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SEISM 1 CODE MODIFICATIONS AND APPLICATION: ASSESSMENT OF NEEDED EFFORT

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1 INTRODUCTION

The purpose of this report is to document the analyses of the SEISM 1 code performed during FY92 and propose details for continuation of the effort during the next fiscal year. This report is organized in three principal sections. First a summary of previous letter reports which have been submitted is provided. The second section comprises proposed items of work for continued efforts in FY93; those that are required to use the code in the Basin and Range tectonic province. The possibility of using published expert opinions for trial code calculations is discussed. Investigation of fault plane solutions, based upon long and short period seismic records of selected Basin and Range earthquakes, is also proposed. The third section is a discussion of required inputs for the SEISM 1 code. Detailed listings of inputs are in Appendix A.

2 SUMMARY OF FY92 WORK ON PFD&SHA CODES AND METHODS

The task related to Probablistic Fault Displacement and Seismic Hazard Analysis (PFD&SHA) codes and methods for FY92 is comprised of the following activities:

- Obtain Lawrence Livermore National Laboratory (LLNL)'s Seismic Hazard Model (SHM) SEISM 1 Code;
- Select alternative acceleration attenuation functions for the Basin and Range tectonic province;
- Assess efforts required for exercising the SEISM 1 code on computer systems available at or accessible from the CNWRA;
- Assess level of effort to convert SEISM 1 for use in modeling Yucca Mountain data with computer systems available at or accessible from the CNWRA.

There are currently three versions of the SEISM code that have been discussed or reported in the literature. They are SEISM β, also known as LLNL Seismic Hazard Codes (SHC), SEISM 1 and SEISM 2. The initial or β version was created for the Nuclear Regulatory Commission (NRC) Office of Nuclear Reactor Regulation (NRR) and reported in NUREG/CR 3756 and by Bernreutter et al. (1984). Test computations for 10 eastern U.S. nuclear power plant sites were made. Results from these initial computations were used as a basis for revisions, largely to attenuation formulae, to produce SEISM 1 (Bernreutter et al., 1989a and 1989b). SEISM 2 was developed for the U.S. Department of Energy (DOE). It contains many statistical options and additional attenuation functions. This version is not available at this time, outside of DOE. A fourth version, SEISM 3, is anticipated to result from a NRR contract with LLNL. It is to include provision for modeling faults directly, additional attenuation functions suitable for sites in the Pacific Northwest of the U.S. and improved handling of statistics which should reduce computation time. A goal of the tasks summarized here was to examine the SEISM 1 code for its applicability to a high level nuclear waste (HLW) repository and recommend an approach to modify the code for this purpose, as necessary.

Obtaining the code proved to be difficult (Hofmann, 1992a). Although Argonne National Laboratory (ANL) originally was DOE's distribution point for computer codes used in nuclear waste assessments, this function was recently transferred to a contractor at Oakridge National Laboratory (ORNL). Codes were not obtainable during the several months the transfer was taking place. When they became available, versions for SUN and CRAY systems could not be found. Initially LLNL could not provide the code because unchargeable staff hours would have been required during a period of budget constraint. Ultimately, copies of the code and documentation were made available by LLNL in response to a number of requests.

Selection of attenuation functions for the Basin and Range was narrowed to two published curves, that of Campbell (1986) and that of Joyner and Boore (1981) and subsequent updates, for distance ranges that are greater than a fault dimension away from the source. However, if sources adjacent to or within the repository must be considered, then additional near-field attenuation functions need to be developed. [Several recent theoretical papers on this subject are summarized in Hofmann (1991). Further literature

review of this topic is recommended in this report.] In addition, for magnitudes larger than about 6, near-field pulses that are independent of magnitude are predicted to be no larger than Campbell's empirical curves derived mostly from far-field dip-slip and strike-slip sources (Hofmann, 1992c).

In the final LLNL evaluation of seismic hazard at eastern U.S. nuclear power plant sites (Bernreutter et al., 1989a), several of the experts preferred attenuation functions based on seismic source theory to those that were empirically derived. A popular choice was that of Hanks and McGuire (1981). This required a revision of the formulae for attenuation functions that were in the initial, β-version of the SEISM code described in Bernreutter et al. (1984). Hanks and McGuire recommended a universal stress drop of 100 bars. Use of a mean stress drop, as determined by Stark and Silva (1992) for Basin and Range earthquakes, of about 36 bars, would result in better attenuation estimates. Questions regarding near-field attenuation with this procedure, however, remain and are discussed in Hofmann (1991).

SEISM 1 code files were investigated and recompiled on the CNWRA SUN Sparcstation 2 (Hofmann, 1992b). It was found that the code contained commands lines specific to the CDC7600, CRAY and SUN computer systems. Lines of code for the machines not being used have to be commented out before compilation. Different library functions were sometimes called in these machine-specific lines of code. All basic library functions required to compile the code were either provided by LLNL or were available on the CNWRAs machines. Obtaining graphical output with the existing coding was not possible with the SUN version although it appeared that minor changes would probably permit the use of the codes graphics capabilities.

The Shearon Harris nuclear power plant test input file, which included data obtained through expert opinions, was used for test computations. Results were graphed using an external plot package and compared to CRAY computation output also supplied by LLNL. Close agreement (within 1 to 3 percent) was indicated between the CNWRA SUN calculations and the example CRAY output. We were advised by B. Davis of LLNL that the number of iterations of calculation by the code can be adjusted for the SUN to produce identical results but that the time required for calculation increases considerably. The required code adjustment is discussed in Hofmann (1992d).

Investigation of references cited in the LLNL code documentation and the FORTRAN code files suggests that adding new attenuation functions of the empirical or source theory types were likely to require only adjustments to coefficients and exponents of existing equations present in the code. However, because modifications to the source theory formulation for a region-specific stress drop will be required for the Basin and Range, sufficient time to add a new attenuation equation for this purpose was included in estimates provided in a previous letter report (Hofmann, 1992c).

