.03229	0.053	0.054	-1.9	638.3	632.1	1.0	0.838
3	4	25.0	0.04535	0.059	0.060	-1.3	678.8	673.4	0.8	0.793
4	4	35.0	0.05319	0.062	0.061	0.2	742.2	742.9	-0.1	0.778
5	4	45.0	0.06279	0.064	0.061	4.4	793.8	818.5	-3.1	0.778
6	4	55.0	0.07111	0.066	0.063	5.5	841.7	876.5	-4.1	0.768
7	2	65.0	0.03643	0.059	0.048	18.7	1800.4	2024.4	-12.4	0.671
8	2	77.5	0.04023	0.062	0.049	21.0	1931.2	2202.7	-14.1	0.655
9	7	92.5	0.04692	0.071	0.088	-23.2	1804.1	2189.1	-21.3	0.587
10	2	107.5	0.06205	0.079	0.061	22.9	1500.0	1828.2	-21.9	0.581
11	2	122.5	0.04994	0.071	0.056	21.0	2040.7	2373.5	-16.3	0.611
12	1	140.0	0.02565	0.048	0.047	0.9	4809.6	4819.5	-0.2	0.862
13	2	160.0	0.04415	0.066	0.053	19.9	2599.1	2953.1	-13.6	0.629

```
 14  2  180.0 0.03388 0.056  0.049     12.3    3562.2    3831.8     -7.6   0.659
 15  2  200.0 0.03098 0.052  0.048      7.8    3991.8    4198.4     -5.2   0.666
 16  2  220.0 0.03044 0.052  0.047      9.4    4344.3    4632.3     -6.6   0.679
 17  2  245.0 0.03208 0.054  0.046     14.3    4264.3    4681.2     -9.8   0.686
+              ITERATION NUMBER  3
1
     EARTHQUAKE   - PARFFN.DAT
     SOIL PROFILE - Jungo Landfill; PARFFN.DAT

  ITERATION NUMBER  3

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------  ------   -----
  1  4    5.0 0.01091 0.046  0.046     -1.1     611.0     607.1      0.6   0.924
  2  4   15.0 0.02897 0.052  0.053     -2.8     647.8     638.3      1.5   0.846
  3  4   25.0 0.04093 0.057  0.059     -3.0     690.8     678.8      1.7   0.799
  4  4   35.0 0.05144 0.061  0.062     -0.9     746.6     742.2      0.6   0.777
  5  4   45.0 0.06289 0.064  0.064      0.0     793.6     793.8      0.0   0.754
  6  4   55.0 0.07210 0.067  0.066      0.3     839.5     841.7     -0.3   0.737
  7  2   65.0 0.03995 0.062  0.059      5.8    1738.0    1800.4     -3.6   0.596
  8  2   77.5 0.04461 0.066  0.062      6.1    1853.3    1931.2     -4.2   0.574
  9  7   92.5 0.05493 0.063  0.071    -12.0    1670.5    1804.1     -8.0   0.484
 10  2  107.5 0.07112 0.085  0.079      6.3    1403.7    1500.0     -6.9   0.477
 11  2  122.5 0.05343 0.074  0.071      3.6    1982.0    2040.7     -3.0   0.526
 12  1  140.0 0.02368 0.046  0.048     -3.6    4848.0    4809.6      0.8   0.860
 13  2  160.0 0.04489 0.067  0.066      1.0    2581.8    2599.1     -0.7   0.553
 14  2  180.0 0.03526 0.057  0.056      2.7    3510.1    3562.2     -1.5   0.613
 15  2  200.0 0.03397 0.056  0.052      6.4    3861.6    3991.8     -3.4   0.633
 16  2  220.0 0.03268 0.054  0.052      5.1    4235.8    4344.3     -2.6   0.637
 17  2  245.0 0.03464 0.057  0.054      5.3    4146.6    4264.3     -2.8   0.625
+              ITERATION NUMBER  4
1
     EARTHQUAKE   - PARFFN.DAT
     SOIL PROFILE - Jungo Landfill; PARFFN.DAT

  ITERATION NUMBER  4

  VALUES IN TIME DOMAIN

 NO TYPE DEPTH  UNIFRM. <---- DAMPING ---->   <---- SHEAR MODULUS ----->    G/Go
         (FT)   STRAIN  NEW    USED   ERROR      NEW       USED    ERROR   RATIO
--- ---- ----  ------- ----- ------  ------   -------   -------  ------   -----
  1  4    5.0 0.01066 0.045  0.046     -0.3     612.1     611.0      0.2   0.930
  2  4   15.0 0.02812 0.052  0.052     -0.4     649.5     647.8      0.3   0.859
  3  4   25.0 0.03947 0.057  0.057     -1.1     695.1     690.8      0.6   0.813
  4  4   35.0 0.05074 0.061  0.061     -0.4     748.4     746.6      0.2   0.782
```

