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User Manual for the NTS Ground Motion Data Base Retrieval Program

ntsgm

Containment and Explosion Phenomenology Project & LANL Source Region Project

Frederick N. App
Geophysics Group EES-3
Earth and Environmental Sciences Division
Los Alamos National Laboratory

Thomas W. Tunnell
EG&G/EM
Los Alamos Operations

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Section I. Introduction

The NTS (Nevada Test Site) Ground Motion Data Base is composed of strong motion data recorded during the normal execution of the U. S. underground test program. It contains surface, subsurface, and structure motion data as digitized waveforms. Currently the data base contains information from 148 underground explosions This represents about 4200 measurements and nearly 12,000 individual digitized waveforms. Most of the data was acquired by Los Alamos National Laboratory (LANL) in connection with LANL sponsored underground tests. Some was acquired by Los Alamos on tests conducted by the Defense Nuclear Agency (DNA) and Lawrence Livermore National Laboratory (LLNL), and there are some measurements that were acquired by the other test sponsors on their events and provided to us for inclusion in this data base.

Data acquisition, creation of the data base, and development of the data base retrieval program (ntsgm) are the result of work in support of the Los Alamos Field Test Office and the Office of Non-proliferation and Arms Control, both sponsored by the U. S. Department of Energy. Neither the Los Alamos National Laboratory, nor any of its employees, nor any of its contractors, subcontractors, or any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of either the program or data base.

Section II. Access to the Ground Motion Data Base

If you are a new user on the Los Alamos Integrated Computer Network (ICN), you will need to obtain an ICN password from Group C-1 at (505) 665-1805 and must have a laboratory account with an active cost center and charge code. For information regarding the ICN, operating systems, software, etc., you should contact the Los Alamos Consulting Office at (505) 667-5745, which can either answer your questions or direct you to someone who can.

The ntsgm program resides in the Los Alamos common file system (CFS) as an executable file named **ntsgm.x.** To retrieve **ntsgm.x** and the associated document file **ntsgm.doc**, use the following command:

cfs get dir=/lanl_db/users **ntsgm.x ntsgm.doc**

The **ntsgm.doc** is a printable text file that is a near duplicate of this manual. Unlike this manual, however, it will be periodically updated to reflect changes and additions to the data base and the **ntsgm.x** program. In the future, **ntsgm.doc** will become the principal reference document for the data base.

You need to be on machine RHO or GAMMA to execute **ntsgm.x.** Machine ZETA, which also is in the open partition, has an insufficient user disk quota limit for data base retrieval. Upon executing **ntsgm.x**, the program will search your local file space for a file named **ntsgm.db.** This is the name reserved for the ground motion data base. If a file by this name is not present, the program will call for it from the CFS. The stored data base resides in CFS as four separate, specially packed binary files. Retrieval involves unpacking the files (after reading them onto local disk), performing some special operations, and merging them to form a single, direct access, CRAY binary file. The entire retrieval process takes about 30 minutes wall clock time (1 CPU minute). The **ntsgm.db** file will remain in your local file space for 48 hours following the most recent activity on it, unless specifically removed by you.

Currently, the total user disk quota limits on RHO and GAMMA are 5.28 GBytes each. For ZETA the limit is 2.43 GBytes. The complete **ntsgm.db** file occupies about 1.58 GBytes of disk, but the retrieval process uses a total of about 3.5 GBytes, thus eliminating ZETA as a host machine.

The **ntsgm.db** program is interactive and menu driven. It is intended to be user friendly to the point that a person completely unfamiliar with the program, or the contents of the data base, can use it with a minimum of prior instruction. You have five menus from which to choose. Each menu contains a manual/help selection that describes each menu selection option in detail. This manual, and its corollary **ntsgm.doc,** contains additional information, which probably is not critical for most applications.

Section III. Menu Manuals

Following are the menu manuals which can be accessed during program execution.

A. Main Menu Manual

Select an option by number and press CR. Control is always returned to the main menu after you make your hole (event), station, or measurement selections, i.e., you are returned to the main menu after hole selections, then again after station selections, etc.

Option 1 - Hole Selection Menu. Produces a menu for hole selection. On the first time through, this option must be the first one selected. The program operates on the basis of hole names (such as U4n, U19x), *not* event names (such as HEARTS, BACKBEACH). Option 5 provides a complete cross-reference listing between hole and event names, along with event execution dates.

Option 2 - Station Selection Menu. Produces a menu for station selection. A station is defined as a specific location at which one or more measurements are made. This must be the second option selected.

Option 3 - Measurement Selection Menu. Produces a menu for measurement selection. This must be the third option selected.

Once having selected from each of the above three menus, you can do one of three things: 1) you can choose the Actions Menu to perform certain functions on the selected measurements, 2) you can return to the Hole Menu and select a new set of holes for a different selection of stations and measurements, or 3) you can return to the Station Menu to select a new set of stations and measurements for the already selected holes.

Option 4 - Actions Menu. Produces a menu of actions to be taken on the selected data. Select this only after you have completed your hole-station-measurement selections. When you return to the Main Menu from the Actions Menu, all memory of your previous hole-station-measurement selections is erased, and you need to start over (or exit).

Option 5 - List all Hole/Event Names and Dates. Provides a cross-reference listing of holes, events, and dates. Unless you are familiar with the event-hole name designations, you may want to choose this option before doing anything else.

Option 6 - Main Menu Manual. You're looking at it.

Option 7 - Exit Program. Terminates program execution.

B. Hole (Event) Selection Manual

Option 1 - All Holes. You are choosing all holes (events) in the data base—be aware that this could produce a very large volume of data—possibly in excess of the available disk space. The data base alone occupies 1.58 GBytes, and it is a relatively efficiently packed file; user disk quota limit is 5.28 GBytes each for machines RHO and GAMMA.

Option 2 - Specific Hole Name(s). For this option you should be aware of which hole names go with which events. Choose Option 5 in the Main Menu to obtain this information. You will be queried for the specific hole names, which you enter one name per line (CR after each); up to 30 names are allowed.

Option 3 - Area Number(s). You will be queried for a list of selected Test Areas. You should be familiar with how the NTS is partitioned into areas (shown on most maps of the NTS).

Option 4 - NTS Coordinates. Select all holes within the bounds of your specified Nevada State Coordinates (separate query). Nevada state coordinates are indicated on most maps of the NTS. This option is not relevant for events that lie outside Nevada, e.g., MILROW (Ua2) in the Aleutians.

Option 5 - WP Depth. Select on basis of event working point (WP) depth, which is specified as a range of depths (separate query).

Option 6 - WP Material. Select on basis of WP rock type (separate query - currently alluvium, tuff and/or lava). This option is not yet implemented.

Option 7 - Surface Material. Select on basis of rock type present at surface ground zero (SGZ) (separate query - currently alluvium, tuff and/or lava). This option is not yet implemented.

Option 8 - Thickness of Qal. Select on basis of thickness of alluvium in the geologic section (separate query - specified as minimum and maximum depth of Qal; e.g., 0 to 100m)

Option 9 - WP Distance above/below Qal-Tu. Select on basis of WP distance above/below the alluvium-tuff interface (separate query). Relevant only to NTS events.

Option 10 - WP Distance above/below SWL. Select on basis of WP distance above/below the local static water table (separate query).

Option 11 - WP Distance above/below TMRM. Select on basis of WP distance above/below the welded member of the Rainier Mesa Tuff (separate query). This is a particularly hard geologic unit that contrasts sharply with other rock types in certain areas of the NTS. It is not present in all areas, so holes in those areas will always fail to meet the criteria.

Option 12 - WP Distance above/below Pz. Selection on basis of WP distance above/below the surface of the Paleozoic aged (Pz) rocks present at the NTS (separate query). The Pz surface constitutes a sharp impedance contrast to the overlying tuffs and alluvium at the NTS.

Option 13 - Hole Selection Manual. You're looking at it.

Option 14 - Exit this Menu. You are returned to the Main Menu.

Option 15 - Exit Program. Terminates program execution.

COMBINING SELECTIONS: You can make a single selection for any of the above options. For some, you can make multiple selections on a single line, separated by commas. Options 3-12 can be combined as logical conjunctions (.AND.). For example: 3,5,6<CR> would produce all holes in the selected Test Areas that have WPs within the specified depth interval and selected rock type. Material selections queried for under options 6 and 7 can be combined as logical disjunctions (.OR.), e.g., in alluvium or tuff.

C. Station Selection Manual

Option 1 - All Stations. You are choosing all stations for the selected holes (events).