Another change that will be needed for application of the SEISM codes to the Basin and Range, is the accommodation of faults as earthquake sources, rather than source zones. The current code uses only source zones. By using several long narrow source zones with earthquake depth restrictions, the effects of fault plane sources can be approximated. NRR, however, plans to have LLNL modify the code to directly accommodate fault plane sources. When this revised version of the code, SEISM 3, becomes available, it would be preferred over version 1. Until version 3 is available, continued evaluation and operation of version 1 to permit a full assessment of its applicability to the HLW program, is advised. DOE's version, SEISM 2, has been used to evaluate the earthquake hazard at certain DOE facilities, (e.g. Beavers et al., 1990).

3 PROPOSED FY93 WORK

3.1 BACKGROUND

Fault displacements and seismic hazards are concerns for potential repositories. Effective assessment of postclosure fault-displacement and earthquake ground-motion hazards is influenced by the validation, and extrapolation in time, of tectonic models. Displacements on faults and effects of seismic activity in general may have a significant influence on repository design and performance, determination of site suitability, and containment and isolation of waste material. Computational and graphical analyses, using existing computer codes when feasible and developing conceptual models and numerical methods when necessary, will be required to evaluate the technical validity and viability of the applicant's potential compliance demonstration methods.

The initial work for this subtask, in FY92, was to obtain the LLNL and/or the Electric Power Research Institute (EPRI) Probablistic Seismic Hazard Analysis (PSHA) codes and make them operational on CNWRA computers. The SEISM 1 code was developed to evaluate eastern U.S. nuclear power plant sites. Use of SEISM 1 for hazard evaluations at the proposed Yucca Mountain HLW repository site in the Basin and Range tectonic province was evaluated. EPRI regards its code as proprietary and would provide it only with the payment of a $20,000 fee and no further effort was made to obtain the code.

Goals of this effort are to: (i) assess the special requirements in applying PSHA to a HLW repository; (ii) extend the process to analyze probabilities of fault displacements (PFD); and (iii) provide NRC staff with experience and access to the codes which are likely to be used in analyses of the Yucca Mountain site.

Development of PSHA codes was initiated at LLNL by the NRC/NRR, in response to an Advisory Committee on Reactor Safety (ACRS) letter acknowledging that new developments in technology should be considered in addition to the deterministic methods described in 10 CFR Part 100, Appendix A, and because of a U.S. Geological Survey (USGS) letter which stated that earthquakes like the one in 1886 in Charleston, South Carolina could occur anywhere in the eastern U.S. with some probability. Because of the diversity of technical opinions and lack of consensus concerning eastern U.S. seismic potential, a means of quantifying probabilities and uncertainties in expert opinion as well as data, was employed.

These PSHA methods appear to be required to provide a means of estimating compliance with the Environmental Protection Agency (EPA) probabilistic standards concerning radionuclide releases to the biosphere. The estimate is ultimately made using performance assessment techniques which require, as input, probabilistic hazard estimates for many factors including earthquake shaking and fault movement. Although the Nuclear Waste Policy Act (NWPA) and the remanded EPA rule recognized that judgement would be required which could not be easily quantified, a desire to quantify these opinions exists because performance assessment (PA) techniques require numerical values.

The proposed work will support Systematic Regulatory Analysis (SRA) activities by providing the necessary technical foundation for development of Compliance Determination Methods (CDMs) and refinement of Technical Review Components (TRCs). Iterative Performance Assessment (IPA) is directly supported by providing information for identification of pertinent processes and conditions, and development of scenarios. The proposed work also has the potential of providing methods and computer

codes for critical evaluation of the effects of fault displacement and seismic activity on postclosure performance of the repository engineered and natural barriers.

Work performed will provide NRC and CNWRA staff with essential capabilities to review and evaluate model results, analyses, and interpretive conclusions presented by a license applicant in the technical areas of PFD and SHA. The necessary technical computing capabilities will be obtained to quickly and interactively test conclusions drawn by the applicant on these issues. Output from a PSHA code, e.g. SEISM 1, are necessary to couple seismic and faulting information with tectonic processes and groundwater flow used in transport calculations, in a probabilistic manner. The SEISM 1 code is selected for this effort because of its availability to NRC and the CNWRA.

3.2 SUBTASK DESCRIPTION

The NRC staff will require the capability to comprehensively review and evaluate complex probabilistic fault displacement and seismic hazard models of the site and geologic setting of a proposed repository for HLW. The CNWRA staff will support the NRC in the attainment and maintenance of this capability. They will do so by acquisition of the computer hardware and software systems, identification and integration of existing methods, and development and documentation of specially tailored methods for computer-assisted analysis of probabilistic fault displacement and SHMs. The CNWRA staff will develop techniques, by incorporating certain types of new and existing models, that can be used by NRC staff in the probabilistic assessment of earthquake and surface faulting hazards. These techniques also have application in the assessment of associated or coupled processes (e.g., fracture and fault control of groundwater flow, deformation and stress changes on the scale of the repository block associated with faulting).

SEISM 1 is presently specific to the eastern U.S. In its original, β-version, the code employed the best estimates of LLNL staff concerning the seismic source zones and ground motion attenuation functions that were likely to be preferred by the experts to be empaneled for the analysis of nuclear power plants in the eastern U.S. The current code contains other source zones and attenuation functions than originally envisioned by LLNL staff. To make initial estimates at Yucca Mountain, suitable source zones and attenuation functions must be tentatively assigned and input or programmed into the code.

The tasks are primarily to incorporate tentative seismic source zones or long thin zones to model faults, and to program the 3 attenuation functions suggested earlier (Hofmann, 1992c), including one near-field peak acceleration attenuation function which is yet to be selected.

