INL/EXT-05-00672

INL Seismic Monitoring Annual Report: January 1, 2004 – December 31, 2004

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J.M. Hodges
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The INL is a U.S. Department of Energy National Laboratory
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Idaho Falls, Idaho 83415

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SUMMARY

During 2004, INL analyzed more than 2,300 earthquakes. There were 487 earthquakes with magnitudes up to 4.0 located within the 161-km (100-mile) radius of the Idaho National Laboratory (INL). Seventeen small to moderate earthquakes of magnitudes from 3.0 to 5.0 occurred with the region outside the 161-km radius. Earthquakes activity occurred in areas that have experienced seismic activity in the past, the Basin and Range northwest of the INL, southwestern Montana, Yellowstone Park, Wyoming, Jackson, Wyoming, and southeastern Idaho. One earthquake was located northeast of Idaho Falls, Idaho within the eastern Snake River Plain (ESRP). No earthquakes were located within the INL boundaries. Earthquakes were not recorded by strong-motion accelerographs located in INL facilities.

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ACKNOWLEDGMENTS

We especially appreciate Alan Marley's (BEA) support of the seismic computer systems. We also would like to thank John Rogers and Robert Banfill of DAQSystems and Banfill Software Engineering for their continued efforts and support. We also thank staff at the University of Utah Seismograph Stations, U. S. Geological Survey, Montana Bureau of Mines and Geology, and BYU-Idaho for their earthworm data shares.

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CONTENTS

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FIGURES

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TABLES

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ACRONYMS

ANL	Argonne National Laboratory
BLM	Bureau of Land Management
CFA	Central Facilities Area
DAAS	Data Acquisition/Analysis System
DOE	Department of Energy
DSL	Digital Subscriber Line
EFS	Experimental Field Station
ESRP	Eastern Snake River Plain
GPS	Global Positioning System
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IRC	INL Research Center
LOFT	Loss of Fluid Test
MFC	Materials and Fuels Complex
NEIC	National Earthquake Information Center
NRF	Naval Reactor Facility
PBF	Power Burst Facility
P-wave	Compressional Wave
RTC	Reactor Technology Complex
RWMC	Radioactive and Waste Management Complex
S-wave	Shear Wave
SMA	Strong Motion Accelerograph
STC	Science and Technology Complex
TAN	Test Area North

TRA Test Reactor Area

USGS United States Geological Survey

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1. Introduction

The Idaho National Laboratory (INL) has accumulated 32 years of earthquake data (1972-2004). This report covers the earthquake activity from January 1, 2004 through December 31, 2004 within a 161-km (100-mile) radius from the center of the INL designated as 43° 39.00' N, 112° 47.00' W. The report briefly discusses earthquakes greater than magnitude 3.0 that have occurred around the local region. It discusses the instrumentation used to record earthquake data and how the data were analyzed. It also includes a discussion of continuous GPS (Global Positioning System) stations co-located at INL seismic stations in support of crustal deformation studies. The report is a continuation of previous annual reports on earthquake activity surrounding the eastern Snake River Plain and within and near the INL.

1.1 History of INL Seismic Monitoring Program

1.1.1 Purpose

The purpose of the INL Seismic Monitoring Program is to provide the INL with earthquake data and staff expertise in support of seismic safety of ongoing reactor operations and waste management activities, seismic and volcanic hazards assessments for new and existing buildings, and acquisition of new major programs. In 2004, the INL Seismic Network operated 27 permanent seismic stations, and 24 strong-motion accelerographs (SMA) to collect earthquake data. The INL started its seismic network in December, 1971 for the purpose of monitoring earthquake activity on and around the eastern Snake River Plain (ESRP) in the vicinity of the INL (Figure 1). The INL collects seismic data to develop a historical earthquake database. The INL began its SMA network in 1973 for the purpose of recording strong ground motions from local moderate or major earthquakes. The SMAs are located within Department of Energy (DOE) buildings to determine the response of these buildings to ground motions in the event of a large earthquake. Several SMAs are located at "free-field" sites (not within buildings) near facilities and are used to determine the levels of earthquake ground motions at the ground surface (rock or soil). SMAs are also co-located with INL seismic stations to record acceleration data from small to large magnitude normal faulting earthquakes. The INL Seismic Monitoring Program supports the requirements for safety of workers and the public set by Nuclear Regulatory Commission regulations, Executive Orders, and DOE Directives and Orders. For example, the earthquake data are used to assess seismic hazards and develop seismic design criteria for the INL as required by DOE Order 420.1A "Facility Safety" (DOE, 2003).

1.1.2 Seismic Stations

The INL seismic network has evolved from a single analog station to its current configuration of 27 digital seismic stations, and records data from 14 seismic stations owned by other seismic networks. The INL seismic network began with a single station in 1971 and expanded to three stations by October of 1972. In 1977, the INL began monitoring a station operated by BYU-Idaho in Rexburg, Idaho, and the INL installed two additional stations in 1979. From 1979 to 1985, the INL monitored earthquake activity using six seismic stations. In 1985, the INL installed a simulated Wood-Anderson system to improve the capabilities of measuring the magnitude of local earthquakes ($3.0 \leq M_L \leq 5.0$). During 1986, the INL began receiving seismic data from a station located in Pocatello, Idaho and operated by the University of Utah in Salt Lake City. Also, in 1986, the INL began receiving data from a station located near Palisades Reservoir that is operated by BYU-Idaho. Another seismic station was added to the INL Seismic

Network in 1987. During 1990, four seismic stations were installed within the INL Site boundaries. In 1991, thirteen new stations were installed, but only one was operational before the end of December, 1991. Monitoring of BYU-Idaho seismic station near Palisades Reservoir was terminated in 1991 to accommodate the addition of new seismic stations. By June of 1993, all new seismic stations were operating. In 1994, two seismic stations were installed near Gray's Lake. During 1999, the Howe Scarp (HWSI) seismic station was relocated further east to a new location now referred to as HWFI because of a lawsuit filed against the Bureau of Land Management (BLM). With the implementation of the EARTHWORM computer software in 2000, up to 14 stations from several nearby networks were being recorded in real-time along with the INL seismic stations. During 2001-2003, analog seismic instruments at all INL seismic stations were replaced with digital instruments. In 2003, the University of Utah transferred ownership of the Pocatello, Idaho (PTI) seismic station to the INL Seismic Network at which time a digital seismic station was installed. With addition of the PTI station, INL currently operates 27 seismic stations.