Option 2 - Specific Station Names. For this option you should be familiar with the stations associated with your selected holes. Depending on your needs, you may wish to choose option 1 (above) the first time through, and create an ASCII "headers" file (see Actions Menu and Actions Menu Manual), to familiarize yourself with the stations and comments that go with them, prior to performing other actions on your selections. Specific station names are entered one name per line (CR after each); up to 30 names are allowed. The various station descriptors used in the data base are described at the end of this Station Selection Manual.

Option 3 - All GM. Select all stations with the GM prefix. These are always free surface motions, but they do not necessarily represent all surface motions. See the station designator descriptions at the end of this Station Selection Manual.

Option 4 - All Surface Ground Zero. Select all stations that are located in close proximity to surface ground zero (SGZ); these stations are generally within about 15 m of SGZ.

Option 5 - All Trailer Park. Select all stations located on the prepared (graded and packed) surface at the event recording trailer park (usually only one such station at each event site, and usually designated as GM2).

Option 6 - All 1-DOB Surface Range. Generally, certain stations are located about one depth-of-burial (1 DOB) surface range from SGZ—there is some variability. This option selects those stations.

Option 7 - Select Surface Range. Select on basis of surface range from SGZ (separate query). For tunnel motion, selections will be based on horizontal range from the WP.

Option 8 - All Emplacement Hole Stations. Select on basis of stations located in the emplacement hole, usually in coarse stemming material (3/8th inch pea gravel).

Option 9 - All Exploratory Hole Stations. Select on basis of stations located in special (usually nearby) exploratory or instrumentation holes. These holes usually are grouted, so the instrument station is well coupled to the surrounding rock, but to be certain of this you should consult the "headers" file.

Option 10 - All EES-3 Stations. These are special accelerometer stations fielded either directly by Los Alamos Group EES-3 or by others in coordination with EES-3. Normally these are surface stations but there could be some subsurface measurements as well —see "headers" file. EES-3 stations are usually located a substantial distance from SGZ, typically outside the spall zone.

Option 11 - All Tunnel Motion Stations. These are special measurements made at tunnel level in association with Defense Nuclear Agency (DNA) tunnel events. Normally the gauge stations are emplaced in grouted holes about 6 m into the tunnel floor or wall—see "headers" file.

Option 12 - All Transformer Stations. Select on the basis of station gauges attached to electrical transformers at the NTS - for purpose of assessing vulnerability of transformer to ground motion.

Option 13 - All Tower Stations. Select on the basis of station gauges attached to rack assembly towers at the NTS - for purpose of assessing effects of ground motion on tower motion and stability.

Option 14 - All Trailer Stations (on/in). Select on basis of station gauges located at various locations in and on the event recording trailers, including on equipment racks.

Option 15 - Station Selection Manual. You're looking at it.

Option 16 - Exit This Menu. You are returned to the main menu.

Option 17 - Exit Program. Terminates program execution.

COMBINING SELECTIONS: Options 3-14 can be combined as logical disjunctions (.OR.); for example, a selection of: 4,5,8<CR> will get all SGZ, Trailer Park, and Emplacement Hole stations.

STATION DESCRIPTORS:

GMn - Surface ground motion station - "n" is the station number (e.g., GM1, GM2).

ESn - "EES-3" ground motion station - "n" is the station number.

TMn - Tunnel motion station - "n" is the station number.

SMn - Structure motion station (transformer, tower, trailer, other) - "n" is the station number.

BFa - Backfill station measurement (emplacement hole motion measurement made in conjunction with radiation and pressure measurements, all contained in a single "RAMS" package) - "a" is a letter designator (e.g., BFA, BFB).

MHn - Main hole ground motion station - distinguished from BFn in that it is not associated with a "RAMS" package.

Other - Any stations that are not prefixed with the above designators are exploratory/satellite/other "down hole" stations. There is no set pattern - usually starts with the hole designator of the satellite hole, followed by a number or letter.

Example 1 - E4F1, E4F2, ..., where E4F designates the satellite hole name (Ue4f without the U, which stands for underground).

Example 2 - SAT2-A, SAT2-B, ..., where SAT2 means it is satellite hole number 2 for the reference event.

Example 3 - 7AL1 where, in this case, the 7AL stands for emplacement hole U7al, which is not the emplacement hole for the reference event, but whose backfill package #1 instrumentation was turned on to measure motion from an event executed in another hole (in this case RUMMY in hole U7au).

You should consult the "headers" file of the source event for information on special stations such as these.

D. Measurement Selection Manual

Option 1 - All Measurements. You are choosing all measurements for the selected stations.

Option 2 - Specific Measurements. For this option, you need to be familiar with the measurement descriptors and conventions used; these are discussed at the end of this Measurement Selection Manual. Specific measurements are entered one per line (CR after each).

Option 3 - All Accelerations. Taken by itself, selects all components of acceleration for the selected stations.

Option 4 - All Velocities. Taken by itself, selects all components of particle velocity for the selected stations.

Option 5 - All Displacements. Taken by itself, selects all components of displacement for the selected stations.

Option 6 - All X-Components. Taken by itself, selects all X-direction components for the selected stations. See below for direction conventions.

Option 7 - All Y-Components. Taken by itself, selects all Y-direction components for the selected stations. See below for direction conventions.

Option 8 - All Z-Components. Taken by itself, selects all Z-direction components for the selected stations. See below for direction conventions.

Option 9 - Measurement Selection Manual. You're looking at it.

Option 10 - Exit this Menu. You are returned to the main menu.

Option 11 - Exit Program. Terminates program execution.

COMBINING SELECTIONS:
Options 3-5 can be combined as logical disjunctions (.OR.).
Options 6-8 can be combined as logical disjunctions (.OR.).
Option selections from 3-5 can be combined with selections from 6-8 as logical conjunctions (.AND.).
Example: 3,4,8 <CR> will select all Z-Components of acceleration and velocity.

MEASUREMENT DESIGNATORS AND DIRECTION CONVENTIONS:

All have the general form "GMa_bc" where:

"GM" stands for ground motion, and is always present.

"a" is a letter from A to D. There is always an A measurement; B, C and D represent additional (redundant) measurements of the same type and direction, but that are made with different gauges for backup and redundancy (the gauges may be ranged for different peak values). Consult the "headers" file for specific information on the measurements. Most SGZ stations have redundant measurements.

Always use the underscore "_".

"b" is X, Y or Z, indicating the direction component, using the "right-hand-rule" convention.

X is horizontal, radial from the vertical axis that passes through the WP and SGZ, with the positive pole directed toward that axis (for surface stations, positive toward SGZ).

Y is horizontal, tangential to the vertical axis that passes through the WP and SGZ, with the positive pole to the left while facing toward that axis (for surface stations, positive to the left when facing toward SGZ).

Z is vertical, with the positive pole upward.

"c" is the data type: A for acceleration, V for particle velocity or D for displacement. <u>Important note on units:</u> accelerations are in Gs (9.8 m/s/s), velocities are in m/s, displacements are in m.

Examples for measurements recorded at the surface:

GMA_ZA is vertical acceleration (positive up).

GMB_XV is radial velocity - first redundant measurement (positive toward SGZ).

GMC_YD is tangential displacement - second redundant measurement (positive to the left as viewed from the station while facing toward SGZ).

E. Actions Manual

You select one of the following actions to be applied to the current selection of measurements. Additional queries will be made appropriate to the particular actions option selected. Some queries are common to the actions that involve writing special files or plotting (options 1, 2,10,11,12). These are 1) start and stop times for data retrieval, 2) nth point selection (points can be skipped if a more coarse sampling density is desired), 3) version (or run) number. There is additional information on version number at the end of this Actions Manual. Upon completion of the specified action, control is returned to you for another actions menu selection on the same set of measurements. The process can be repeated as often as desired. Once control is returned to the main menu (option 13 below), all memory of hole-station-measurement selections is erased.

Option 1 - Write mini-database. Will write a miniature database, named "**ntsgm.dat**", of the selected holes, stations, and measurements; this file can in turn be used as your personalized database for subsequent runs. In order to run from such a "mini-database", you will need to remove [rm] the existing "**ntsgm.db**" (or move [mv] it to a different file name) and replace it with your new file. This is useful if you will be working with a given set of data on a continuing basis. Response time will be improved, disk usage decreased, and you can save the file into your own storage area.

Option 2 - Plot. Will make simple time history plots of the selected measurements either to be displayed online or written to a common graphics system (CGS) metafile for post-process plotting. Depending on your graphics console and associated software, online plotting can be somewhat unpredictable. Satisfactory results are not guaranteed for the online option because of the great variety of graphics consoles available.