5	4	45.0	0.06246	0.064	0.064	-0.2	794.6	793.6	0.1	0.754
6	4	55.0	0.07182	0.067	0.067	-0.1	840.2	839.5	0.1	0.735
7	2	65.0	0.04115	0.063	0.062	1.8	1717.9	1738.0	-1.2	0.576
8	2	77.5	0.04619	0.068	0.066	2.0	1827.0	1853.3	-1.4	0.551
9	7	92.5	0.05891	0.060	0.063	-5.6	1611.3	1670.5	-3.7	0.448
10	2	107.5	0.07466	0.087	0.085	2.2	1369.5	1403.7	-2.5	0.446
11	2	122.5	0.05362	0.074	0.074	0.2	1978.9	1982.0	-0.2	0.511
12	1	140.0	0.02292	0.045	0.046	-1.5	4863.6	4848.0	0.3	0.867
13	2	160.0	0.04386	0.066	0.067	-1.4	2606.2	2581.8	0.9	0.550
14	2	180.0	0.03649	0.059	0.057	2.3	3465.3	3510.1	-1.3	0.604
15	2	200.0	0.03533	0.057	0.056	2.7	3805.9	3861.6	-1.5	0.612
16	2	220.0	0.03325	0.055	0.054	1.2	4209.2	4235.8	-0.6	0.621
17	2	245.0	0.03536	0.057	0.057	1.4	4115.2	4146.6	-0.8	0.608

```
+              ITERATION NUMBER  5
1
     EARTHQUAKE   - PARFFN.DAT
     SOIL PROFILE - Jungo Landfill; PARFFN.DAT

  ITERATION NUMBER  5

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01059	0.045	0.045	-0.1	612.4	612.1	0.1	0.931
2	4	15.0	0.02783	0.052	0.052	-0.1	650.1	649.5	0.1	0.861
3	4	25.0	0.03890	0.056	0.057	-0.4	696.8	695.1	0.2	0.818
4	4	35.0	0.05053	0.061	0.061	-0.1	748.9	748.4	0.1	0.784
5	4	45.0	0.06231	0.064	0.064	-0.1	794.9	794.6	0.0	0.755
6	4	55.0	0.07171	0.066	0.067	0.0	840.4	840.2	0.0	0.736
7	2	65.0	0.04160	0.064	0.063	0.7	1710.5	1717.9	-0.4	0.569
8	2	77.5	0.04681	0.068	0.068	0.8	1816.9	1827.0	-0.6	0.543
9	7	92.5	0.06102	0.058	0.060	-2.9	1581.4	1611.3	-1.9	0.432
10	2	107.5	0.07607	0.087	0.087	0.8	1356.3	1369.5	-1.0	0.436
11	2	122.5	0.05329	0.073	0.074	-0.3	1984.3	1978.9	0.3	0.510
12	1	140.0	0.02267	0.045	0.045	-0.5	4868.8	4863.6	0.1	0.870
13	2	160.0	0.04334	0.065	0.066	-0.7	2618.8	2606.2	0.5	0.555
14	2	180.0	0.03724	0.059	0.059	1.3	3439.1	3465.3	-0.8	0.596
15	2	200.0	0.03590	0.058	0.057	1.1	3783.4	3805.9	-0.6	0.603
16	2	220.0	0.03334	0.055	0.055	0.2	4205.1	4209.2	-0.1	0.617
17	2	245.0	0.03601	0.058	0.057	1.2	4087.5	4115.2	-0.7	0.603