1.1.3 Strong Motion Accelerographs

The INL began an accelerograph network by installing SMAs in buildings at INL facility areas, and more recently at free-field sites for both rock and soil conditions. In 1973, the INL began an accelerograph network by installing eleven SMAs. Three were located within buildings at the Idaho Nuclear Technology and Engineering Center (INTEC) (formerly referred to as Idaho Chemical Processing Plant - ICPP), two within the Materials and Fuels Complex (MFC) facilities (formerly referred to as Argonne National Laboratory – ANL), three within the Power Burst Facility (PBF), two within buildings at the Reactor Technology Complex (RTC) (formerly referred to as Test Reactor Area – TRA), and one at the Old Fire Station (OFS). From 1978 to 1979, four SMAs were installed at Test Area North (TAN) within the Containment Test facility (formerly referred to as Loss of Fluid Test – LOFT facility). Just prior to the October 1983 Borah Peak, Idaho earthquake, one SMA was installed at the INL Research Center (IRC), which is now part of the Science and Technology Complex (STC) in Idaho Falls, Idaho. Following the 1983 earthquake, two SMAs were installed within buildings at the Naval Reactor Facility (NRF). In 1984, two additional SMAs were placed within buildings at INTEC. During 1990, one SMA was installed at the Central Facilities Area (CFA). A digital SMA was co-located with an analog SMA at MFC in 1993. In 1996, two free-field SMA sites were installed, one at NRF and the other at PBF. In 1997, one SMA was installed as a free-field site at the Radioactive Waste Management Complex (RWMC). In 2003, the SMAs were upgraded to digital NetDAS SMAs. At that time, one NetDAS digital SMA replaced two SMAs co-located at Building ANL-767 (Kinemetrics analog SMA-1 and digital SSA-2 accelerograhs). The SMA on the crane beam at PBF-620 was not upgraded, but removed due to decommissioning activities.

Over the years, several SMAs have been relocated because buildings have been decommissioned and demolished. In 1995, the SMA at OFS was moved to a storage building directly behind the fire station because the fire station was decommissioned, which in 1997 when the storage building was demolished, the SMA was relocated to the Experimental Field Station (EFS). In 1996, the Containment Test facilities or LOFT facilities were decommissioned. Three of the SMAs from LOFT were moved to the TAN Hot Shop and one was placed at the TAN Air Monitoring building. In 2004, the TAN Air Monitoring building was demolished so the SMA was removed and will be reinstalled at a free-field site in 2005. In 1997, the SMA at CFA was relocated to CFA-1607 Refueling Building. In 2004, the PBF building was demolished and the three SMAs were removed. The SMAs will be reinstalled in 2005 as free-field sites near PBF and RWMC.

Three-component accelerometers were added to some of the seismic stations. In 2002, accelerometers were added to four seismic stations: Gray's Range (GRRI), New Production Reactor (NPRI), HWFI, and Bear Canyon (BCYI). In 2003, accelerometers were added to seismic stations

Telchick Spring, Idaho (TCSI), Split Crater (SPCI), and PTI. During 2004, the INL Accelerograph Network operated 24 SMAs within or near INL Site facility areas and 7 three-component accelerometers at seismic stations.

2. Instrumentation

2.1 Seismic Station Network

During 2004, the INL Seismic Network operated 27 permanent seismic stations and monitored 14 seismic stations from other networks (Figure 1). Table 1 lists the location and date of installation for the seismic stations operated by the INL Seismic Network, and Table 2 lists the location and operation dates for stations monitored by the INL. The seismic station at IRC (IRCI) did not operate during 2004 because the IRC fire-water pit (where the seismometers are located) was renovated. The seismic station was formerly a simulated Wood-Anderson system, which was replaced with a low-gain digital seismograph capable of recording amplitudes of local earthquakes on scale for magnitudes from 3.0 to 6.0.

A digital seismic station consists of a DAQSystems NetDAS field unit, which is an embedded LINUX computer with a GPS clock and Symmetric Research 24 bit digitizer. The NetDAS units have nearly 22 bits of data resolution over ± 20 volts for a four-channel unit or ± 10 volts for an eight-channel unit. Four channel units (NetDAS-CH4) are located at seismic stations that have one or three sensors; eight channel units (NetDAS-CH8) are at seismic stations that have more than three sensors (such as three seismometers and three accelerometers). The seismic stations have pre-amplifiers that improve signal to noise ratios. The NetDAS digitizes data at the seismic station and time stamps the data with accuracies greater than 0.001 seconds. The seismic signals are transmitted by FreeWave Technologies DGR115 900 MHz Wireless Modem radios. These radios use standard IP (Internet Protocol) networking features that are included in the embedded LINUX.

Single-component seismic stations have vertically oriented velocity sensors that are a Mark Products model L-4C, Teledyne Geotech (TG) model S-13 or TG model S-13 Jr. seismometer buried within 3 m of the ground surface. All seismic stations located within the ESRP have a TG model S-13 J seismometer located at the bottom of 18 m or greater borehole to help dampen wind and cultural noise (Seismic, 1993). Seismic stations with horizontally oriented velocity sensors have two Teledyne Geotech model S-13 seismometers located within a concrete vault. Seismic stations with acceleration sensors have Applied MEMs Inc. model SF1500A, SF2500A, or SF3000L tri-axial accelerometers.

Seismic stations are powered by batteries, solar panels, and at some locations small wind generators where AC power is not available. Radio frequency compatible antennas transmit and receive the seismic signals. Several seismic stations are used as relay stations to allow transmission of seismic signals to the IRC in Idaho Falls. The seismic data are relayed by digital radios or Internet Digital Subscriber Line (DSL) links (Appendix A). The data are acquired through EARTHWORM data shares on the Internet (discussed in Section 2.5). Digital seismograms are continuously displayed on two of four computer monitors referred to as “Webicorders.” Two monitors display maps of current earthquakes.