Option 3 - Set Flag for Integration. Most, but not all, ground motion waveforms are stored in the data base as accelerations, velocities, and displacements (all three). At the present time, acceleration always is the basic measurement and the velocities and displacements are first and second integrations of the accelerations. A variety of minor corrections have been made to the data to compute the stored integrated waveforms. If you want to perform your own integrations (ignoring the stored values), choose this option to set an internal integration flag. The flag will remain set until explicitly turned off by you (option 9), or until you return to the main menu. For acceleration data with no previously stored integrated values, you will need to turn on this flag to obtain velocities and/or displacements.

Option 4 - Set Flag for Data Repair. A separate file, named "**ntsgm.dr**", contains special repair "correction sets" to be applied to the data. Data retrieval using these correction sets provides a level of data repair many times improved over what is provided in the initial stored velocities and displacements (see above). These "correction sets" repair for noise spike, clipping, and gauge tilt effects and usually provide final waveforms that are more physically realistic than the originals (e.g., late time velocities go to zero). However, personal judgment went into creating these correction sets, so the true motion may not always be captured. In the current implementation of data repair, the start time and nth point options (above) are disallowed - you will get all of the data up to your stop time. This is an inconvenience, but not a serious limitation. You could choose to write a mini-database composed entirely of repaired data, then turn around and use it as your personal data base ("**ntsgm.db**"). You will then be able to make your own start/stop time and nth point selections since you will not be selecting data repair the second time around. If you were to choose data repair for an already repaired data set, you are guaranteed bizarre results - there is no internal check on this.

Just over half of the measurements in the data base have correction sets. The program will print a message if a particular waveform cannot be corrected (no correction set). In addition to the waveform corrections, selection of this option will correct for gauge misorientations, where gauges are not radial or tangential. Presently there are only three events with this complication - MINERAL QUARRY (U12n22), HUNTERS TROPHY (U12n24) and the NPE (U12n25). If the data repair option is not chosen for any of these three events, the raw measurements will be retrieved and the gauge orientations will be unchanged—you should consult the "headers" file regarding the actual orientations.

If you choose the data repair option, it will remain active until explicitly turned off by you, or until you return to the main menu. Use of this option will automatically turn on the integration flag. If the "**ntsgm.dr**" file is not in your local file space at the time you ask for data repair, the program will retrieve it for you from the CFS.

Option 5 - Write Headers File. Selection of this option will cause an ASCII "headers" file, named "**ntsgm.hdr**", to be written. This file contains the hole-station-measurement headers for your selections. No measurement vectors (waveforms) are written. The main purpose of this printable file is to provide you with information regarding what data is present for you to select, locations, gauge information, special comments and cautions, etc.

Option 6 - Write Error Log File. For data retrievals involving large amounts of data, messages that normally would go to the console may become excessive in number. Selection of this option will divert all special messages from the console to an ASCII text error log file named "**ntsgm.err**". For online plotting, special messages are automatically diverted to this file.

Option 7 - Actions Manual. You're looking at it.

Option 8 - Unused. Reserved for future use (currently is a no-op).

Option 9 - Clear Data Repair and Integration Flags. Clears flags set by choosing options 3 and/or 4 above.

Option 10 - Write SAC Files. SAC is the LLNL developed Seismic Analysis Code that provides extensive analysis capabilities for ground motion data (technical contacts - William C. Tapley and Joseph E. Tull, Lawrence Livermore National Laboratory, Mail Stop L-205, Livermore, CA 94550). Selection of this option causes a separate SAC-compatible binary file to be written for each measurement selected. Currently these files are written in VAX-VMS binary format, so that they can be used directly, without further modification, with VAX implementations of the SAC program. For SUN applications, the files must be converted to a SUN-compatible file structure, for which there is a special conversion program available. SAC is not implemented on the CRAY-UNICOS machines. The SAC file names assigned by the ntsgm program are made unique to each particular hole-station-measurement by concatenating the hole, station and measurement names, separated by underscores and eliminating non-essential characters—the names are lower case.

Example: Hole U12n25
Station TM10
Measurement GMA_XA
SAC file name = "u12n25_tm10_axa"

Option 11 - Write ASCII File. Selection will create a simple time vs. value ASCII file, one time/value pair per line. This is intended primarily for users desiring experimental data in a simple format for use in comparing with computed waveforms, such as those calculated by stress wave codes, or just to be able to look at the values in tabular form. It makes inefficient use of disk space, so care should be exercised with this option so that you do not generate excessive amounts of data. Header information, in the same format as used for the "headers" file (option 5), is included with each data set. This file is named "**ntsgm.asc**".

Option 12 - Write Geodes "add" File. Selection will create a special format ASCII file for input to the LANL GEODES data management system, currently implemented on the LANL-EES-5 VAX computer. This option is primarily for database system maintenance and updating. However you may find the format of the file more convenient to your needs than the ASCII file produced by selection of option 11 above. The data is better packed; the start time and time increment are provided in each measurement header and there are multiple values per line. The file is named "**ntsgm.add**".

Option 13 - Exit this Menu. Returns user to the main menu.

Option 14 - Exit Program. Terminates program execution.

VERSION NUMBERS: For option selections 1, 2, 5, 10, 11, and 12 there will be a query to select one or more version numbers. There can be two versions of the very same measurement. This happens when, for example, waveforms are digitized at two different rates, or recorded both digitally and by analog recording. Currently there are 13 events in the data base with version 2 data - TOWANDA (U19ab), ALAMO (U19au), HOUSTON (U19az), BEXAR (U19ba), JUNCTION (U19bg), HEARTS (U4n), PYRAMID (U7be), PANCHUELA (U3mh), MILROW (Ua2), MISTY ECHO (U12n23), MINERAL QUARRY (U12n22), HUNTERS TROPHY (U12n24), and the NPE (U12n25). For MISTY ECHO, HUNTERS TROPHY, and the NPE, there are both short term (a few seconds) and long term (over 20 seconds) data sets that were recorded on different systems. These are versions 1 and 2 respectively. For MINERAL QUARRY, there is only version 2 (the long term data). For most of the other events, version 2 data is associated with satellite holes. In any case, you should consult the "headers" file.

STATIONS WITHOUT VECTOR DATA:
It is possible that selected stations will contain no vector data for your particular selection of measurements. For options 5, 11, and 12, the hole and station headers will be written regardless, even if there are no measurements that pass your criteria. For option 1, if the file is void of any measurements, the "**ntsgm.dat**" file will not be written. If there are measurements, but not for all stations, only those station headers with measurements will be written; there will be no "empty" stations. Similarly, SAC files are written only for measurements that are present.

Section IV. Header Descriptions

Following are the definitions of the various fields in the headers, using the abbreviations employed for the **ntsgm.asc** and **ntsgm.hdr** files (Section VI below):

A. Hole (Event) Header

Hole Name	See Hole Selection Manual (Section III-B)
Area Num	NTS test area where the event was executed.
N-NEV	North Nevada coordinate for hole/event (meters).
E-NEV	East Nevada coordinate for hole/event (meters).
ELEV	Elevation of the hole at the well head (surface ground zero - meters). For events conducted in tunnels, the elevation at the ground surface vertically above the WP.
TD	Total depth of the drilled hole (meters).
DIAM	Hole diameter (meters).
WP	Working point depth below surface (meters).
SWL	Static water level (water table) depth below surface (meters).
ATCD	Alluvium-tuff contact depth below surface (meters).
TPCD	Tuff (Tertiary) - Paleozoic contact depth below surface (meters).
AVRAD	Not used - set to zero.
WP MED	Geologic abbreviation for WP medium (see appendix).

Fault Prox	Fault proximity indicator: 1AR — fault within 1 "cavity radius" of WP. 2AR — fault between 1 and 2 "cavity radii" of the WP. 3AR — fault between 2 and 3 "cavity radii" of the WP. 3AR+ — fault greater than 3 "cavity radii" from the WP. Not very useful in the current implementation of the data base - not kept up-to-date and probably should be disregarded.
COMMENT	Sometimes present - description of the experiment, special cautions, etc. Maximum of 240 characters.
STRAT	Stratigraphic log of the geologic section at the hole location - provides geologic abbreviations and depths to tops of stratigraphic units. Stratigraphic logs are provided for most (about 80%) of the holes in the data base.

A complete listing of the stratigraphic unit abbreviations with brief descriptions is included in the appendix. Additional information on stratigraphic units can be obtained from the Data Base Manager (Section IX).