Programming will be minimal because the two selected attenuation functions appear to be similar to existing coding. A revision of coefficients and exponents of existing formulae are anticipated to accommodate most if not all the differences. Near-field attenuation functions, however, appear sufficiently different from formulae available in the code so that additional programming will be required. The seismic source zones will require some coding to employ suitable digital maps for the western U.S. These maps are available, however, and need only to be incorporated in the code. Tentative source zones are produced primarily by way of input files which must be created.

Preliminary activities include acquisition of entire texts referenced by the code and literature concerning expert opinions on potentially active faulting or source zones in the Basin and Range, and some study of these documents. Task completion activities include testing of the completed code and

preparation of documentation. The testing would include tentative calculations which would form a basis for future work by NRC staff or others as required. The referenced texts are at least partially available (pertinent sections were acquired) and have received some study as a part of Activities 1 through 3 of this subtask.

3.3 DETAIL OF PROPOSED TASKS

Two individuals are anticipated to work on this task, a Principal Investigator and a Programming Specialist.

3.3.1 Task List

The following specific activities will be conducted.

- Review software references.

  Study the references and subroutines called out in the SEISM 1 program documentation to analyze potential areas of impact caused by the proposed software modifications. This will include a further review of near-field attenuation functions and planning for their incorporation in the code.

- Set-up new seismic zone and fault maps for the western U.S. using published expert opinions.

- Design code modifications for the PRDS, ALEAS and COMAP (three of the four main modules of the SEISM 2 code whose principal functions are defined subsequently) to permit its being tested for a Basin and Range tectonic province site.

- Code modification.

- Code testing and evaluation of the design.

- Code testing and verification (including "debugging" as needed).

- Documentation preparation.

- Investigate literature for published expert opinions concerning fault activity and other input variables.

- Augment published expert opinions with those of NRC and CNWRA staff for example test calculations.

- Perform a test calculation of seismic hazard for the vicinity of the potential Yucca Mountain site.

- Perform sensitivity analyses on input variables with several sets of computations.

- Develop a design for incorporating paleofaulting information into the SEISM programs for the purposes of extending the time span of seismic history and to calculate probabilistic fault displacements.

- Estimate scope of effort for a later implemention of the above paleofaulting logic by way of additional coding.

- Develop capability at CNWRA to calculate fault plane solutions from both long period Institutions for Research in Seismology (IRIS) digital seismograms, as well as short period Nevada Test Site (NTS) array data, to permit determination of overall fault movement as well as the initiating movement. This activity involves the acquisition of software for processing IRIS data and for calculating fault plane solutions. [Information published by Vetter and Ryall (1983) suggests that there may be differences in long and short period based fault plane solutions that could have an impact on the development of tectonic models. Whether these differences occur with regularity is not known.]

- Calculate fault plane solutions for selected Basin and Range tectonic province earthquakes.

3.3.2 Products

Progress will be summarized in the monthly Program Manager's Progress Reports (PMPRs). The final report, due 11 months from project initiation, will include documentation of code changes, a description of test calculations and recommendations concerning use of the revised code and a summary of the fault plane solution investigation.

3.3.3 Discussion

Coding performed on SEISM 1 can probably be easily transferred to versions 2 or 3 should they become available in FY93 or later. LLNL anticipates that new versions of mathematical and statistical libraries will be used in developing SEISM 3, however, so this new code version would have to be recompiled at the CNWRA. Some additional effort can be expected if later code versions with their added flexibility and anticipated efficiency are desired for use by Division of High-Level Waste Management (DHLWM).

4 DISCUSSION OF SUBROUTINE INPUT REQUIREMENTS

There are a large number of inputs required for the various subroutines of the SEISM codes. Many are discussed in Bernreutter et al. (1984, 1985, 1989a and 1989b) and Davis (1991). Data transfers between subroutines are not all documented but doing so may be desirable for tracing computational flow when difficulties arise. Consequently, code should be investigated to document input data required by one subroutine that is produced by another preceding subroutine in the data flow. A list of inputs is in Appendix A to this report. The list is derived from Davis (1991) and a limited perusal of source code and data-transfer files. Some hard coded data such as digitized maps of the eastern U.S. are identified in the Appendix. However, locations in the code where changes may be required or where data-transfer file parameters are located usually have not been identified. These reside within the code but are not specified as input. If the SEISM codes are to be used in locations other than the eastern U.S., additional map data, for example, will be required.

Input data is designated as permanent or temporary for each site analysis suite of calculations. The temporary input files are usually created by one of the SEISM subroutines for each calculation, e.g. by the SHC executive routine (principal function is described in Section 4.1) and input to another subroutine. A brief summary of data flow is in Hofmann (1991) after Bernreutter (1984). A more detailed flow diagram is in Davis (1991). Subroutine generated temporary files are not well documented but are in ASCII form which suggests that they can be edited, e.g. to carry out sensitivity studies. Sometimes two sets of output files are generated. One set, with additional information, is available for inspection but is not passed on to the next subroutine. These internally generated input files are not all listed in Appendix A. Formats for those that are listed can sometimes be determined from an inspection of example files. Permanent input files were generated by elicitation of the various experts. For the eastern U.S. study, there were originally 13 experts which results in 26 expert data input files. The temporary files, automatically are deleted when the computations are completed. They are recreated in a following computation and may change if the permanent data files or flags are changed.

4.1 DISCUSSION OF FILE TYPES

Permanent files are defined as those generated from expert elicitation and prepared by the user. Temporary files are created by the code during execution for further processing. The distinction between the two types of files is sometimes blurred. For example the output created by the SHC executive module is the result of elicitation of data through screen interaction. The SHC module locates the data in the proper row and column format required by FORTRAN coding.

Other inputs must be manually entered into the proper rows and columns of an input file. The columns for entries are not given in the draft documentation but often may be determined from an examination of example files. A columns number heading, in the following lists of input, is largely for future use. Where file descriptions are required, columns are sometimes specified by the documentation and are so indicated. For additional information about the input variables, see the references by Bernreutter et al. (1984, 1985, 1989a and 1989b) and by Davis (1991).