2.2 Strong Motion Accelerographs

The INL Accelerograph Network has 24 strong-motion accelerographs at INL Site facilities; 23 are located at the INL Site and 1 is located in the IRC at the STC. The reduced number of accelerographs resulted from demolition of the PBF reactor building in 2004. Table 3 lists the location and date of installation for each of the SMAs in operation during 2004. There are 1 to 5 accelerographs at each INL Site facility area (Figure 2). Where possible, several SMAs are interconnected at a facility area so that if one instrument triggers to record data then others at that same area will also record data. Three SMAs are interconnected at TAN and two at INTEC. During 2004, no earthquake data were recorded by the SMAs.

INL SMAs are DAQSystems NetDAS digital accelerographs that have Applied MEMS SiFlex SF2500 tri-axial accelerometers. Each SMA is set to record to compact flash when ground motions exceed 2500 counts, which is equivalent to about 0.005 g. The record lengths are set for 30 s of pre- and post-trigger thresholds. The triaxial accelerometers have two horizontal components oriented in an orthogonal manner, generally aligned in the north-south and east-west directions. Appendix B lists the accelerometer orientation and instrument response for the horizontal and vertical components of each SMA. SMAs at free-field sites have GPS clocks to synchronize the internal clocks to an absolute time system. For some SMAs at free-field sites and locations within buildings, acceleration data are transmitted to the IRC via digital radios or the Internet. Other SMAs record data on compact flash disks that are retrieved by INL seismic personnel using a laptop PC computer.

2.3 Continuous GPS Stations

The INL Seismic Monitoring program has a geodetic network for the purpose of monitoring horizontal crustal deformation in support of INL seismic hazards assessments. GPS data are used to investigate active crustal deformation that is on the order of millimeters of movement per year within the eastern Snake River Plain, the surrounding Basin and Range, and Yellowstone Plateau. GPS data define regions of high velocity gradients having more frequent damaging earthquakes (e.g., Yellowstone – Hebgen Lake, Montana) than regions of low velocity gradients (e.g., eastern Snake River Plain). The spatial patterns of GPS data also constrain the fundamental geodynamic processes driving active continental deformation (e.g., Yellowstone hotspot). GPS data collected by INL also contribute to the larger scientific effort for the Plate Boundary Observatory operated under University NAVSTAR Consortium (UNAVCO) to understand western United States crustal deformation processes.

GPS receivers are co-located at INL seismic stations (Figure 3). In 1998, INL assisted the University of Utah with installation of a continuous recording GPS station at the Great Rift, Idaho (GTRI) seismic station. In 2003, a GPS station was installed at BCYI. An INL GPS station consists of a Trimble NetRS GPS receiver connected to a L1/L2 dual frequency choke ring antenna. The antenna is attached to a 2.4 m steel rod that is drilled into a rock outcrop to a depth of about 1 m. Above ground the antenna is stabilized using a much larger PVC pipe filled with sand. This reduces the amount of wind noise within the GPS data, improving the accuracy. The NetRS receivers continuously collect GPS data. The data are relayed along with the seismic station data to DSL links, which are then accessed from the Internet at the IRC. Also, the data are downloaded daily from the Internet and archived by UNAVCO.

2.4 Seismic Data Acquisition and Analysis System

The INL records earthquake data on a computer Data Acquisition/Analysis System (DAAS) at the IRC. INL began recording earthquake data on the DAAS June 8, 1991 using the U. S. Geological Survey (USGS) CUSP processing software. Since 2001, significant upgrades have been made to the DAAS as a result of computer hardware and software advances. The USGS CUSP data acquisition and analysis software that supported use of the TIMIT program were replaced with the earthquake analysis program SEISAN (developed by the University of Bergen, Norway) in 2002 and the USGS EARTHWORM processing software in 2003. From June 1991 to November 2002, earthquake data were analyzed using the USGS TIMIT program. As of December 2002, earthquake data are now being analyzed using the SEISAN program. Use of the SEISAN and EARTHWORM programs facilitated the upgrades of seismic stations and SMAs to the NetDAS digital units, allowing concurrent waveform analyses of both velocity and acceleration data. Instrument responses of the NetDAS units at seismic stations and SMAs are now routinely performed and are integrated into the SEISAN database (see Appendices B and C). All digital earthquake data are also routinely archived to DVD media after analysis.

For acquisition of the earthquake data, the EARTHWORM program compares the digitized seismic data to the average noise or voltage level determined over a time interval of 1,000 s. The program determines that an earthquake has occurred when the amplitude of the voltage level over a 1-second time-interval for several stations within a subnet exceeds a threshold value of 2.5 times this average noise level. When an earthquake is detected, the seismograms for all stations within triggered subnets and the time codes are saved in a file on a disk. This file is labeled with a sequential number based on the date and time of the trigger for later reference to the earthquake in the SEISAN database. Each seismogram has 30 s of pre-event data and 20 s of post-event data stored within the file. In some instances, earthquakes have low-amplitude emergent P-waves with larger amplitude S-waves. When this occurs the DAAS may trigger on the S-waves instead of the P-waves, thus, saving 30 s of pre-event time allows recording of the P-waves also.

The earthquake detection software is set up to trigger on earthquakes detected by several stations within a subnet. Subnets contain several stations that are located in a small area and which are likely to detect the same local earthquake. All INL seismic stations usually detect earthquakes of magnitude 1.5. Since the INL stations cover a small area (as compared to the state of California, for example), the subnets were designed to reduce false triggers due to radio noise no longer an issue with digital communications. Subnets are specified for stations in close proximity to each other and their relationship to known seismic sources. For the ESRP though, a subnet was created for detection of small magnitude ($M < 0.5$) microearthquakes.

The EARTHWORM program also enables data sharing with other seismic networks in near real time over the Internet. The INL provides data from various seismic stations to the University of Utah, Montana Bureau of Mines and Geology, National Earthquake Information Center (NEIC), and BYU-Idaho (Table 2), which in return provide data to INL. EARTHWORM records seismic data from these agencies and INL, which are analyzed using the SEISAN program.

Table 1. Seismic stations operated by INL.