```
+              ITERATION NUMBER  6
1
     EARTHQUAKE   - PARFFN.DAT
     SOIL PROFILE - Jungo Landfill; PARFFN.DAT

  ITERATION NUMBER  6
```

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	4	5.0	0.01054	0.045	0.045	-0.1	612.6	612.4	0.0	0.932
2	4	15.0	0.02767	0.051	0.052	-0.1	650.4	650.1	0.0	0.861
3	4	25.0	0.03862	0.056	0.056	-0.2	697.6	696.8	0.1	0.820
4	4	35.0	0.05046	0.061	0.061	0.0	749.1	748.9	0.0	0.784
5	4	45.0	0.06225	0.064	0.064	0.0	795.1	794.9	0.0	0.755
6	4	55.0	0.07166	0.066	0.066	0.0	840.5	840.4	0.0	0.736
7	2	65.0	0.04177	0.064	0.064	0.2	1707.9	1710.5	-0.2	0.567
8	2	77.5	0.04705	0.069	0.068	0.3	1813.1	1816.9	-0.2	0.540
9	7	92.5	0.06215	0.057	0.058	-1.5	1565.9	1581.4	-1.0	0.424
10	2	107.5	0.07664	0.088	0.087	0.3	1351.1	1356.3	-0.4	0.431
11	2	122.5	0.05297	0.073	0.073	-0.3	1989.6	1984.3	0.3	0.511
12	1	140.0	0.02257	0.045	0.045	-0.2	4870.9	4868.8	0.0	0.871
13	2	160.0	0.04308	0.065	0.065	-0.4	2625.0	2618.8	0.2	0.558
14	2	180.0	0.03763	0.060	0.059	0.7	3425.3	3439.1	-0.4	0.592
15	2	200.0	0.03613	0.058	0.058	0.4	3774.1	3783.4	-0.2	0.600
16	2	220.0	0.03332	0.055	0.055	-0.1	4206.2	4205.1	0.0	0.616
17	2	245.0	0.03641	0.059	0.058	0.7	4070.5	4087.5	-0.4	0.599

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	4	10.0	5.0	0.01622	99.35	29.52
2	4	10.0	15.0	0.04258	276.77	29.51
3	4	10.0	25.0	0.05942	414.03	29.50
4	4	10.0	35.0	0.07763	581.39	28.24
5	4	10.0	45.0	0.09577	761.32	28.24
6	4	10.0	55.0	0.11025	926.55	28.24
7	2	10.0	65.0	0.06426	1099.15	28.23
8	2	15.0	77.5	0.07239	1315.22	28.23
9	7	15.0	92.5	0.09561	1512.03	28.22
10	2	15.0	107.5	0.11790	1599.09	28.22
11	2	15.0	122.5	0.08149	1616.93	28.19
12	1	20.0	140.0	0.03472	1690.48	28.16
13	2	20.0	160.0	0.06628	1735.76	27.82
14	2	20.0	180.0	0.05789	1990.95	28.35
15	2	20.0	200.0	0.05559	2103.26	28.34
16	2	20.0	220.0	0.05126	2155.44	28.32
17	2	30.0	245.0	0.05601	2289.48	28.41

PERIOD = 1.30 FROM AVERAGE SHEAR VELOCITY = 797.

```
  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  12.06
 FOR FREQUENCY         =   0.94 C/SEC.
     PERIOD            =   1.06 SEC.
     Option NO.    5   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -PARFFN.DAT
  SOIL DEPOSIT - Jungo Landfill; PARFFN.DAT
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH SAVED
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC. RECORD
     WITHIN            0.0        0.29401          29.51           2.77               0.000                  0
     WITHIN           10.0        0.25505          29.51           2.47               0.000                  0
     WITHIN           20.0        0.23625          28.22           2.07               0.000                  0
     WITHIN           30.0        0.23988          28.23           1.98               0.000                  0
     WITHIN           40.0        0.24983          28.89           2.22               0.000                  0
     WITHIN           50.0        0.22334          28.89           2.51               0.000                  0
     WITHIN           60.0        0.18493          31.28           2.64               0.000                  0
     WITHIN           70.0        0.19000          28.44           2.58               0.000                  0
     WITHIN           85.0        0.17901          28.43           2.41               0.000                  0
     WITHIN          100.0        0.17639          28.39           2.59               0.000                  0
     WITHIN          115.0        0.22258          28.36           3.22               0.000                  0
     WITHIN          130.0        0.22627          28.35           3.20               0.000                  0
     WITHIN          150.0        0.20280          28.35           2.92               0.000                  0
     WITHIN          170.0        0.19109          28.71           3.49               0.000                  0
     Option NO.    6   has been concluded.
     Option NO.    6   is started.