The principal subroutines of the SEISM 1 program are called modules. These modules perform most of the functions of the program. The modules are PRDS, COMAP, ALEAS and COMB. A simplified overview of their principal functions follows.

- PRDS accepts site coordinates and seismic zones. It calculates the distances from the sites to various parts of the zones.

- COMAP accepts alternative seismic zones generated by the expert.

- ALEAS performs the hazard calculations.

- COMB combines results from other modules and formats them for screen presentation and plotting.

- SHC is also called the "executive module". It produces an interactive screen that accepts user input which is then formatted for the ALEAS module.

An attempt also was made to list temporary file inputs. These are not described in detail in the draft documentation but formats can sometimes be ascertained from example files provided with the program. Ultimately, temporary files should be documented so their content can be used to resolve calculational problems when they occur. This attempt at determining data transfer file input and outputs is not intended to be complete at this time but serves to inform the reader that certain types of data are being generated by one routine and used by another.

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APPENDIX A

SEISM 1 Data File Documentation

Compiled by J. Bangs
Programming Specialist

FILENAME: amenu

ORIGIN: Generated by the SHC executive module of the program, consequent to interactive on-screen questioning of the operator. This file could be saved and modified or reused. Therefore, although technically it is a temporary file, is regarded as a permanent file whose data must be entered manually.

UTILIZATION: Input file to the ALEAS module.

STATUS: Temporary, generated prior to each execution.

GENERAL DESCRIPTION: This file contains program execution flags and titles/labels for output plots and other instructions.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
1	1-80		Comment describing file
2-4	1-50		Comment lines appearing on first page of hard copy output
5	1-80		Comment line describing following information
6		1	Flag for plotting arithmetic averages along with percentile curves: 0-no, 1-yes
6		2	Flag for plotting arithmetic averages on a separate frame: 0-no, 1-yes
6		3	Flag for plotting geometric averages along with the percentile curves: 0-no, 1-yes
6		4	Flag for plotting geometric averages on a separate frame: 0-no, 1-yes
6		5	Seed for random number generator: 0-machine generated, fixed seed, or user chosen seed between $1x10^7$ and 2,147,438,646
7,8	1-50		Plot titles that go on each individual plot
9		1	Flag selecting ground motion parameter calculation: -1-PGA, 0-PGV, 1-PSV (peak ground acceleration, peak ground velocity and pseudo-velocity spectra respectively)

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
9		2	Number of spectral frequencies for which analysis will be performed
9		3	Number of return periods for which the analysis will be performed
9		4	Number of simulations per attenuation expert
9		5	Flag controlling whether information from the **gmfxb** and **sitecor** files will printed to the output file: 0-no, 1-yes
10		1-9	Frequencies to be used in the analysis
11		1-5	Indices of the models from the attenuation file **atnfb** to be used in the calculation.
12		1	Flag specifying graphics destination: 1-screen only, 2-postscript file, 3-screen and postscript file
13		1	Lower earthquake magnitude bound for integration
13		2	Lower earthquake intensity bound for integration
13		3	Number of magnitude integration steps to be used
13		4	Number of intensity integration steps to be used
13		5	Size of the magnitude integration steps
13		6	Size of the intensity integration steps
13		7	Upper earthquake magnitude bound
13		8	Upper earthquake intensity bound
14		1	Lower magnitude value to be used in calculations
14		2	Lower intensity value to be used in calculations
15		1	Upper magnitude value to be used in calculations
15		2	Upper intensity value to be used in calculations
16		1	Number of ground motion parameters for which the hazard will be calculated - the maximum number is 10

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
16		2,3,4	Number of lines (starting at line 20) that must be skipped to read parameters for which the hazard is being calculated: parm2-PGA, parm3-PGV, parm4-PSV
17		1	Flag indicating the extent of calculations: enter 0 for calculation of simulations and percentiles or 1 for best estimates only.
18		1-5	Return periods for which the analysis will be performed
19		1-3	Boundary percentile values associated with the return period
20		1-80	Comment for following PGA values
21		1-10	PGA values for which hazard is calculated
22		1-80	Comment line for PGV option - Note: the PGV option is not implemented in this version of the code.
23		1-80	Comment line for PSV values
24		1-10	PSV values for which hazard is calculated
25 to 35 (max)			These are repeat values of line 24 for each pseudo-velocity spectral peak for various frequencies, up to the maximum allowed on line 9 by parameter 2.

FILENAME: ax/j/

ORIGIN: Generated by a digitization of an expert's manually generated zonation map. This file must be manually entered.

UTILIZATION: Input to the PRDS module

STATUS: Permanent data file

GENERAL DESCRIPTION: Eastern U.S. zonation map for Seismicity Expert number /j/. The file contains a sequence of nodes, given in lat-long format defining the polygons making up this particular expert's latitude-longitude seismic zonation.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
1	1-80		Expert's name & description
2	1-80		Date file was finalized
3		1	Number of seismic zones. These are called maps in the documentation
3		2	Number of nodes in map #1
		3	Number of nodes in map #2...repeat until number of nodes is given for each map
3		4	Number of digitized zones for map #1
3		5	Number of digitized zones for map #2...repeat until number of digitized zones is given for each map
4		1	Total number of digitized zones for all maps
4		2	Flag indicating whether file contains element information required by the MAO* program: 0-yes, 1-no (this flag is no longer required or used).
4		3	Total number of nodes in all maps
4		4	No longer used
4		5-8	Not-used debugging flags

*Note: The MAO program was used in the early development of the SEISM codes but is no longer required.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
4		9	Flag indicating whether a zonation map will be created: 0-no map, 1-create map and distance distribution calculations, 2-create map with no distance distribution calculations
4		10	Flag indicating whether U.S. map will be plotted: 0-no map plotted, 1-map plotted
4		11-12	Not-used debugging flags
4		13	Number of distance bands in developing distance probability density function
4		14	Flag indicating source of site information: 0-ax/j/ file, 1-sitesid file, 2-whatsite file

The length of the next block of data in the file is controlled by the number of nodes in all of the experts' maps.