Code	Station Name	Sensors Types	Latitude North (°)	Longitude West (°)	Elevation (m)	Date Installed (Yr/Mon)
ARNI	Argonne North, Idaho	Borehole Vertical Seismometer	43.6667	112.6235	1533	09/90
BCYI	Bear Canyon, Idaho	Vertical Seismometer, Three-component Accelerometers, and GPS Receiver	44.3108	113.4052	2194	05/92
CBTI	Cedar Butte, Idaho	Borehole Vertical Seismometer	43.3875	112.9115	1734	07/86
COMI	Craters of the Moon, Idaho	Vertical Seismometer	43.4618	113.5938	1890	03/92
CNCI	Crows Nest Canyon, Idaho	Vertical Seismometer	43.9283	113.4522	1914	05/92
CRBI	Circular Butte, Idaho	Borehole Vertical Seismometer	43.8303	112.6345	1520	11/87
ECRI	Eagle Creek, Idaho	Vertical Seismometer and Three-component Accelerometers	43.0535	111.3705	2086	08/94
EMI	Eightmile Canyon, Idaho	Vertical Seismometer	44.0742	112.9262	1963	04/92
GBI	Big Grassy Butte, Idaho	Borehole Vertical Seismometer	43.9875	112.0633	1541	10/81
GRRI	Grays Range, Idaho	Vertical Seismometer	42.9380	111.4217	2207	08/94
GTRI	Great Rift, Idaho	Borehole Vertical Seismometer and GPS Receiver	43.2440	113.2410	1522	05/92
HHAI	Hell's Half Acre, Idaho	Borehole Vertical Seismometer	43.2950	112.3795	1371	06/92
HPI	Howe Peak, Idaho	Vertical Seismometer	43.7113	113.0983	2597	10/72
HWFI	Howe Fault, Idaho	Three-component Seismometers and Accelerometers	43.9257	113.0973	1743	10/99
ICI	Italian Canyon, Idaho	Vertical Seismometer	44.3293	112.9412	2463	04/92

Code	Station Name	Sensors Types	Latitude North (º)	Longitude West (º)	Elevation (m)	Date Installed (Yr/Mon)
IRCI	INL Research Center, Idaho	Low-gain Three-component Seismometers	43.5153	112.0333	1442	11/88
JGI	Juniper Gulch, Idaho	Three-component Seismometers	44.0927	112.6768	1657	11/79
KBI	Kettle Butte, Idaho	Borehole Vertical Seismometer	43.5907	112.3767	1678	05/92
LJI	Lemhi Junction, Idaho	Vertical Seismometer	43.8208	112.8440	1643	05/90
LLRI	Little Lost River, Idaho	Three-component Seismometers and Accelerometers	43.7230	112.9330	1476	05/90
NPRI	New Production Reactor, Idaho	Three-component Seismometers and Accelerometers	43.5975	112.8272	1495	09/90
PZCI	Patelzick Creek, Idaho	Vertical Seismometer	44.3410	112.3172	2073	12/91
PTI	Pocatello, Idaho	Vertical Seismometer and Three-component Accelerometers	42.8703	112.3702	1670	10/84
SMBI	Sixmile Butte, Idaho	Borehole Vertical Seismometer	43.5022	113.2677	1716	05/92
SPCI	Split Crater, Idaho	Three-component Seismometers and Accelerometers	43.4500	112.6370	1553	06/92
TCSI	Telchick Spring, Idaho	Vertical Seismometer and Three-component Accelerometers	43.6193	113.4783	1731	05/92
TMI	Taylor Mountain, Idaho	Three-component Seismometers	43.3057	111.9182	2179	10/72

Table 2. Stations monitored by the INL that are operated by other agencies.

Code	Station Name	Latitude North (º)	Longitude West (º)	Elevation (m)	Operating Dates (Yr/Mon)	
BYU-Idaho, Rexburg, Idaho						
CMI	Centennial Mountains, Idaho	44.6175	111.5165	2267	N/A	Pres
IMW	Indian Meadows, Wyoming	43.8970	110.9392	2624	7/80	Pres
RRI	Red Ridge, Idaho	43.3640	111.3190	2408	7/85	Pres
U. S. National Seismic Network, Golden, Colorado						
AHID	Auburn, Idaho	42.7653	111.1003	1960	11/97	Pres
BW06	Boulder, Wyoming	42.7667	109.5582	2224	5/96	Pres
HLID	Hailey, Idaho	43.5625	114.4063	1498	8/88	Pres
University of Utah, Salt Lake City, Utah						
BEI	Bear River Range, Idaho	42.1167	111.7823	1859	11/84	Pres
BMUT	Black Mountain, Utah	41.9582	111.2342	2243	10/79	Pres
MCID	Moose Creek, Idaho	44.1903	111.1827	2149	N/A	Pres
MLI	Malad Range, Idaho	42.0268	112.1255	1896	10/74	Pres
NPI	North Pocatello, Idaho	42.1473	112.5183	1640	4/75	Pres
Montana Bureau of Mines and Geology, Butte, Montana						
MCMT	McKenzie Canyon, Montana	44.8277	112.8488	2323	9/89	Pres
MOMT	Monida, Montana	44.5933	112.3943	2220	10/95	Pres
TPMT	Teepee Creek, Montana	44.7298	111.6657	2518	10/92	Pres

Table 3. Strong-motion accelerographs operated by INL.

INL Site Facility Area	Building Number	Location	SMA Code	Year Installed
MFC	ANL-767	Basement	EBR	1973
MFC	ANL-768	Basement	FCF	1973
CFA	CFA-1607	Free-field	CFAF	1996
CFA	EFS	Free-field	EFSF	1997
INTEC	CPP-668	Free-field	CPPF	1992
INTEC	CPP-601	First Floor	CPP1	1973
INTEC	CPP-601	Second Basement	CPP2	1973
INTEC	CPP-666	Second Floor	FAS1	1984
INTEC	CPP-666	Second Basement	FAS2	1984
NRF	NRF-768	Free-field	NRFF	1996
NRF	NRF-A1W	First Floor	A1W	1983
NRF	NRF-S1W	First Floor	S1W	1983
PBF	PBF-625	Free-field	PBFF	1996
PBF	PBF-620	First Basement	PBF1	1973
PBF	PBF-620	Second Basement	PBF2	1973
RTC	TRA-602	Free-field	TRAF	2003
RTC	TRA-642	Basement	TRA1	1973
RTC	TRA-670	Basement	TRA2	1996
RWMC	NA	Free-field	RWMC	1997
STC	IRC-602	First Floor	IRC	1983
TAN	TAN-618	Free-field	TANF	1996
TAN	TAN-607	First Floor	TAN1	1996
TAN	TAN-607	Second Floor	TAN2	1996
TAN	TAN-607	Third Floor	TAN3	1996

NA – Not within a building.