1******   OPTION  6  ***  COMPUTE MOTION IN NEW SUBLAYERS

   EARTHQUAKE -PARFFN.DAT
  SOIL DEPOSIT - Jungo Landfill; PARFFN.DAT
     LAYER           DEPTH        MAX. ACC.          TIME      MEAN SQ. FR.         ACC. RATIO       TH SAVED
                      FT            G                SEC          C/SEC             QUIET ZONE       ACC. RECORD
     WITHIN          190.0        0.18850          28.70           3.75               0.000                  0
     WITHIN          210.0        0.15425          28.26           4.17               0.000                  0
     WITHIN          230.0        0.17835          28.75           4.48               0.000                  0
     WITHIN          260.0        0.20948          28.68           5.87               0.000                  0
     OUTCR.          260.0        0.25000          28.68           5.88               0.000                  0
     Option NO.    6   has been concluded.
     Option NO.    7   is started.

1******   OPTION  7  ***  COMPUTE STRESS/STRAIN HISTORY

  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    7
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Stress at the top of layer
```

```
  COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF  LAYER    7
  SCALE FOR PLOTTING     0.0000
 IDENTIFICATION - -- Strain not saved
     Option NO.    7   has been concluded.
```

```
          ***********
    **                  **
    **   D I S P L M T   **
          ***********
```

Jungo Landfill, Seismic Slope Stability, BVLTFP.DAT

Yield Acceleration = 0.1400

DT = 0.0029 Accn. due to gravity = 32.200 Nlines = 2419

A max = 0.19317 Acc Factor = 1.00000 Static F.S.= 1.860

Vmax = 0.13084 Ft/S

COMPUTED PERMANENT DISPLACEMENT = 0.03379 Ft

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          ***********
    **                  **
    **   D I S P L M T   **
          ***********
```

Jungo Landfill, Seismic Slope Stability, CHY080FP.DAT

Yield Acceleration = 0.1400

DT = 0.0050 Accn. due to gravity = 32.200 Nlines = 2760

A max = 0.17684 Acc Factor = 1.00000 Static F.S.= 1.860

Vmax = 0.00000 Ft/S

COMPUTED PERMANENT DISPLACEMENT = 0.00000 Ft

```
          ***********
    **                  **
    **   D I S P L M T   **
          ***********
```

Jungo Landfill, Seismic Slope Stability, PARFFN.DAT

Yield Acceleration = 0.1400

DT = 0.0050 Accn. due to gravity = 32.200 Nlines = 1367

A max = 0.22305 Acc Factor = 1.00000 Static F.S.= 1.860

Vmax = 0.29737 Ft/S

COMPUTED PERMANENT DISPLACEMENT = 0.05293 Ft

ATTACHMENT C
LIQUEFACTION EVALUATION RESULTS

STANDARD PENETRATION TEST-BASED LIQUEFACTION ANALYSIS USING CETIN ET AL. (2004) PROCEDURE

Referrence: "Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential" by Cetin et al. (2004), *Journal of Geotechnical and Geoenvironmental Engineering* , Vol. 130, No. 12, December 2004.

Project	**Jungo Landfill**
Test Boring No	**EB**

Depth to ground water table[1]		45 feet
Earthquake magnitude	M_w	6.2
Peak horizontal ground surface acceleration	a_{max}	0.312 g
Moist unit weight of soil	γ_m	120 pcf
Saturated unit weight of soil	γ_{sat}	130 pcf
Shear wave velocity over the upper 12 meters, in m/s	$V^*_{s,12m}$	275 m/s

N correction factors:

Correction for non-standardized sampler configuration	C_S	1.00
Correction for short rod length	C_R	1.00
Correction for borehole diameter	C_B	1.00
Correction for hammer energy efficiency	C_E	1.00