5to(5+nodes-1)	1	Node number
5to(5+nodes-1)	2	Node longitude
5to(5+nodes-1)	3	Node latitude
5to(5+nodes-1)	4	Polygon (an expert's seismic source zone) identifier. It is zero at the beginning of each list of nodes except for the first in the list.

The next block of data contains a compilation of the digitized sections that form the seismicity zones. The block is comprised of pairs of lines. **NOTE:** This block of data is no longer read or used by the current version of the program. The length of this block is equal to 2 times the number of digitized sections. Therefore the first line number after this block is calculated as:

= 5 + nodes + 2 (No. of digitized sections)

The next two lines describe the distance bands in kilometers.

#	1	Outer circle band #1
#	2	Outer circle band #2
#	3	Outer circle band #3
#	4	Outer circle band #4
#	5	Outer circle band #5
#	6	Outer circle band #6

LINE COLUMNS NO.	PARAMETER NO.	COMMENT
#	7	Outer circle band #7
#	8	Outer circle band #8
#+1	1	Inner circle band #1
#+1	2	Inner circle band #2
#+1	3	Inner circle band #3
#+1	4	Inner circle band #4
#+1	5	Inner circle band #5
#+1	6	Inner circle band #6
#+1	7	Inner circle band #7
#+1	8	Inner circle band #8

The next line contains integration parameters for developing the distance density function.

#+2	1	Inner circle size increment
#+2	2	Increment size outside the outer circle
#+2	3	Inner circle radius (km)
#+2	4	Outer circle radius (km)
#+2	5	Outer circle size increment
#+2	6&7	No longer used
#+3	1	Site name
#+4	1	Site longitude
#+4	2	Site latitude
#+4	3	Method 2 site conditions
#+4	4	Method 3 site conditions
#+4	5	Site host region
#+5	1	Digitized zones which completely envelope another zone(s).

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
			If the parameter in line #+5 is non-zero, then this line would be followed by a line containing the number of digitized zones that form an envelope, and then the number of digitized zones inside the envelope. This line would be followed by line(s) containing the indices of the digitized zones that define the envelope. These lines would be followed by lines containing the indices of the enveloped zones. If the value in line #+5 was zero, the next line in the file is #+6.
#+6		1	Number of zones for which distance distributions must be calculated. Line #+6 is the number of background zones for which distance distributions must be calculated. These zones will be read from the bottom of the digitized zone list.
#+7		1	Number of seismicity zones defined by the seismicity expert The following block of lines define the manner in which the digitized zones are combined to form the seismicity zones. The block is comprised of one pair of lines for each seismicity zone. The first seismicity zone is defined by the first pair of lines, the second seismicity zone by the second pair of lines and so forth until all zones have been defined.
#+8		1	Number of digitized zones used in the seismicity zone
#+9		1 through n	Indices of the digitized zones that make up the seismicity zone.

NOTES: The manner in which the distance density functions are derived is not documented in the User's Manual. The derivation of these functions should be researched to gain further insight to the operation of PRDS.

FILENAME: c/j/altz where /j/ is the seismicity expert number

ORIGIN: Externally created by the seismicity experts. Must be manually entered.

UTILIZATION: Input to the COMAP program

STATUS: Permanent

GENERAL DESCRIPTION: This file contains alternate combinations of zonations and the confidence the expert has in the alternate zonation.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
1	1-80		Comment line describing file
2		1	Radius of zone of inclusion in km
2		2	Lower threshold of the portion of the best estimate map's weight under which a potential map is disregarded.
2		3	Radius of the circle of influence
2		4	Flag for debugging purposes

The next set of lines (one for each seismicity zone) all have the same format

3	1	Seismicity zone number
3	2	Confidence the expert has in the existence of the zone
3	3	Zone number that the zone becomes if it does not exist
3	4	Confidence the expert has in the boundary location of the zone

The number for the line following the confidence parameters is

= 2 + number of zones + 1

#	1	Confidence - no entry indicates full weight of 1.00 for all zones; if lower confidence than a full weighting, values may be 0 to 0.99
#+1	1	Number of zones described in the seismicity file, c/j/sis, which corresponds to the number defined by this seismicity expert

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT

The next lines are used to provide an index of the order in which the zones appear in the c/j/sis seismicity file. Each line can have up to 20 indices. As many lines as needed are used to list all of the zone indices. The next line number is determined as

# = 2 + number of zones + 2 + (integer)		Integer is the number of zones/20, rounded to the nearest integer, + 1
#	1	Number of zones in the best estimate map
#	2	Flag indicating whether the zone indices are sequential or must be read: 0=sequential
#	3	Maximum number of actual maps to be retained for the calculations
#+1	1	Index of the first zone of the best estimate map
#+2	1	Number of alternative zone clusters

The final block of lines is used to explain the cluster replacement. Each alternative zone cluster is explained by 4 lines. These sets of lines are repeated until all cluster replacements are documented.

#+3	1	Number of zones on best estimate map to be replaced on the alternative map
#+3	2	Number of zones replacing those on the best estimate map
#+4	1-m	Indices of best estimate map zones being replaced
#+5	1-n	Indices for the alternative zones
#+6	1	Index of the zone in which any unaccounted for area will fall when zone cluster replacement occurs.

FILENAME: combin

ORIGIN: Generated by the SHC executive program as a consequence of interactive screen responses by the user.

UTILIZATION: Input file to COMB

STATUS: Temporary, but file can be saved and modified for future use so is listed with permanent files.