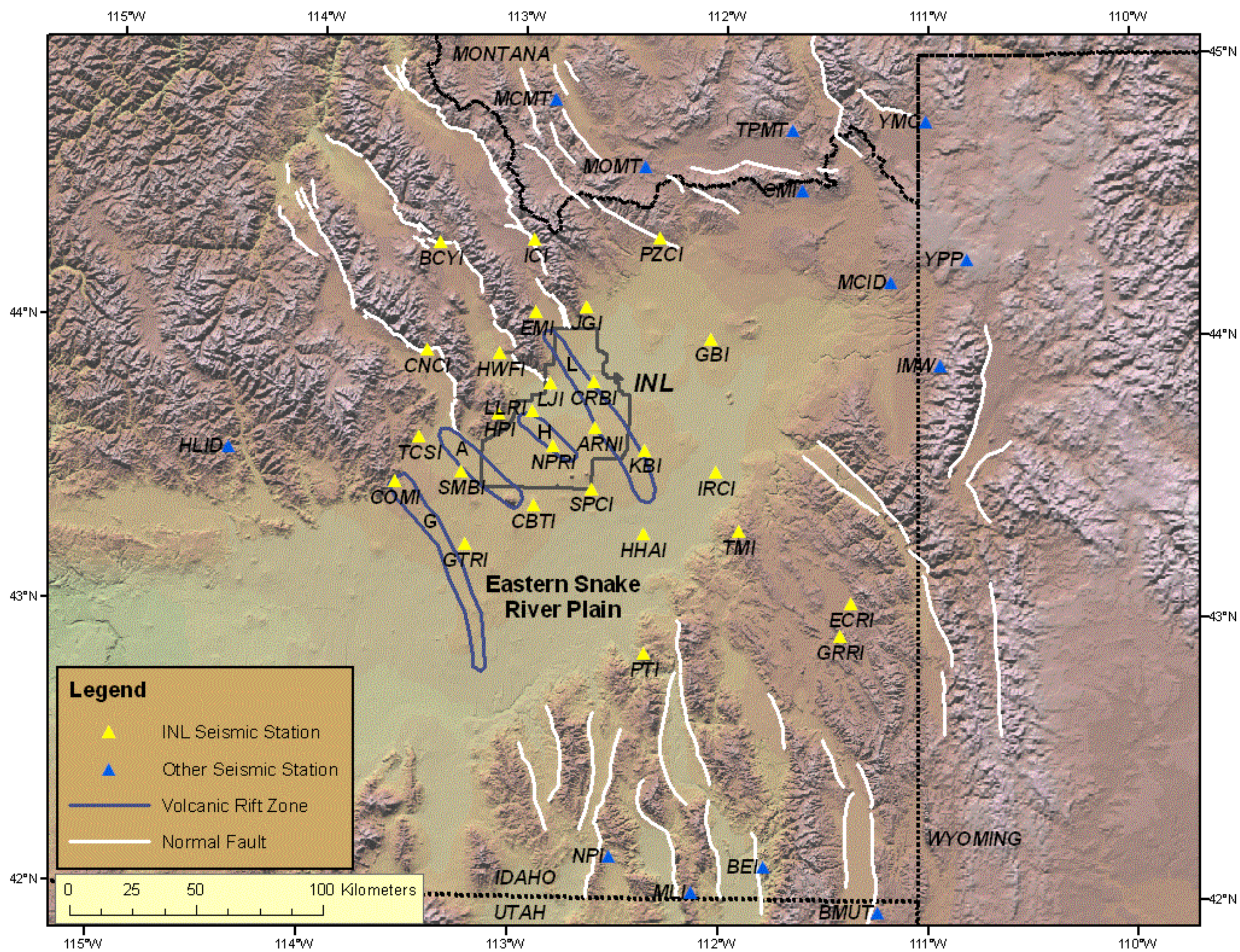

Figure 1. Locations of INL seismic stations and stations monitored by INL that are operated by other institutions. Volcanic rift zones: G – Great Rift, A – Arco, H – Howe-East Butte, and L – Lava Ridge-Hell's Half Acre.