Factor of Safety Against Liquefaction

Depth[2] (ft)	d[3,4] (ft)	N	σ_v (psf)	σ'_v (psf)	$\sigma_{e(rd)}$	r_d	CSR_{eq}	C_N	$N_{1,60}$	Fines Content (%)	FC[5] (%)	P_L	CRR	$(FS)_L$
20	5	29	600	600	0.028	1.00	0.203	1.60	46	84	35	99.9	9.965	**49.16**
25	10	20	1200	1200	0.051	1.00	0.203	1.33	27	84	35	99.9	1.504	**7.43**
30	15	28	1800	1800	0.072	1.00	0.202	1.08	30	84	35	99.9	1.861	**9.20**
35	20	25	2400	2400	0.092	0.99	0.202	0.94	23	84	35	99.9	0.953	**4.72**
40	25	**Clay**												
45	30	**Clay**												
50	35	**Clay**												
55	40	48	4800	4800	0.164	0.96	0.195	0.66	32	83	35	99.9	1.613	**8.28**
60	45	16	5400	5400	0.164	0.94	0.191	0.63	10	83	35	99.9	0.240	**1.26**
65	50	**Clay**												
75	60	69	7350	6414	0.164	0.87	0.201	0.57	40	83	35	99.9	2.891	**14.37**
80	65	**Clay**												
90	75	**Clay**												
100	85	**Clay**												
105	90	43	11250	8442	0.164	0.81	0.218	0.50	22	98	35	99.9	0.569	**2.61**
110	95	34	11900	8780	0.164	0.80	0.220	0.49	17	98	35	99.9	0.372	**1.69**
120	105	45	13200	9456	0.164	0.79	0.223	0.47	21	98	35	99.9	0.540	**2.42**

[1]Ground water table assumed at elev. 4115'

[2]Measured from the ground surface at boring location

[3]From top of landfill base assumed at elev. 4160' with no waste

[4]The highlighted depths are above water table

[5]For fines content < 5%, FC = 0; for fines content > 35%, FC = 35

STANDARD PENETRATION TEST-BASED LIQUEFACTION ANALYSIS USING CETIN ET AL. (2004) PROCEDURE

Referrence: "Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential" by Cetin et al. (2004), *Journal of Geotechnical and Geoenvironmental Engineering* , Vol. 130, No. 12, December 2004.

Project	**Jungo Landfill**
Test Boring No	**MW-1**

Depth to ground water table[1]		45 feet
Earthquake magnitude	M_w	6.2
Peak horizontal ground surface acceleration	a_{max}	0.312 g
Moist unit weight of soil	γ_m	120 pcf
Saturated unit weight of soil	γ_{sat}	130 pcf
Shear wave velocity over the upper 12 meters, in m/s	$V^*_{s,12m}$	275 m/s

N correction factors:

Correction for non-standardized sampler configuration	C_S	1.00
Correction for short rod length	C_R	1.00
Correction for borehole diameter	C_B	1.00
Correction for hammer energy efficiency	C_E	1.00

Factor of Safety Against Liquefaction

Depth[2] (ft)	d[3,4] (ft)	N	σ_v (psf)	σ'_v (psf)	$\sigma_{\varepsilon(rd)}$	r_d	CSR_{eq}	C_N	$N_{1,60}$	Fines Content (%)	FC[5] (%)	P_L	CRR	$(FS)_L$
20	5	28	600	600	0.028	1.00	0.203	1.60	45	35	35	99.9	8.690	**42.87**
25	10	40	1200	1200	0.051	1.00	0.203	1.33	53	35	35	99.9	14.605	**72.12**
30	15	30	1800	1800	0.072	1.00	0.202	1.08	33	72	35	99.9	2.240	**11.08**
35	20	40	2400	2400	0.092	0.99	0.202	0.94	38	35	35	99.9	3.181	**15.77**
40	25	**Clay**												
45	30	**Clay**												
50	35	**Clay**												
65	50	71	6050	5738	0.164	0.92	0.196	0.61	43	35	35	99.9	4.018	**20.49**
70	55	33	6700	6076	0.164	0.89	0.199	0.59	19	35	35	99.9	0.523	**2.62**
75	60	**Clay**												
85	70	**Clay**												
95	80	**Clay**												

[1]Ground water table assumed at elev. 4115'

[2]Measured from the ground surface at boring location

[3]From top of landfill base assumed at elev. 4160' with no waste

[4]The highlighted depths are above water table

[5]For fines content < 5%, FC = 0; for fines content > 35%, FC = 35

STANDARD PENETRATION TEST-BASED LIQUEFACTION ANALYSIS USING CETIN ET AL. (2004) PROCEDURE

Referrence: "Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential" by Cetin et al. (2004), *Journal of Geotechnical and Geoenvironmental Engineering* , Vol. 130, No. 12, December 2004.