B. Station Header

Station Name	See Station Selection Manual (Section III-C)
N-NEV	North Nevada coordinate for station (meters).
E-NEV	East Nevada coordinate for station (meters).
ELEV	Elevation of the station (meters).
SEISFA	Geophone (as opposed to accelerometer) recorded first arrival time (seconds - relative to event zero-time). If there was no geophone recording, this field is set to zero.
STATITL	Descriptive title given to the station - text that is to be displayed in association with the station, such as with waveform plots.
STALOC	Special identifier which identifies this station as being located: SGZ — at surface ground zero. SURF1 — at 1 DOB surface range from SGZ. SURFTP — at the trailer park.

	SURFEX	as part of an expanded surface array (expanded over the "minimum" array which usually consists of the above three locations only).
	EMPL	in the event emplacement hole.
	EXPL	in an exploratory/instrument hole.
	TRANS	on a transformer.
	TOWER	on a rack assembly tower.
	TRAILER	in or on an event recording trailer.
STAMED	Special identifier which identifies the type of emplacement material:	
	SAND	sand packed around the instrument package (for surface motion measurements).
	COARSE	coarse gravel (usually 3/8th inch pea gravel) used as emplacement hole backfill material.
	FINES	fines material used as emplacement hole backfill material.
	PLUG	TPE (two part epoxy), CTE (coal tar epoxy), or grout stemming plug material.
	RMG	special "rock matching" grout.
	STRUCT	attached to an above ground structure.
DATACQ	The organization that acquired the data—not always present:	
	LANL	Los Alamos National Laboratory
	SNLA	Sandia National Laboratory
	LLNL	Lawrence Livermore National Laboratory
COMMENT	Sometimes present—description of the station, special cautions, etc. Maximum of 240 characters.	

C. Measurement Header

Measurement Name	See Measurement Selection Manual (Section III-D)
TIM(1)	Data start time (sec).
DELTAT	Time increment between data points (sec).
No. of values	Vector length—number of data points.
FSA	Full scale amplitude. Used during initial processing of the data.

PCTFSC	Percent full scale. Used during initial processing of the data.
FILTER	High cut value used for filtering the data during initial processing (Hz).
GMTITLE	Descriptive title given to the measurement—text that is to be displayed in association with the station, such as with plots.
DIGSYS	System used in digitizing the data—for analog recorded data only.
TRANS	Description of the transducer used in acquiring the data.
RUN NUMBER	The run, or version number of the data. There is a discussion of version numbers in the Actions Manual, Section III-E.
COMMENT	Sometimes present—description of the measurement, special cautions, etc. Maximum of 60 characters.
DATSYS	Data/recording system or organization—not always present:

J8FM	FM recording by Los Alamos Group J-8.
RIDS	Digitally recorded with EG&G RIDS system.
GRMPY	Recorded with the Los Alamos GRMPY digital system.
LLNL	Recorded by LLNL - recording system unknown.
SNLA	Recorded by SNLA - recording system unknown.
OTHER	All others.

An important point regarding measurement headers is that only the acceleration measurement headers are complete with comments. Acceleration is the root measurement so it was decided in creating the data base that the most complete set of header information should be associated with accelerations.

Section V. Data Repair

There are certain difficulties associated with recording ground-motion data from underground nuclear tests. This section identifies these problems, explains their nature, and describes how these problems are "corrected".

Corrections to be applied to surface and some subsurface data reside in a repair parameter file named **ntsgm.dr**. The format of this file is described in Section VI-H. This file is generated in a separate data processing step, independent of **ntsgm.x**, and it contains all the information required to produce repaired data from raw data "on-the-fly". We refer to the application of the parameters in the data repair file to raw data as "regeneration" repair. Data repair is a user option—the default is for raw (unrepaired) data.

The data types for which repairs are made can be divided into two main categories—free-surface and free-field. The repair parameter file pertains primarily to the free-surface motions, but some emplacement hole measurements also fall into this grouping. The repair of free-field data is somewhat more involved than that for surface motion. Currently, the only truly free-field data for which repairs are made are the tunnel events MISTY ECHO, MINERAL QUARRY, HUNTERS TROPHY, and the NPE, and in the following discussion any mention of "tunnel motion" refers specifically to these four events (there is other tunnel motion data in the data base for which there are no repairs).

An important feature of data repair is that, to the extent possible, all data are repaired in a consistent manner. It is a semi-automated process and data repairs are not tailored to specific measurements or events, with the NPE being the sole exception (discussed below). About 90% of the events in the data base have repairs to at least some of their measurements and there are repair data sets for 53% of the measurements If you ask for repair on a measurement for which repair is unavailable, you will receive a message to that effect.

A. Potential Problems with the Data. Following are descriptions of specific problems associated with ground motion data for which repairs are attempted.

1) Electromagnetic pulse (EMP). A major problem with the older data sets is the transmission of EMP signals through the recording

cables. These signals occur early in time, well before the arrival of any ground motion associated with the test. These data are recognized by unusually large signals (strong EMP signals) or by an unusual occurrence in the statistics of the noise at early times (weak EMP signals). The EMP correction is parameterized in terms of the end point of any detectable EMP. This end point determines the EMP time interval as the time between the beginning of the data set and the end point of the EMP. In the regeneration of the repair, the data are simply set to zero over this time interval

2. Direct current (dc) offset. A common problem in many data recording situations concerns the definition of the base line. This is also a problem in the recording of the ground-motion data. A non-zero base line can be the result of poor setup, drift in the electronics, or a number of other reasons. The problem is easily corrected by rebaselining the data. This is done by computing the average of the data before the main signal first arrival. This average is then subtracted from all of the non-EMP data.

For repaired data, it is sometimes possible to discern a non-zero displacement before the first seismic arrival. This tends to occur more with data sets that have small displacements, and is caused by the fact that the dc correction sets the average acceleration to zero before the signal first arrival, but not the velocity or displacement. An alternative approach would be to simply zero the data before the signal first arrival; however, this would deny the user of possibly useful noise statistics before the signal first arrival.

Thus, the dc correction is parameterized in terms of an average value. In the regeneration of the repaired data, this average is subtracted from all non-EMP data. This correction is applied following the EMP correction.

3. Noise spikes. Extraneous noise spikes also occur in the recording of the ground motion. Characteristically, these are large signals for which there are no clear explanations. They can completely mask the true nature of the ground motion. Once noise spikes are identified, they are eliminated by replacing the data with a simple linear interpolation between the surrounding valid data. The line is based upon the averages of the data over a small time interval just preceding and following the spike. As was the case for EMP, noise spikes tend to be more prevalent in the older data sets.

The following information is required in the data repair set to effect noise spike corrections:

a) The number of noise spikes.
b) The data points affected.
c) The slope and intercept of the linear interpolation.

The noise-spike corrections are applied following the EMP and dc corrections.

4. Gauge clipping. Gauge clipping commonly occurs when the accelerometer is subjected to accelerations exceeding its rated value. An accelerometer contains a piezoelectric (or similar) material that produces a voltage when subjected to a stress across the normal area of the material. The stress occurs due the force associated with acceleration. The voltage is assumed to be proportional (i.e., linear) to the stress, hence force, hence acceleration. This assumption of linearity is valid up to a value of acceleration referred to as the gauge value. For example, an accelerometer with a 20 g gauge value is expected to provide valid data over accelerations between +/- 20 g.

When the acceleration exceeds the gauge value, the accelerometer is expected to respond in a non-linear manner. Normally, recording channel limits are set to produce a constant voltage (i.e., constant acceleration value, or clipping) at the gauge limit value until the true acceleration reenters the linear regime of the accelerometer.

The presence of gauge clipping is easily revealed as a constant offset in the velocity or a linear ramp in the displacement at late times. The degree of gauge clipping can be determined as the constant in the late-time velocity, or ramp in the late-time displacement. This degree represents lost data values or lost velocity that must be returned to the data. Due to the nature of gauge clipping, the data are returned to where the motion is of highest amplitude. The lost acceleration values are simply added to the data at the peak, in the form of a parabola such that the area under the parabola equals the gauge clipping error. If no one single peak is dominant, then values are added to two or more peaks, the amounts determined by the relative strengths (combination of pulse amplitude and broadness) of the peaks.

A phenomenon very similar to gauge clipping will occur in rapidly oscillating data. Because of an inadequate sampling frequency, the recording system acts like a low-pass filter that eliminates the higher frequencies. The result is identical to gauge clipping; however, the criteria for identifying where to replace the lost data have changed. Rather than replacing data at the strongest peaks, the data are replaced at the peak (or peaks) with the highest frequency content.