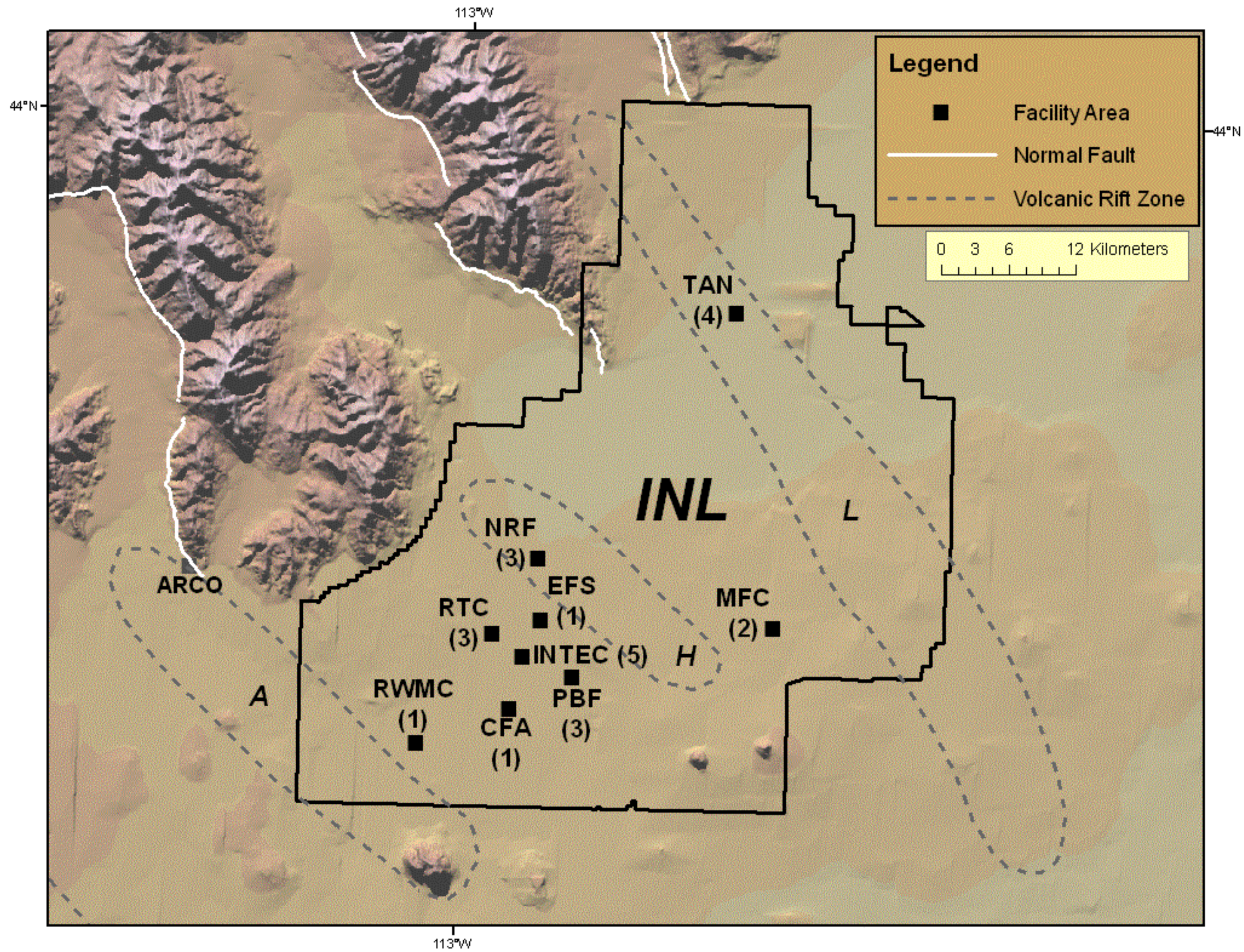

Figure 2. Locations and numbers (in parentheses) of SMAs at the INL Site. Volcanic rift zones: A – Arco, H – Howe-East Butte, and L – Lava Ridge-Hell's Half Acre.

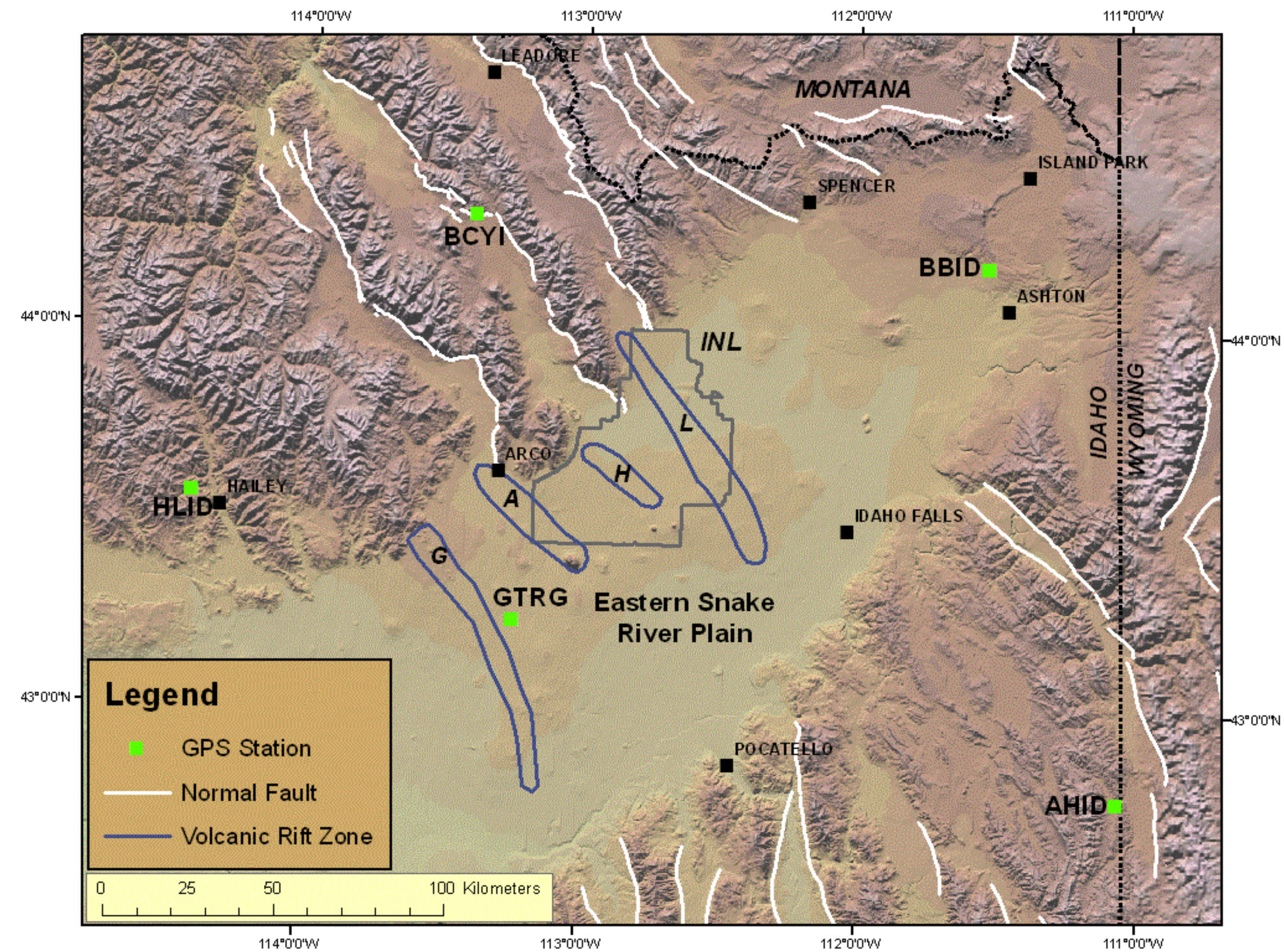

Figure 3. Locations of the continuous GPS stations co-located at INL seismic stations (BCYI and GTRG) and operated by other agencies. Volcanic rift zones: G – Great Rift, A – Arco, H – Howe-East Butte, and L – Lava Ridge-Hell's Half Acre.