Project	**Jungo Landfill**
Test Boring No	**MW-2**

Depth to ground water table[1]		45 feet
Earthquake magnitude	M_w	6.2
Peak horizontal ground surface acceleration	a_{max}	0.312 g
Moist unit weight of soil	γ_m	120 pcf
Saturated unit weight of soil	γ_{sat}	130 pcf
Shear wave velocity over the upper 12 meters, in m/s	$V^*_{s,12m}$	275 m/s

N correction factors:

Correction for non-standardized sampler configuration	C_S	1.00
Correction for short rod length	C_R	1.00
Correction for borehole diameter	C_B	1.00
Correction for hammer energy efficiency	C_E	1.00

Factor of Safety Against Liquefaction

Depth[2] (ft)	d[3,4] (ft)	N	σ_v (psf)	σ'_v (psf)	$\sigma_{g(rd)}$	r_d	CSR_{eq}	C_N	$N_{1,60}$	Fines Content (%)	FC[5] (%)	P_L	CRR	$(FS)_L$
20	5	19	600	600	0.028	1.00	0.203	1.60	30	90.3	35	99.9	2.534	**12.50**
25	10	33	1200	1200	0.051	1.00	0.203	1.33	44	35	35	99.9	6.592	**32.55**
30	15	20	1800	1800	0.072	1.00	0.202	1.08	22	35	35	99.9	0.886	**4.38**
35	20	**Clay**												
40	25	**Clay**												
45	30	18	3600	3600	0.130	0.98	0.200	0.77	14	6.4	6.4	97.9	0.240	**1.20**
50	35	31	4200	4200	0.148	0.97	0.198	0.71	22	6.4	6.4	98.9	0.455	**2.30**
55	40	24	4800	4800	0.164	0.96	0.195	0.66	16	35	35	99.9	0.412	**2.12**
60	45	17	5400	5400	0.164	0.94	0.191	0.63	11	81.6	35	99.9	0.254	**1.33**
65	50	16	6050	5738	0.164	0.92	0.196	0.61	10	35	35	99.9	0.230	**1.18**
70	55	18	6700	6076	0.164	0.89	0.199	0.59	11	61.1	35	99.9	0.245	**1.23**
75	60	21	7350	6414	0.164	0.87	0.201	0.57	12	35	35	99.9	0.273	**1.36**
80	65	25	8000	6752	0.164	0.84	0.203	0.56	14	35	35	99.9	0.318	**1.57**
90	75	**Clay**												
95	80	**Clay**												

[1]Ground water table assumed at elev. 4115'

[2]Measured from the ground surface at boring location

[3]From top of landfill base assumed at elev. 4160' with no waste

[4]The highlighted depths are above water table

[5]For fines content < 5%, FC = 0; for fines content > 35%, FC = 35

STANDARD PENETRATION TEST-BASED LIQUEFACTION ANALYSIS USING CETIN ET AL. (2004) PROCEDURE

Referrence: "Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential" by Cetin et al. (2004), *Journal of Geotechnical and Geoenvironmental Engineering* , Vol. 130, No. 12, December 2004.

Project		**Jungo Landfill**
Test Boring No		**MW-3**

Depth to ground water table[1]		45 feet
Earthquake magnitude	M_w	6.2
Peak horizontal ground surface acceleration	a_{max}	0.312 g
Moist unit weight of soil	γ_m	120 pcf
Saturated unit weight of soil	γ_{sat}	130 pcf
Shear wave velocity over the upper 12 meters, in m/s	$V^*_{s,12m}$	275 m/s

N correction factors:

Correction for non-standardized sampler configuration	C_S	1.00
Correction for short rod length	C_R	1.00
Correction for borehole diameter	C_B	1.00
Correction for hammer energy efficiency	C_E	1.00