GENERAL DESCRIPTION: This file contains parameters controlling the execution of COMB as well as plot label and title information.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
1	1-80		Comment describing file contents
2		1	Number of seismic experts (m) to be combined in the run
2		2	Number of return periods (r) for the run
2		3	Number of ground motion experts (n) to be combined in the run
2		4-n	Indices of ground motion experts to be combined in the run
3		1-m	Indices of seismicity experts to be combined in the run
4		1	Number of percentiles (p) to be plotted
4		2-p	List of the percentiles to be plotted
5		1-r	List of the return periods to be plotted
6		1	Graphics destination: 1-screen, 2-postscript file, 3-screen & postscript file
7-9	1-5		Title comment lines that appear on the first page of the output
10	1-80		Comment line describing information following
11,12	1-50		Titles for individual plots
13	1-80		Comment line describing information following

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
14		1	Flag for plotting arithmetic averages along with percentile curves: 0-no, 1-yes
14		2	Flag for plotting arithmetic averages on a separate frame: 0-no, 1-yes
14		3	Flag for plotting geometric averages along with the percentile curves: 0-no, 1-yes
14		4	Flag for plotting geometric averages on a separate frame: 0-no, 1-yes
14		5	Flag for plotting the design PGA and design response spectra on the hazard curve: 0-no, 1-yes
14		6	Flag identifying source of design response spectra: 0-ALEAS, 1-COMBIN
14		7	Flag for plotting best estimate with percentile curves for all return periods: 0-no, 1-yes
14		8	Flag for plotting best estimate hazard curves for individual experts on one frame: 0-no, 1-yes

If design response spectra information is given in COMBIN, it is provided in the remaining lines in the file. Each site is described individually using the same line format for all sites.

15		1	File number identification
15		2	Number of design PGA numbers to be compared
15		3	Number of design spectra values to be compared
16		1-8	design PGA values
17		1	Number of frequencies (f) for which values are given in the design spectra
17		2-f+1	Frequencies in the design spectra in ascending order
18		1-f	Velocities corresponding to the to the above frequencies

This set of lines is repeated until all sites have been documented.

FILENAME: eltxylg

ORIGIN: Created by LLNL for the NRC

UTILIZATION: Input to PRDS

STATUS: Permanent

GENERAL DESCRIPTION: This file contains the geodetic grid coordinate information to transform latitude-longitude pairs into the coordinate system used in SEISM 1.

No documentation in the user manual.

NOTE: Modification of a SEISM code version to work in the western U.S. must support the mapping system utilized for this work. Factors determining which mapping system should be used include existing data format, source code conversions, and existing in-house software capabilities, e.g. the Interactive Surface Modeling Program (ISM) which is available CNWRA. More sophisticated mapping capabilities are expected in SEISM 3 being prepared for NRC/NRR.

FILENAME: gmfxb

ORIGIN: Prepared from ground motion expert elicitation as an integral part of the SEISM program

UTILIZATION: Input to the ALEAS program

STATUS: Permanent

GENERAL DESCRIPTION: This file contains the best estimate and bounds for random variation of the attenuation equations developed by the Ground Motion Experts.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
1	1-80		Comment line describing file
2		1	Number of ground motion experts
2		2	Maximum number of models per expert
2		3	Number of regions covered by the study
3		1-# of experts	Self weight ascribed by each of the experts to themselves

The rest of the file is divided into sections according to the number of experts utilized in the particular run. Each section is divided into a set of parameter lines followed by specific PGA, PGV and PSV parameters.

4		1	Numerical index of ground motion expert
5		1	PGA best estimate correction index
5		2-5	Weights for each correction method
6		1	PGV best estimate correction index
6		2-5	Weights for each correction method
7		1	PSV best estimate correction index
7		2-5	Weights for each corrections method
8		1	Index for PGA truncation method
8		2	Maximum absolute bound
8		2	Number of sigmas
9		1	Index for PGV truncation method

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
9		2	Maximum absolute bound
9		2	Number of sigmas
10		1	Index for PSV truncation method
10		2	Maximum absolute bound
10		2	Number of sigmas

The possible truncation methods are: 1-ground motion parameter is not bounded, 2-ground motion parameter saturates with absolute maximum, 3-ground motion parameter saturates at n sigmas, 4-ground motion parameter saturates with absolute maximum at n sigmas.

11	1-80		Comment line describing proceeding lines
12		1	Region 1 best estimate on attenuation model
12		2	Region 1 lower bound for sigma in attenuation model
12		3	Region 1 upper bound for sigma in attenuation model
13		1	Region 2 best estimate on attenuation model
13		2	Region 2 lower bound for sigma in attenuation model
13		3	Region 2 upper bound for sigma in attenuation model
14		1	Region 3 best estimate on attenuation model
14		2	Region 3 lower bound for sigma in attenuation model
14		3	Region 3 upper bound for sigma in attenuation model
15		1	Region 4 best estimate on attenuation model
15		2	Region 4 lower bound for sigma in attenuation model
15		3	Region 4 upper bound for sigma in attenuation model
16		1-4	Best estimate attenuation model index for each of the four regions - magnitude scale
17		1-4	Best estimate attenuation model index for each of the four regions - intensity scale
18		1,2	PGA model #1 index and corresponding weight used in simulation for Region #1 with magnitude scaling