3. Data Analysis

Digital seismograms are analyzed using the SEISAN program. SEISAN displays multiple seismograms on a computer screen with corresponding times codes having accuracy to ± 0.001 s. P- and S- wave arrival times are selected to ± 0.01 s. Either duration or amplitude of a seismic signal is selected and then used to calculate the magnitude of an earthquake. The arrival times, durations, and amplitudes measured for an earthquake are saved in a computer file directly from the SEISAN program. A separate program then calculates the location and magnitude of an earthquake. The locations and magnitudes of the earthquakes are plotted on maps to assess seismically active regions near the INL.

3.1 Location Method

The HYPOINVERSE computer program (Klein, 1989) is used to determine locations for all earthquakes recorded. Phase data files (arrival times of the earthquake) from the output of SEISAN are input into the HYPOINVERSE location program. At a minimum, four P-wave and two S-wave arrival times (six total) are used to determine the location of an event. According to Zollweg and Sprenke (1995), stable locations are usually obtained from about seven to ten arrival times for recorded events that are not surrounded by INL seismic stations. Within the INL network, stable locations can be obtained with a minimum of six arrival times. Because of the density and sensitivity of the INL network, the majority (usually more than 95%) of earthquakes located within the 100-mile radius have a minimum of seven arrival times. Seismic stations from other agencies monitored by the INL provide coverage outside the INL network and phase arrivals from these stations supplement phase data from INL stations.

Six P-wave velocity models are used in the HYPOINVERSE location program depending on the location of the earthquakes (Table 4). The “ESRP” velocity model is used for locating earthquakes that occur within the ESRP including the mountainous terrain on the northern and eastern edge of the Plain (Olsen et al., 1979; Sparlin et al., 1979; Braile and Smith, 1979; and Ackerman, 1979). The “INL ESRP” velocity model is used to locate earthquakes that occur on the ESRP and are near or within the INL Site boundaries. This model was developed from Sparlin et al. (1982) and Braile et al. (1982) and checked with respect to a few microearthquakes located within the ESRP (Jackson et al., 1989). The “BPEAK” velocity model is used for locating earthquakes that occur in the Borah Peak aftershock area and the mountainous terrain northwest of the Plain (Richins et al., 1987). The “PAL BFR” velocity model is used to locate earthquakes that occur near the Palisades and Blackfoot River reservoirs (Wood, 1988). The “SMT” velocity model is used to locate earthquake in southwestern Montana (Stickney, 1997). Finally, the “UTAH” velocity model is used to locate earthquakes that occur near the Idaho-Utah border (Nava et al., 1990). For all velocity models, a P-wave velocity to S-wave velocity ratio of 1.75 is used (Bones, 1978; Greensfelder and Kovach, 1982; and Richins et al., 1987).

Other parameters used in the HYPOINVERSE location program are the starting focal depth, distance weighting, and cut off for the root mean square of the timing residuals. These parameters are set as follows:

- Starting focal depth is 5 km
- Distance cut off for weighting is 50 km
- Root mean square of timing residuals is 0.16 sec

Zollweg and Sprenke (1995) evaluated the parameters chosen for the HYPOINVERSE program used by INL. They determined that the parameters chosen yield good location results despite the poor coverage in azimuth of earthquakes outside the network. An evaluation of the difference between the observed and computed latitude and longitude was less than 0.25 km.

3.2 Magnitude Calculations

Magnitudes are determined using two methods 1) coda magnitudes using signal duration of digital seismograms and 2) local magnitudes using amplitudes from digital seismograms. Coda magnitudes (M_c) are calculated for earthquakes of magnitudes less than 3.0 using signal durations of several earthquakes recorded on different seismic stations. Local magnitudes (M_L) are calculated using the largest peak-to-peak trace amplitude measured from digital waveforms and the Richter magnitude equation. If a magnitude cannot be determined for a local earthquake, then magnitudes determined by other seismic networks may be used. These include the University of Utah (referred to as SLC), Montana Bureau of Mines and Geology (referred to as BUT), NEIC, Boise State University (referred to as BSE), and the U.S. Bureau of Reclamation (referred to as USB).

The following expression is used to calculate coda magnitudes for the signal duration method (Arabasz et al., 1979):

$$M_c = -3.13 + 2.74 \log \tau + 0.0012 \Delta \quad [1]$$

Where:

τ = Total signal duration in seconds;

Δ = Epicentral distance from each station in km.

The duration is measured at the start of the earthquake signature (P-wave arrival) to the end of the coda, where the signal fades into the background noise of the trace. The final magnitude is determined by averaging the coda magnitude calculated for each seismogram. The SEISAN program automatically selects the duration of the earthquake when the P-wave arrival time is selected. Equation (1) is usually used to estimate magnitudes for events located by the HYPOINVERSE location program.

Local magnitudes calculated from the digital seismograms are based on the Richter magnitude scale. Richter (1958) defined the local magnitude scale from the following equation:

$$M_L = \text{Log } A - \text{Log } A_o \quad [2]$$

Where:

A = Recorded maximum trace amplitude from the zero-line measured in millimeters on a standard seismogram;

A_o = Maximum trace amplitude from the zero-line in millimeters for a selected standard earthquake.

Dr. Richter developed the scale for a standard earthquake of magnitude 3.0 at 100 km for A_o = 0.001 mm and amplitude of 1.0 mm measured on the standard seismogram. He constructed a table of magnitudes based on distance and -Log A_o for maximum trace amplitudes recorded on the standard Wood-Anderson seismogram.

SEISAN has a program that uses equation [2] with amplitudes measured on a synthetic Wood-Anderson digital seismogram. The program allows the user to select the option to convert a horizontal time history for an accelerometer or seismometer of an INL seismic station to a synthetic Wood-Anderson seismogram. The SEISAN program uses the instrument response information contained in Appendix B for accelerograms and Appendix C for seismograms to calculate synthetic Wood-Anderson seismograms at a magnification of 2800. The user then selects the largest peak-to-peak amplitude (or A) in millimeters from the digital display of the synthetic Wood-Anderson seismogram. The SEISAN program then uses the distance of the simulated Wood-Anderson station to the earthquake's epicenter and ½ the peak-to-peak amplitude to determine local magnitude using Richter's table. The program determines the local magnitude for each of the amplitudes selected. The program calculates a median magnitude for the earthquake.