Instruments being what they are, many units begin to deviate from linearity at near 80% of their rated gauge value. During the repair, some gauge clipping is always assumed to have occurred. If the scan of the data shows that none of the peaks exceed 80% of the gauge value, then any gauge-clipping error is assumed to be of the high frequency variety.

The following information is required in the data repair set to effect gauge clipping corrections:

a) The number of gauge-clipping events.

b) The data points where the clipping occurred.

c) The amount (i.e., lost velocity) associated with each clipping event.

The gauge-clipping correction is applied concurrent with the gauge-tilt correction, described next.

5. Gauge tilt. Gauge tilt occurs when the instruments themselves tilt relative to their initial orientation. When this occurs, horizontal accelerometers are subjected to a new force, namely gravity, and the vertical accelerometers are subjected to less force. The result is that the units will have a new base line, starting at the time of tilt. The degree of gauge tilt can be determined from a linear ramp in the velocity, or from a parabola in the displacement at late times. If there are indications of gauge tilt, all of the tilt is assumed to occur at the time of strongest peak acceleration.

The following information is required in the data repair set to effect gauge tilt corrections:

A) The time at which tilt occurs.

b) A constant value of acceleration to be subtracted (for horizontal measurements) or added (for vertical measurements) to the data.

B. Repair Procedure for Free-surface Data. The surface ground motion data are repaired in the following order:

1. EMP corrections (if needed)
2. dc correction
3. noise-spike correction

4. gauge-clipping and gauge-tilt corrections (together)
Gauge-clipping and gauge-tilt corrections are determined simultaneously from a linear fit to the late-time velocity data, after most of the main signal has passed. For data sets that terminate early, the fit is indeterminable and the data cannot be repaired. The fitting process is iterative, and each iteration provides an improved estimate of the gauge-clipping and gauge-tilt corrections. The effect of any change in the acceleration, unless balanced by an opposite change elsewhere, will be greatly amplified after double integrating to displacement. The interval used to determine the gauge-clipping and gauge-tilt corrections is chosen to minimize the final average displacement. Displacement minimization is not a physical requirement; it simply is a way to standardize the corrections from event to event. In data repair, all integrations are done using a simple trapezoidal rule.

C. **Repair Procedure for Free-field Data.** Free-field data present a different set of goals and problems for data repair. As mentioned above, the only truly free-field repaired data currently in the data base is that from four tunnel events. An as-accurate-as-possible determination of displacement is of interest for tunnel motion; therefore, the practice of minimizing final displacement is inappropriate for this data. The gauge-tilt and clipping corrections take advantage of the long lengths of the records, most of which are considerably longer than 20 s. It is possible, in principle, to determine a good linear fit to data for the gauge clipping and tilt corrections without resorting to displacement minimization. However, the late-time tunnel motion includes significant low-frequency signals (below 1 Hz) that complicate the determination of these corrections. These signals are thought to be elastic reverberations in the earth, but their true nature is unimportant for repair purposes if it is assumed that the final displacement is determined by the high-frequency energy (above 1 Hz) contained in the initial transient signal. We make the above assumption, and choose to apply a high pass filter to the data prior to performing the linear fit for clipping and tilt repair. A simple $(f/1.31\ \mathrm{Hz})^6$ filter is applied to the data below f = 1.31 Hz. No filtering is applied to data above 1.31 Hz. The filter passes 50 % of the amplitude near 1.2 Hz and 20 % near 1 Hz. If you are interested in retaining the low frequency content of the data, you are advised to use raw, rather than repaired, tunnel motion waveforms.

The repaired tunnel motion waveforms are stored in the data base as complete waveforms. They are not repaired "on-the-fly" using correction sets as is done for surface motion. This distinction is invisible to you unless you choose to interrogate the data repair file (**ntsgm.dr**); i.e., you will find no tunnel motion repair sets in the file. The reason for this change in approach is that there are problems with numerical accuracy in applying data repair sets to long term data that is to be double integrated, and where final displacements are very small—the required resolution of the repair parameters exceed their true accuracy.

During the repair procedure, the filtering is performed before any other repair steps. Following that, repair steps are the same as for surface motion.

The NPE (U12n25) presents a unique problem. Whereas the other tunnel events were repaired in a consistent manner, the NPE received its own unique repair. The character of the data appears to change after the first 2-3 s. The reason for this is unknown (it most likely is a recording problem); however, the effect is that there is no easy way to determine gauge clipping and tilt corrections from the late time data. Instead, repair parameters were derived from the 0.50 - 2.0 s time interval. This choice reflects the best compromise of selecting good data while performing the fitting procedure over a relatively quiet interval. The repaired data do not go past 2.0 s, despite the fact that the raw data extend past 20 s.

D. Reorientation. For each of the three tunnel events MINERAL QUARRY, HUNTERS TROPHY, and the NPE, some of the recording stations were originally located and oriented for one event, and then reused for a subsequent event. The direction components labeled as radial and tangential were not truly radial and tangential to the event that followed the one for which the gauges were originally emplaced. As part of the definition of data repair, and where both horizontal components are present, such measurements are corrected to reflect the motion had they been properly oriented in the first place. If only one horizontal component is present, there is no correction and an informational message is printed. Also, raw data is not reoriented. Currently, there are no other events in the data base with this complication.

Section VI. File Formats

A. Mini-database (ntsgm.dat)

Binary (unformatted) direct access file with fixed record lengths of 2048 CRAY words (16384 bytes).

Record 1 - Main pointer record - first word is number of holes/events in mini-database (nholes). This is followed by three successive vectors, each of "nholes" length containing a) a list of hole names, b) record pointers to the specific hole header records, and c) number of recording stations associated with each hole/event.

Record 2 - Header information for the 1st hole in mini-database including the number of recording stations for the hole/event.

Record 3 - Contains the stratigraphic (strat) log for the hole. The strat log is composed of the geologic abbreviations for the geologic units present at the event site as a function of depth.

Record 4 - Pointer record for the recording stations associated with the hole/event. First word is the number of stations (nsta), followed by three successive vectors, each of "nsta" length containing station names, b) record pointers to the station headers, and c) number of measurements at each station.

Record 5 - Header information for 1st station at the hole/event site. Also includes the number of measurements (nmeas) made at this station location.

Record 6 - Header for 1st measurement at the station, which includes the number of values in the measurement vector.

Record 7 to n - The 1st measurement vector.

Record n+1 - Header for the 2nd measurement at this station.

Record n+2 to m - The 2nd measurement vector.

The number of records required for each measurement vector is a function of the vector length. The measurement header/vector sequence repeats until the number of measurements for the station is exhausted. This is followed by the next station header, or, if the previous station was the last station for the particular hole/event, it is followed by the next hole/event header. Holes-stations-measurements are physically grouped together in the file.

A utility program named read_db is available for retrieval from the /lanl_db/users directory. It can be used as-is for interrogating the contents of a mini-database file, or it can be used as a template for developing your own custom software. The source (FORTRAN) code is **read_gm.f** and the executable is **read_gm.x.**

B. SAC file ("hole"_"sta"_"mea")

Binary (unformatted) direct access file with fixed record lengths of 128 VAX words (512 bytes). This file is in VAX-VMS format for direct input to VAX implementations of the Seismic Analysis Code (SAC). Each SAC file contains information for a single measurement.

Record 1 - Contains the first 128 words of header information.

Record 2 - Contains the last 30 words of header information plus the first 98 words of data.

Record 3 to the end-of-file contains data, 128 words per record.

You should consult the SAC user manual for more information regarding the format of the file and locations of specific header information (see SAC reference in Section III-E).

Each file name is made unique by concatenating the hole, station, and measurement names, separated by underscores and eliminating some non-essential characters.

There is a version of SAC for use on SUN computer systems. The SAC files generated by **ntsgm.x** must be converted to SUN binary format for running on a SUN computer. A utility program named sacv2s is available to do the conversion. The source (FORTRAN) code resides as a standard text file under the name **sacv2s.f_std** in lanl_db/users. The program must be compiled and executed on a SUN computer. SAC is not implemented on the Los Alamos CRAY computers.