Factor of Safety Against Liquefaction

Depth[2] (ft)	d[3,4] (ft)	N	σ_v (psf)	σ'_v (psf)	$\sigma_{e(rd)}$	r_d	CSR_{eq}	C_N	$N_{1,60}$	Fines Content (%)	FC[5] (%)	P_L	CRR	$(FS)_L$
20	5	26	600	600	0.028	1.00	0.203	1.60	42	47.8	35	99.9	6.608	**32.60**
25	10	25	1200	1200	0.051	1.00	0.203	1.33	33	35	35	99.9	2.655	**13.11**
30	15	25	1800	1800	0.072	1.00	0.202	1.08	27	35	35	99.9	1.409	**6.97**
35	20	31												
40	25	29												
45	30	**Clay**												
50	35	**Clay**												
55	40	**Clay**												
60	45	15	5400	5400	0.164	0.94	0.191	0.63	9	35	35	99.9	0.228	**1.19**
65	50	22	6050	5738	0.164	0.92	0.196	0.61	13	35	35	99.9	0.315	**1.61**
70	55	39	6700	6076	0.164	0.89	0.199	0.59	23	72.1	35	99.9	0.708	**3.55**
75	60	**Clay**												
80	65	**Clay**												
85	70	**Clay**												
90	75	**Clay**												
95	80	**Clay**												
100	85	**Clay**												

[1]Ground water table assumed at elev. 4115'

[2]Measured from the ground surface at boring location

[3]From top of landfill base assumed at elev. 4160' with no waste

[4]The highlighted depths are above water table

[5]For fines content < 5%, FC = 0; for fines content > 35%, FC = 35

STANDARD PENETRATION TEST-BASED LIQUEFACTION ANALYSIS USING CETIN ET AL. (2004) PROCEDURE

Referrence: "Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential" by Cetin et al. (2004), *Journal of Geotechnical and Geoenvironmental Engineering* , Vol. 130, No. 12, December 2004.

Project	**Jungo Landfill**
Test Boring No	**MW-4**

Depth to ground water table[1]		45 feet
Earthquake magnitude	M_w	6.2
Peak horizontal ground surface acceleration	a_{max}	0.312 g
Moist unit weight of soil	γ_m	120 pcf
Saturated unit weight of soil	γ_{sat}	130 pcf
Shear wave velocity over the upper 12 meters, in m/s	$V^*_{s,12m}$	275 m/s

N correction factors:

Correction for non-standardized sampler configuration	C_S	1.00
Correction for short rod length	C_R	1.00
Correction for borehole diameter	C_B	1.00
Correction for hammer energy efficiency	C_E	1.00

Factor of Safety Against Liquefaction

Depth[2] (ft)	d[3,4] (ft)	N	σ_v (psf)	σ'_v (psf)	$\sigma_{s(rd)}$	r_d	CSR_{eq}	C_N	$N_{1,60}$	Fines Content (%)	FC[5] (%)	P_L	CRR	$(FS)_L$
20	5	29	600	600	0.028	1.00	0.203	1.60	46	35	35	99.9	9.965	**49.16**
25	10	30	1200	1200	0.051	1.00	0.203	1.33	40	35	35	99.9	4.687	**23.15**
30	15	36	1800	1800	0.072	1.00	0.202	1.08	39	84.1	35	99.9	3.909	**19.33**
35	20	31	2400	2400	0.092	0.99	0.202	0.94	29	35	35	99.9	1.544	**7.65**
40	25	**Clay**												
45	30	**Clay**												
50	35	**Clay**												
55	40	**Clay**												
60	45	75	5400	5400	0.164	0.94	0.191	0.63	47	0	0	99.9	3.037	**15.91**
65	50	35	6050	5738	0.164	0.92	0.196	0.61	21	0	0	99.9	0.434	**2.21**
70	55	65	6700	6076	0.164	0.89	0.199	0.59	38	0	0	99.9	1.542	**7.74**
75	60	68	7350	6414	0.164	0.87	0.201	0.57	39	0	0	99.9	1.601	**7.96**
85	70	**Clay**												
95	80	**Clay**												

[1]Ground water table assumed at elev. 4115'

[2]Measured from the ground surface at boring location

[3]From top of landfill base assumed at elev. 4160' with no waste

[4]The highlighted depths are above water table

[5]For fines content < 5%, FC = 0; for fines content > 35%, FC = 35