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
18		3,4	PGA model #2 index and corresponding weight used in simulation for Region #1 with magnitude scaling
18		5,6	PGA model #3 index and corresponding weight used in simulation for Region #1 with magnitude scaling
18		7,8	PGA model #4 index and corresponding weight used in simulation for Region #1 with magnitude scaling
19		1,2	PGA model #1 index and corresponding weight used in simulation for Region #2 with magnitude scaling
19		3,4	PGA model #2 index and corresponding weight used in simulation for Region #2 with magnitude scaling
19		5,6	PGA model #3 index and corresponding weight used in simulation for Region #2 with magnitude scaling
19		7,8	PGA model #4 index and corresponding weight used in simulation for Region #2 with magnitude scaling
20		1,2	PGA model #1 index and corresponding weight used in simulation for Region #3 with magnitude scaling
20		3,4	PGA model #2 index and corresponding weight used in simulation for Region #3 with magnitude scaling
20		5,6	PGA model #3 index and corresponding weight used in simulation for Region #3 with magnitude scaling
20		7,8	PGA model #4 index and corresponding weight used in simulation for Region #3 with magnitude scaling
21		1,2	PGA model #1 index and corresponding weight used in simulation for Region #4 with magnitude scaling
21		3,4	PGA model #2 index and corresponding weight used in simulation for Region #4 with magnitude scaling
21		5,6	PGA model #3 index and corresponding weight used in simulation for Region #4 with magnitude scaling
21		7,8	PGA model #4 index and corresponding weight used in simulation for Region #4 with magnitude scaling
22		1,2	PGA model #1 index and corresponding weight used in simulation for Region #1 with intensity scaling

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
22		3,4	PGA model #2 index and corresponding weight used in simulation for Region #1 with intensity scaling
22		5,6	PGA model #3 index and corresponding weight used in simulation for Region #1 with intensity scaling
22		7,8	PGA model #4 index and corresponding weight used in simulation for Region #1 with intensity scaling
23		1,2	GA model #1 index and corresponding weight used in simulation for Region #2 with intensity scaling
23		3,4	PGA model #2 index and corresponding weight used in simulation for Region #2 with intensity scaling
23		5,6	PGA model #3 index and corresponding weight used in simulation for Region #2 with intensity scaling
23		7,8	PGA model #4 index and corresponding weight used in simulation for Region #2 with intensity scaling
24		1,2	PGA model #1 index and corresponding weight used in simulation for Region #3 with intensity scaling
24		3,4	PGA model #2 index and corresponding weight used in simulation for Region #3 with intensity scaling
24		5,6	PGA model #3 index and corresponding weight used in simulation for Region #3 with intensity scaling
24		7,8	PGA model #4 index and corresponding weight used in simulation for Region #3 with intensity scaling
25		1,2	PGA model #1 index and corresponding weight used in simulation for Region #4 with intensity scaling
25		3,4	PGA model #2 index and corresponding weight used in simulation for Region #4 with intensity scaling
25		5,6	PGA model #3 index and corresponding weight used in simulation for Region #4 with intensity scaling
25		7,8	PGA model #4 index and corresponding weight used in simulation for Region #4 with intensity scaling

The above sequence of lines is repeated for the PSV and PGV model for Expert 1 and all three (PGA, PGV, PSV) are repeated for each ground motion expert.

FILENAME: sitesid

ORIGIN: Must be keyed in for specific sites

UTILIZATION: Input to the PRDS module

STATUS: Semi-permanent, modified as new sites are to be built

GENERAL DESCRIPTION: This file contains site names, numbers, their coordinates and ground motion parameters.

This file contains pairs of lines that provide information about sites. These pairs all have the same format and are repeated until all sites have been described.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
1		1	Site name
1		2	Site number
2		1	Site longitude
2		2	Site latitude
2		3	Method 2 categorical correction
2		4	Method 3 categorical correction
2		5	Site host region

FILENAME: atnfb

ORIGIN: Generated external of the SEISM program

UTILIZATION: Input file to ALEAS

STATUS: Permanent

GENERAL DESCRIPTION: This file contains the attenuation model coefficients and model type to be analyzed.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
1	1-80		Comment line for file
2		1	Maximum number of coefficients for a given model
2		2-7	Counters for skipping through the file depending on whether PGA, PGV, PSV calculations were chosen.

Lines 3-35 contain the coefficients for the PGA models selected by the ground motion experts.

Lines 36-200 contain the coefficients for the PSV models.

The PGV models have not been implemented.

NOTE: Although the Fortran format of the lines containing the coefficients is given as (40x,4f10.5, 2 (1,8f10.5)), the individual parameters are not documented in the user manual.

FILENAME: whatsite

ORIGIN: Created by the SHC executive program

UTILIZATION: Input to PRDS

STATUS: Temporary, updated by each run of SHC

GENERAL DESCRIPTION: This file contains the site number to be analyzed.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
1		1	Site number

FILENAME: bfile/j/ where /j/ is the seismicity expert number

ORIGIN: Created by the PRDS program

UTILIZATION: Input to the COMAP module

STATUS: Temporary

GENERAL DESCRIPTION: This file contains the distance distributions for each seismicity zone specified by the seismicity expert. It is not documented.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
1	1-80		Comment line describing file
2		1	Seismic expert number
3		1	Site name
3		2	Site longitude
3		3	Site latitude
4		1	Site identification number
4		2	Method 2 category
4		3	Method 3 category
4		4	Host region number
5		1	Number of seismicity zones
5		2	Number of concentric distance "bins" (also described as "bands") centered on the site that intercept each seismicity zone
5		3	Step increment , in km, to be used in integration of the distance bin in each intercepted seismic zone

The next set of lines contains the distance boundary for each of the distance bins specified on line 5. Each of the lines can contain a maximum of 8 bounds. The distance bounds are followed by sets of lines that contain the distance distribution values for each seismicity zone. There is one set of lines for each seismicity zone specified by the expert.

The line number for the first line of the first set is: # = 5 + (int) (number of dist. bins/8 + 0.5) + 1

#	1	Digitized zone number
#	2	Corresponding seismicity zone

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
#+1		1	Area of seismicity zone (km^2)
#+2		1-8	Distance distribution for bins 1 through 8
#+3		1-8	Distance distribution for bins 9 through 16

The number of distance distributions for the seismicity zone is equal to the number of distance bins defined on line 5. This sequence of lines is repeated for each seismicity zone.

NOTE: The derivation and units associated with the distance distribution was not documented in the user's manual. This should be investigated.