C. **ASCII File (ntsgm.asc).**

Text (formatted) file that contains all selected measurements from a **ntsgm.x** session. There is no particular order to the holes/events within the file, but the stations and measurements for each hole are grouped together following the hole (event) to which they apply, and similarly, the measurements for each station are grouped following the station to which they apply. FORTRAN formats used in writing the file are as follows:

Hole (Event) Header:

```
    format(' Hole Name = ',a12,/,' Area Num = ',i2,/,
   & ' N-NEV = ',1pe13.5,' E-NEV = ',1pe13.5,' ELEV = ',1pe13.5,/,
   & ' TD = ',1pe13.5,' DIAM = ',1pe13.5,' WP = ',1pe13.5,/,
   & ' SWL = ',1pe13.5,' ATCD = ',1pe13.5,' TPCD = ',1pe13.5,/,
   & ' AVRAD = ',1pe13.5,' WP Med = ',1pe13.5,' Fault Prox = ',a10,//,
   & 4(1x,a60/)/)
```

Stratigraphic Log:

```
    format(' Stratigraphy',/,
   &' Unit    Depth(top)  Unit    Depth(top)  Unit    Depth(top)'//,
   & 3(1x,a10,4x,f7.1,1x))
```

Station Header:

```
    format(/,' Station Header',/,
   & ' Station Name = ',a12,/,
   & ' Station N-NEV = ',1pe13.5,' E-NEV = ',1pe13.5,
   & '  ELEV = ',1pe13.5,/,
   & ' SEISFA = ',1pe13.5,' STATITL = ',a30,/,
   & ' STALOC = ',a10,' STAMED = ',a10,' DATACQ = ',a10,//,
   & 4(1x,a60/)/)
```

Measurement Header:

```
    format(' Measurement Header',/,
   & ' Measurement name = ',a12,/,
   & ' TIM(1) = ',1pe13.5,' DELTAT = ',1pe13.5,
   & '  No. of values = ',i6,/,
   & ' FSA = ',1pe13.5,' PCTFSC = ',1pe13.5,/,
   & ' FILTER = ',a20,' GMTITLE = ',a30,/,
   & ' DIGSYS = ',a50,/,
   & ' TRANS = ',a50,/,' DDATE = ',a9,/,
   & ' RUN NUMBER = ',i4,//1x,a60,/,
   & ' DATSYS = ',a10,//)
```

Measurement Vector:

```
    format(1x,'     TIME        VALUE',/,
   & (2f13.5/))
```

The type character (a) formats indicate the full length of each character variable. The a60 fields are comment fields, which may be blank.

D. Headers file (ntsgm.hdr)

Text (formatted) file that contains headers for selected measurements from a **ntsgm.x** session. This file is identical to the **ntsgm.asc** file except that it is missing the measurement vectors.

E. Geodes "add" file (ntsgm.add)

Text (formatted) file that contains all selected measurements from a **ntsgm.x** session. This is a special file used for system maintenance and updating, but there is no reason that it cannot be used for other purposes as well. There is no particular order to the holes/events within the file, but the stations and measurements for each hole are grouped together following the hole (event) to which they apply, and similarly, the measurements for each station are grouped following the station to which they apply. The file differs from the **ntsgm.asc** file only in the formats used in writing the headers and the absence of explicit times for the measurement vectors (start time and time increment are contained in each measurement header). Ampersands (&) are used as special characters for header identification. FORTRAN formats used in writing the file are as follows:

Hole (Event) Header:
```
    format('&HOLE=',a,'/HH',/
  & 'AREA=',i2,' NNEV=',f10.2,' ENEV=',f10.2,' ELEV=',f10.2,/
  & 'TD='f7.2,' DIAM=',f6.2,' WP=',f7.2,' AVRAD=',f6.2,/
  & 'WPMED=',a,''ATCD=',f7.2,' TPCD=',f7.2,' SWL=',f7.2)
```
A hole header comment (if any) following the above may have up to a maximum of 240 characters, as contiguous 80 character records. The entire comment is enclosed in quotes.

Stratigraphic Log:
```
    format(&HOLE=',a,'/LOG=STRAT/LH/RUN=1'/
  & (f7.1,1x,f7.1,1x,a))
```
where the two "f7.1" fields are for the depths to the top and bottom of each stratigraphic unit.

Station Header:

```
    format('&HOLE=',a,'/HH',/
   & 'STATITL="',a,'"',/
   & 'STANNEV=',f10.2,'STAENEV=',f10.2,' STAELEV=',f10.2,/
   & 'STALOC=',a,' STAMED=',a,' SEISFA=',f7.4,' DATACQ=',a)
```

The "DATACQ=" field may be absent if there is no station entry for it. A station header comment (if any) following the above may have up to a maximum of 240 characters, as contiguous 80 character records. The entire comment is enclosed in quotes. The "&HOLE=" field will contain both the hole and station names, separated by an underscore, e.g., U19X_GM1.

Measurement Header:

```
    format('&HOLE=',a,'/LOG=',a,'/LH/RUN=',i2,/
   & 'GMTITL="',a,'"',/
   & 'FSA=',f8.2,' FILTER="',a,'" PCTFSC=',f7.2,/
   & 'DDATE=',a,' DIGSYS="',a,'" DATSYS=',a,/
   & 'TRANS="',a,'"')
```

The "DATSYS=" field may be absent if there is no measurement entry for it. A measurement header comment (if any) following the above may have up to a maximum of 60 characters and is enclosed in quotes.

For all of the above character (a) fields, trailing blanks are removed.

F. Plot metafile (ntsgm)

This is the standard common graphics system (CGS) plot file that can be used with the system pscan, pfilm, prpp, etc., utilities.

G. Error Log file (ntsgm.err)

A text file that contains special error and other messages from an **ntsgm.x** session in which 1) the user asked for online plotting and/or 2) the user chose option 6 in the actions menu (write error log file). Any previous **ntsgm.err** files are overwritten. The file is not written if neither of the above two actions are taken.

H. Data repair file (ntsgm.dr)

This is the text file used as input to the **ntsgm.x** program if data repair is requested. The purpose of this file is described above in

Section V. All measurement repair data sets are grouped together by hole name in the data repair file. The first line of each grouping identifies the hole name. Following is an example of a repair data set accompanied by line-by-line descriptions:

EXAMPLE:

```
  AUTO- 4
U4J_GM1_GMA_ZA
      175         620          3.844E-02           3.854E-02  1.336E-01
        6
     2123        2246         -1.001E+00          -2.979E-04
     3260        3513         -1.042E+00           9.535E-05
     3870        4023         -1.030E+00          -4.078E-05
     4447        4702         -9.783E-01          -4.018E-05
     4826        4979         -8.667E-01           2.750E-03
     7895        8033         -3.689E-01           1.189E-03
        1        5062      10307      13996     4.353E-01    1.226E-01
     5027        5131          1.000E+00
    -2.841E-03        7.416E-07        -1.623E+00
  1.00000E-01   3.10000E-01   4.00000E+00   7.00000E+00
 -2.00000E+00   1.00000E+01   1.50000E+01
  2.50000E-02   2.50000E-02   2.50000E-02   2.50000E-02
  0.00000E+00   0.00000E+00   0.00000E+00
```

Part 1 - Control information.

Line 1: Identifies the version of the repair code used to generate the repair data set. Currently there are four versions—named AUTO- 4 through AUTO- 7.
Line 2: Uniquely identifies the data set by concatenating the measurement name with the station and hole name. In the example, the data set is for measurement GMA_ZA at station GM1 for hole U4J.

Part 2 - EMP and dc offset correction variables.

(Line 3 in the example)
LAST   NO   AVE   DC   RMS

where the integer LAST is the last EMP data point (LAST = 0 if no EMP), the integer NO is an estimate of the first seismic arrival, the real variable AVE is the average acceleration data between LAST and N0, the real variable DC is the dc correction (slightly different from AVE), and the real variable RMS is the root-mean-square deviation in the signal about AVE between LAST and N0. The EMP correction is contained entirely by the integer LAST, while the dc correction information is contained by LAST and DC.

Part 3 - Noise-spike correction variables :

(Line 4 in the example)
N_SPIKE

where the integer N_SPIKE is simply the number of noise spikes. If N_SPIKE is greater than 0, then for i equal 1 to N_SPIKE, the following information is presented as

(Lines 5-10 in the example)
ISI(i) ISF(i) SP1(i) SP2(i)

The integers ISI(i) and ISF(i) are, respectively, the beginning and ending data points of the i^{th} noise spike. The real variables SP1(i) and SP2(i) are the corresponding value of the data at ISI(i) and slope of the line that is used to interpolate through the noise spike.

Part 4 - Gauge-clipping and gauge-tilt corrections.

(Line 11 in the example)
NC IL2 N1 N2 VRC ADC

The integer NC is the number of clipping events, and integer IL2 identifies the data point where the gauge tilt correction should begin. The integers N1 and N2 identify the beginning and ending points of the interval over which the linear fit was performed in extracting the gauge-clipping and gauge-tilt correction; they are not explicitly used in the regeneration but rather are listed as part of the documentation. The real variables VRC and ADC are, respectively, the gauge-clipping and gauge-tilt errors—units are g-sec and g.

The gauge-tilt correction is implemented simply by adding ADC to data points after IL2. The gauge-clipping correction is more involved. Completion of the gauge-clipping correction requires additional input. This input is provided in the following NC lines. Each line contains:

(Line 12 in the example)
IT1(i)   IT2(i)   WT(i)

where the integers IT1(i) and IT2(i) identify, respectively, the beginning and ending data points of the i^{th} clipping event. WK(i) is the corresponding weight. The total correction for clipping event i is VRC*WT(i). This amount of velocity is then distributed over the interval IT1(i) to IT2(i). It is distributed so that the integrated acceleration over this interval is larger by an additional amount of VRC*WT(i).

Part 5 - Repair statistics. The final results of the repair in terms of the average acceleration (g), average velocity (m/s), and average displacement (m) obtained over the final averaging interval. These are, respectively,

(Line 13 in the example)
AVE_A   AVE_V   AVE_D

Part 6 - Repair code input (remaining lines in the example). The information presented here is the information that was input to the repair code (separate program) that generated the repair parameters. This information is included as part of the record and for quality control.

Parts 5 and 6 are for information purposes only.

Section VII. Special Cases

The "standard minimum array" for Los Alamos surface motion measurements is composed of a) a Z-component-only station at SGZ with redundant measurements, b) a three component station with one redundant Z-component at the trailer park, and c) three, 3-component stations at one DOB surface range from SGZ but at different azimuths from SGZ. Also, each "backfill" RAMS package (see Section III-C) contains one Z-component accelerometer. Anything that deviates from this standard can be considered "special", but some are more special than others. The following deals with those arrays most in need of further discussion.

Tunnel Measurements. Tunnel motions for MINERAL QUARRY (U12n22), MISTY ECHO (U12n23), HUNTERS TROPHY (U12n24), and the NPE (U12n25) are special in that many of the gauges were reused from one event to the next and therefore the orientations are not true to the standard conventions (see Section III-D for details on direction conventions). MISTY ECHO was the first of the foursome to be conducted, so all orientations for it are correct. For the others, any stations not oriented for the subject event are commented to that effect in the station header. If there is no comment, the station is correctly oriented. If data repair is specified by the user (Section III-E and Section V), as part of this repair the station orientations are adjusted to reflect what the waveforms would have looked like had they been correctly oriented. However, the headers are unchanged, so the comments would still indicate (incorrectly) the need for reorientation.

Because gauges were being reused, they often were not of the optimal acceleration rating for their range from WP. The gauge ratings are given in the measurement headings, so you can determine how well each gauge was matched to the actual signal. Signal amplitudes greater than the rating will result in non-linear response; conversely, signals much less than the gauge response sensitivity range will be noisy.

There are two "versions" of the data for three of the above four events (different recording systems - same measurements). Versions numbers, in the context of these tunnel measurements, are also discussed in Section III-E. For this tunnel data, some of the measurements that are stored as version 1 do not have a version 2, and vice-versa, despite the fact that different versions are from the same gauge packages.

MINERAL QUARRY (U12n22) had an additional problem. There was no event fiducial signal for triggering the recording systems. The "backup" tunnel motion recording system was triggered by the electromagnetic pulse produced by the explosion. Best estimate of start time for the recordings is 40 ms after zero time. All MINERAL QUARRY data is version 2.

For the above waveforms, repair is available only for version 2 data.

GRMPY Stations.

GRMPY surface motion measurements were made in conjunction with a special on-site-inspection, yield verification project at Los Alamos. The objective was to determine how well the yield of an event could be determined from ground motion without foreknowledge of the site parameters and with minimal fielding support. The very nature of the experiments precluded triggering or obtaining zero-time information directly from the event fiducial signal, so for the sake of the ground motion data base, event zero times for the data had to be determined by other means. There are some questionable times for MISTY ECHO (U12n23), and perhaps some other early GRMPY data. Later GRMPY data zero times are thought to be reliable, but you should be aware of at least the potential for reference time problems. GRMPY stations are identified in the station headers by the DATSYS = GRMPY parameter (see Header Descriptions - Section IV).

Structure Motion.

Measurements of above-ground structure response do not have NTS coordinates as part of their headers. Apparently the stations were not surveyed. Anyone desiring additional information on these stations and measurements should channel their request through the Data Base Manager.

Section VIII. Quality Control

As is to be expected for a data base of this size and complexity, there are bound to be some shortcomings and even errors. We define an error as being an inadvertent and undiscovered mistake in acquiring, processing, and/or placing the data into the data base. We do not relate it to how well the measurement replicates the actual ground motion, which varies from event to event and measurement to measurement. If we believe that, for some reason, a measurement is not a true indicator of the motion, we try to document it—we do not remove it from the data base.

The "raw" (as opposed to repaired) data in the data base often go beyond the point where the data is valid, e.g., if a measurement is invalid after 1 sec because of gauge failure, the data may continue on for some time after that. For such cases, there should be a header comment to that effect, but there is no guarantee of this.

Following is a highly subjective accounting of what we believe is the current state of the data base with regard to data quality, based on our own observations in working with the program and data:

a) Errors in fielding and initial processing of the measurements—errors that result in measurements being associated with the wrong station, incorrect assignment of components, reversed polarities, incorrect calibration, etc. Fielding errors probably occur in about five percent of the installations. However, the percentage that go undetected and uncorrected is much less, thought to be less than one percent. Our confidence is based primarily on the fact that a single person, Bob Fitzhugh of Los Alamos Group J-8 (now DX-12), provided very careful review of nearly all of the vector data that eventually made its way into the data base.

b) Errors in header information. Much of the header information, such as station coordinates, elevations, etc., is entered by hand from the notes of others. Also, the values had been entered by various persons over the years. There has been no systematic attempt to validate the header data - errors generally are found and corrected as the data are used and an error becomes obvious. We would place the error rate for header information (at least one entry in a header being incorrect) at about 5 percent. As time permits, it is our intent to go back and systematically review all headers for such errors.

c) Errors of omission. This would apply primarily to such header entries as comments warning the user of some shortcoming of the data. This is highly subjective (one person may consider something worthy of comment, another may not) and probably is the most prevalent shortcoming of the data base. The standard approach has been to enter all comments made by J-8 (Fitzhugh) regarding the quality of the data plus any others that we might have come up with after additional review of the data.

Section IX. Data Base Support

Persons providing user support for the data base and associated software are:

Fred N. App and Roy G. Boyd*
Mail Stop F659
Group EES-3 Geophysics
Earth and Environmental Sciences Division
Los Alamos National Laboratory
P. O. Box 1663, Los Alamos, NM 87545
fa@lanl.gov (505)667-5872 (App)
(505)667-6278 (Boyd)
(505)665-5826 (Boyd)
(505)667-8464 (EES-3)
(505)665-3681 (FAX)
*EG&G on assignment to EES-3

In general, questions regarding the **ntsgm.x** software, operation of the program, and specific measurements should be directed to App. Questions about, and requests for, additional documentation should be directed to Boyd. The additional documentation that may be of interest to you are map view layouts for specific experiments and internal memo correspondences related to the measurements. Boyd has many of these correspondences on file. Questions regarding the CRAY-UNICOS system and utilities should be directed to the C-Division consulting office (505)667-5745. You are responsible for obtaining any system related documentation from C-Division; our limited resources do not allow us to be a conduit for such requests. Also, you are responsible for your own file transport if you intend to use the data on systems removed from the Los Alamos ICN.

As mentioned in Section VI, we provide source code for two utility programs that may be of use to you. It is our *intent* to make available the stand-alone data repair code used in creating the repair data sets, along with suitable documentation. However, the source code for **ntsgm.x** is not available for distribution, nor is the "raw", compacted format, data base currently residing in CFS. Of course the **ntsgm.db** data base created in your local /usr/tmp file space is available for you to use as you see fit—there are no restrictions.

The Revision History (Section X below) will be changed occasionally to reflect major updates to the data base and/or the **ntsgm.x** program. It is your responsibility to check the Revision History for such changes. There will be no other notifications.

Anyone desiring to incorporate their motion data into the NTS Ground Motion Data Base should contact Fred App. If it is in a suitable form, it can be an excellent way to get your data archived and made conveniently available to the entire research community.

Section X. Revision History

This revision history will be updated periodically in the **ntsgm.doc** online CFS file.

May 1, 1994. Initial Release - 148 holes/events in the data base.