FILENAME: c/j/sis where /j/ = expert number

ORIGIN: Keyed in from expert elicitation

UTILIZATION: Input file to ALEAS

STATUS: Permanent

GENERAL DESCRIPTION: These files contain seismicity parameters for a given expert's zonation.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
1		1	Comment on file contents
2		1	Seismicity expert number
2		2	Number of seismicity zones in file
2		3	Number of regions the zones cover
2		4	Flag for seismic recurrence curve adjustment: 0=LLNL model, 1=truncated exponential
2		5	Level of correction for recurrence parameters: 0=none, 1=some negative, 2=negative
3		1	Region 1 weight
3		2	Region 2 weight
3		3	Region 3 weight
3		4	Region 4 weight

The next lines give the region number each zone falls in. 16 indices may be given per line. All zones will be registered to a region number.

4	1-16	Zone 1 region...

The next line number is given as # = 4 + (integer)(number of zones/16 rounded to the nearest integer) + 1

#	1	a value for Modified Mercalli Intensities
#	2	b value for Modified Mercalli Intensities

The following block of lines are broken into groups of 7 lines each. Each group of lines provides seismicity information for each zone.

#+1	1	Seismicity expert number

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
#+1		2	Seismicity zone number
#+1		3	Flag indicating type of scale being used: 1=m_b, 2=MMI
#+2		1	Not used
#+2		2	Best estimate for the scale being used
#+2		3	Lower bound for scale being used
#+2		4	Upper bound for scale being used
#+3		1	Occurrence rate magnitude
#+3		2	Occurrence rate magnitude, best estimate
#+3		3	Lower bound of occurrence rate magnitude
#+3		4	Upper bound of occurrence rate magnitude
#+4		1	Not used
#+5		1	Occurrence rate cutoff magnitude
#+5		2	Upper magnitude for the zone
#+6&7			Recurrence parameters for best estimate, lower and upper bounds models - this needs more investigation

FILENAME: comenu

ORIGIN: Generated by the SHC module from screen interactions with the operator

UTILIZATION: Input to the COMAP program

STATUS: Temporary

GENERAL DESCRIPTION: This file contains only one flag to define the task definition of the COMAP run. The possible values are:

1 - generate the file of zone areas

2 - generate all possible maps and probabilities

3 - generate file of zone areas and all possible maps and probabilities.

NOTE: For the SUN version of SEISM 1, the flag is set at 3 and cannot be changed without recoding.

FILENAME:	f/j/s/i/ where /j/ = expert and /i/ = site index
ORIGIN:	Output file from COMAP
UTILIZATION:	Input file to ALEAS
STATUS:	Temporary
GENERAL DESCRIPTION:	No documentation. A companion to the similar **g** file which is not generated by the SUN version of the code. It is similar to the **b** file.

FILENAME: sitecor

ORIGIN: File was generated for NRC project outside of SEISM program execution

UTILIZATION: Input file to ALEAS

STATUS: Temporary

GENERAL DESCRIPTION: Local site correction information (Method 2 & 3) is contained in this file. This file may be updated to reflect new studies - hence the temporary status of the file.

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT
1	1-80		File content comment
2		1	Number of sites for which characteristics are given

The following lines indicate the Method 2 and 3 category corrections for each site. The number of lines matches the number of sites indicated in line 2.

3	1	Site identification number
3	2	Method 2 category corrections: 1-no correction, 2-simple base rock model correction
3	3	Method 3 category corrections
3	4	Host region in which the site falls

The next line number is determined as # = 2 + number of sites + 1

The next three lines contain information for the Method 2 correction.

#	1	Number of Method 2 category correction factors given in this file
#	2	Number of frequencies for which the corrections are provided
#	3-12	Frequency values for which correction factors are provided

The next line contains the correction factors for category 1 of Method 2.

#+1	1	PGA correction
#+1	2-10	frequency corrections

LINE	COLUMNS NO.	PARAMETER NO.	COMMENT

The next line contains the correction factors for category 2 of Method 2.

#+2	1	PGA correction
#+2	2-10	Frequency corrections
#+3	1	Number index for the Method 3 category correction factors contained in this file

The next 16 lines contain information of the Method 3 category corrections. The NRC project produced 8 different corrections for the Method 3 category. The following 16 lines are organized in 8 pairs, one pair for each correction type.

#+4	1	PGA correction
#+4	2-10	Frequency corrections
#+5	1-10	Corresponding standard deviations to corrections
#+20	1	Number of sites for which Method 4 category correction will be given

If line #+20 is a positive number, then the next 3 lines would contain Method 4 correction factor in the same format used to provide Method 3 corrections above. If line #+20 is zero the Method 4 category correction lines are not included in the file.

#+21	1	Number of sites for which design response spectra are given

The remaining lines are divided into sets of three lines that define the design response spectra for the number of sites specified in the previous line.

#+22	1	Site identification number
#+22	2	Site name
#+22	3	Number of frequency values in the design response spectra
#+23	1	Design PGA (cm/s/s)
#+23	2-10	Design spectral velocities
#+24	1-9	Design response frequencies corresponding to design spectral velocities; maximum number of design spectral velocities and frequencies is 9

FILENAME: usmap

ORIGIN: Created by LLNL for the NRC

UTILIZATION: Input to PRDS

STATUS: Permanent

GENERAL DESCRIPTION: This file contains the xmap, ymap coordinates of the border of the Eastern U.S. The xmap, ymap coordinate system is derived from the eltxylg transformation. The file contains 5 lines of header information, presumably from the digitizer utility. The remainder of the file is x-y pairs defining the U.S. map border.

NOTE: The use of usmap and eltxylg for mapping purposes is specific to LLNL's mapping/plotting software which includes a coarsely digitized outline map of the eastern U.S. These files could be converted to a more commercially standard digitized map format such as UTM or state-plane rather than modify the less refined map digitized in the code. The forthcoming SEISM 3 will contain a format for the usmap file that is compatible with USGS digital maps.