Section XI. Acknowledgments

This release of the data base into the open computing environment is the culmination of over 10 years of effort in retrieving old (mostly analog) data from archival storage and placing it, along with newly acquired data, into a suitable repository for access and retrieval. The original data base repository was the Los Alamos developed GEODES (Geologic Data Evaluation System), which resided on the Group EES-5 VAX computer in the closed computing environment. Secretary of Energy O'Leary's mandated declassification of previously unannounced U. S. underground tests prompted the move to bring the NTS Ground Motion Data Base into the open environment.

Many individuals contributed over the years to the effort of putting together such a collection of data. Early participants were Judy Winterkamp, Jim Neergaard, and Nancy Marusak of the GEODES

Project, who coordinated with Fred App and made the necessary changes to GEODES to accommodate ground motion data. Roy Saunders, Lorraine Medina, Carol LaDelfe, Bob Deupree, Fred App, and Roy Boyd all were active at one time or another in updating and adding data to the data base. In response to requests from Bob Deupree, Fred App, and Tom Weaver, Tom Tunnell of EG&G developed and applied data repair techniques to much of the data. He developed extensions to some early SNLA repair techniques that semi-automated the process; Albert Martinez of EG&G performed most of the actual repairs. LANL Group J-8 (now DX-12) had the very large task of actually acquiring and processing most of the data (with field support from J-6). Bob Fitzhugh of J-8 deserves special credit for tirelessly reviewing the data and assuring that it was of the highest possible quality. Bob Deupree was instrumental in getting data from other sources and for a time was a key player in keeping the data base effort going. George Jordan (EG&G) and Fred App collaborated on the development of the **ntsgm** retrieval program that allowed the move away from GEODES and the closed computing environment. Jordan was responsible for the internal architecture of the code; App implemented the code onto the Los Alamos CRAY-UNICOS system. James Kamm provided critical peer review of this manual.

None of the Data Base work could have proceeded without the cooperation and long term support of Jack House, in his capacity as Nuclear Test Containment Program Manager, and Tom Weaver, as Deputy Group Leader of the EES-3 Geophysics Group. More recently, Wendee Brunish, in her capacity as Containment Leader, has lent her support to the effort. Finally, none of this would have happened without the concurrence of J-Division (now part of DX-Division) field test office for making the ground motion measurements in the first place.

Appendix - Stratigraphic Units

Qal	QUATERNARY ALLUVIUM
Tt	THIRSTY CANYON TUFFS
Ttt	THIRSTY CANYON, TRAIL RIDGE MEMBER
Ttp	THIRSTY CANYON, PAHUTE MESA MEMBER
Ttr	THIRSTY CANYON, ROCKET WASH MEMBER
Ttl	THIRSTY CANYON, LOWER TUFF
Tat	VITRIC BEDDED, ASHFALL, AND REWORKED TUFF (POST TM)
Tan	ASHFALL AND NONWELDED TUFF (POST TIMBER MOUNTAIN)
Tgs	GRAVEL AND TUFFACEOUS SEDIMENTS
Tma	TIMBER MOUNTAIN TUFF, AMMONIA TANKS MEMBER
Tmb	TIMBER MOUNTAIN BEDDED TUFF
Tmr	TIMBER MOUNTAIN TUFF, RAINIER MESA MEMBER
Tmrb	TIMBER MOUNTAIN TUFF, RAINIER MESA MEMBER, BEDDED
Tp	PAINTBRUSH TUFF
Tt4	TUNNEL BEDS, UNIT 4
Tt3	TUNNEL BEDS, UNIT 3
Tt43	TUNNEL BEDS, UNITS 3 AND 4, BELTED RANGE RELATED
Tpb	AREA 20 TUFFS AND LAVAS, TUFF OF BLACK TOP BUTTE
Tpt	PAINTBRUSH TUFF, TOPOPAH SPRING MEMBER
Tpp	PAINTBRUSH TUFF, PAH CANYON MEMBER
Tprp	PRE-PAH CANYON RHYOLITE
Tsw	STOCKADE WASH TUFF
Tnww	WINDY WASH RHYOLITE
Tnqr	QUARTZ RHYOLITE OF SCRUGHAM PEAK QUAD
Tnbr	BIOTITE RHYOLITE OF SCRUGHAM PEAK QUAD
Tphr	HORNBLENDE RHYOLITE OF SCRUGHAM PEAK QUAD
Tppr	PYROXENE RHYOLITE OF SCRUGHAM PEAK QUAD
Tra	TUFFS AND LAVAS OF AREA 20
Tac	CALICO HILLS RHYOLITE
Tral	AREA 20 TUFFS AND LAVAS, LOWER LAVA UNIT
Trat	AREA 20 TUFFS AND LAVAS, LITHIC RICH TUFF
Trab	AREA 20 TUFFS AND LAVAS, BEDDED AND ASH FLOWS
Tbd	DEAD HORSE FLAT RHYOLITE
Tdp	TRACHYTIC SODIC RHYOLITE LAVA OF DEAD HORSE FLAT
Trq	RHYOLITE LAVA OF QUARTET DOME
Trqu	YOUNGER THAN Trq
Trql	OLDER THAN Trq
Tbg	BELTED RANGE TUFF, GROUSE CANYON MEMBER
Trsr	RHYOLITE LAVA OF SPLIT RIDGE
Tbt	BELTED RANGE TUFF, TUB SPRINGS MEMBER
Tt2	TUNNEL BEDS, UNIT 2
Tcf	CRATER FLAT TUFF
Tt1	TUNNEL BEDS, UNIT 1
Ttu	TUNNEL BEDS, UNDIFFERENTIATED
Tnb	BASALT OF PAHUTE MESA
Trv	REDROCK VALLEY TUFF
Tab	BEDDED TUFFS (PERALKALINE)
Tf	FRACTION TUFF
Tpf	PRE-FRACTION TUFFS
Mzg	MESOZOIC GRANITE
Pz	PALEOZOIC ROCKS - UNIDENTIFIED

Pzt	COLLUVIUM
Pzc	PALEOZOIC CARBONATES
Pzq	PALEOZOIC QUARTZITES
Unk	UNKNOWN TUFFS
Tyf	YUCCA FLAT TUFF
Tmab	TIMBER MOUNTAIN TUFF, AMMONIA TANKS MEMBER, BEDDED
Tpc	PAINTBRUSH TUFF, TIVA CANYON MEMBER
Tmru	TIMBER MOUNTAIN TUFF, RAINIER MESA MEMBER, UPPER
Tmrm	TIMBER MOUNTAIN TUFF, RAINIER MESA MEMBER, MIDDLE
Tmrl	TIMBER MOUNTAIN TUFF, RAINIER MESA MEMBER, LOWER
Tmau	TIMBER MOUNTAIN TUFF, AMMONIA TANKS MEMBER, UPPER
Tmal	TIMBER MOUNTAIN TUFF, AMMONIA TANKS MEMBER, LOWER
Tfbw	BEATTY WASH RHYOLITE
Tcho	HORNBLENDE-ORTHOPYROXENE
Tmda	DACITE
Tnp	POOL UNIT
Tpcu	CPX-BEARING TIVA CANYON MEMBER
Tpcl	HBLD-BEARING TIVA CANYON MEMBER
Tptp	TOPOPAH SPRING MEMBER OF PAHUTE MESA
Tacu	MAFIC-POOR CALICO HILLS
Tacl	MAFIC-RICH CALICO HILLS
Tapr	PLAGIOCLASE-RICH AREA 20 RHYOLITE
Tcpl	MAFIC-RICH PROW PASS
Tcpu	MAFIC-POOR PROW PASS
Tcu	UPPER CRATER FLAT
Tca	ANDESITE
Tcru	MAFIC-RICH LITHIC-RICH CRATER FLAT
Tcrl	MAFIC-POOR LITHIC-RICH CRATER FLAT
Tcrf	FELDSPAR-RICH CRATER FLAT
Tcf	TRAM MEMBER, CRATER FLAT RHYOLITE
Tb	BELTED RANGE RHYOLITE
Tbgu	PHENOCRYST-RICH GROUSE CANYON MEMBER
Tbgl	PHENOCRYST-POOR GROUSE CANYON MEMBER
To	OLDER RHYOLITE
Tcb	BULLFROG MEMBER, CRATER FLAT
Tmnd	BASALTIC ANDESITE
Tmpr	PRE-RAINIER MESA RHYOLITE
Tw	WAHMONIE TUFF
Tfcn	CHANCELLOR TUFF

DATE
FILMED
7/12/94

END

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