3.3 Peak Accelerations

Peak ground accelerations are determined for accelerograms using the SEISAN program (Section 2.4). SEISAN displays the accelerograms for some free-field SMAs located at the INL Site and accelerometers co-located with the seismic stations. The SEISAN program allows the user to correct the accelerograms by removing the instrument responses listed in Appendices A and B. A separate program is used to measure the largest zero-to-peak acceleration amplitude from the corrected acceleration time history.

3.4 Location Quality

Comparisons between earthquake locations determined by the INL and locations determined by other temporary networks or NEIC have been used to approximate locations errors of earthquake epicenters (Jackson et al., 1993a). This method was very general and yielded an approximation of the quality of the INL earthquake locations. In 1995, the State of Idaho requested Zollweg and Sprenke (1995) to perform an independent assessment of the INL Seismic Monitoring program. Zollweg and Sprenke (1995) evaluated the location accuracy of the INL seismic network by two methods: 1) directly comparing INL locations to well-located earthquakes; and 2) indirectly by evaluating the network bias or non-random error through varying independent permutations (or combinations) of recording stations.

For the first method, twenty-two earthquakes having high-quality locations determined from a temporary seismic network installed near Challis, Idaho from July 1, 1992 to July 12, 1992 (by Boise State University) were compared to INL locations for these earthquakes. The earthquakes were located about 120 km from the center of INL, had varying magnitudes ranging from 1.9 to 4.5, and had absolute errors less than 1 km. The epicenters determined by INL seismic stations for these events differed by 1.6 to 11.5 km with an average of 7.1 km. The differences in locations were dependent on magnitude, with the smaller magnitude earthquakes tending to have greater differences in locations (Zollweg and Sprenke, 1995). These results are similar to the earlier estimates of an error radius of 5 km for a comparison to high-quality locations of the aftershocks from the M_s 7.3 October 28, 1983 earthquake (Jackson et al., 1993a). However it is noted that this estimate for an error radius was based on having five stations in the INL seismic network at that time. The closest station to the aftershocks was at a distance of 50 km or more.

The second method used by Zollweg and Sprenke (1995) evaluates the network bias. Unless all earthquakes are located using exactly the same groups of stations and phases (P- and S-waves), the relative locations will be affected by a non-random error or network bias. The network bias is important for the smaller earthquakes that make up the majority of the events in a catalog since fewer stations usually record smaller earthquakes. Five earthquakes located northwest of the INL seismic network and ranging in magnitude from 1.8 to 3.8 were used in the analysis. Because INL has 26 seismic stations, there are millions of possible combinations of recording stations. Zollweg and Sprenke (1995) chose to vary the combination of the ten most influential phase arrivals for the permutation analysis. The locations for most of the permutations clustered about radii ranging from 6.5 to 11 km. For the magnitude 3.8 earthquake, 8% of the permutations resulted in a linear band extending 100 km. Zollweg and Sprenke (1995) suggested that earthquakes located with fewer S-wave arrival times have less well-constrained locations. Some of the larger earthquakes, like the magnitude 3.8 event, have fewer S-wave arrival times because the signals saturate the instrumentation and onset of the S- wave is indistinguishable from the P-waves. Earthquakes with more than three S-wave-arrival times resulted in better-constrained locations.

3.5 Depth Quality

The HYPOINVERSE location program also calculates depth to the hypocenter. Focal depths calculated by this program are not accurate for many of the earthquakes recorded by the INL Seismic Network for two reasons: 1) the station spacing is usually greater than twice the focal depth of the earthquake recorded; and 2) the earthquake usually occurs outside of the network. To calculate accurate focal depths, the earthquake must occur within the seismic network and at a distance equal to or less than its focal depth. Although focal depths are listed in Appendix D, they should be interpreted within the context of the limitations discussed in this section.

3.6 Data Completeness

Local earthquakes are easily discriminated from other seismic data such as local mine blasts, air blasts (or sonic booms), and distant (worldwide) and regional earthquakes occurring far outside of the INL seismic network. For example, man-made blasts are easily discriminated from earthquakes on the basis of P- and S- wave arrival time patterns, the time the event occurred, and the location of the event. Confirmation of distant and regional earthquakes are routinely made using the NEIC website.

Detection threshold can provide a measure of completeness for the INL earthquake catalog. It is defined as the magnitude level at which the seismic network will nearly always locate an earthquake. Zollweg and Sprenke (1995) evaluated the detection threshold by plotting the cumulative number of earthquakes as a function of magnitude to determine the lowest magnitude point that the curve begins to flatten. Zollweg and Sprenke (1995) determined the detection threshold to be a magnitude 1.3 anywhere within a 100-mile radius around INL. Their conclusion was based on a plot of 1360 earthquakes for an 18-month period. Since the seismic stations are all located within 90 km of the center of INL, they suggested that the detection threshold is magnitude 0.8 within the network on the ESRP. The analysis of Zollweg and Sprenke (1995) suggests that the INL earthquake catalog is complete for magnitudes above 1.3 within a 100-mile radius of INL and may be complete for magnitudes as low as 0.8 within the network. Hardware and software upgrades for the current DAAS have increased detection sensitivities on the order of magnitude 0.0 which allow recording of small magnitude microearthquakes within ESRP.

Table 4. P-wave velocity models used in location programs.

Velocity Model Code	Velocity (km/sec)	Depth to Top of Layer (km)	Layer Thickness (km)	References
ESRP	4.90	0.00	2.00	Olsen et al., 1979; Sparlin et al., 1979; Braile & Smith, 1979; Ackerman, 1979.
	6.00	2.00	15.00	
	6.70	17.00	23.00	
	7.90	40.00	Half-space	
INL ESRP	3.30	0.00	1.00	Sparlin et al., 1982; Braile et al., 1982; Jackson et al., 1989.
	4.90	1.00	2.00	
	5.30	3.00	2.00	
	6.15	5.00	2.00	
	6.53	7.00	10.00	
	6.80	17.00	23.00	
	8.00	40.00	Half-space	
BPEAK	4.75	0.00	1.64	Richins et al., 1987.
	5.59	1.64	5.31	
	6.16	6.95	11.05	
	6.80	18.00	22.00	
	8.00	40.00	Half-space	
PAL BFR	4.80	0.00	2.00	Wood, 1988.
	5.45	2.00	3.90	
	6.14	5.90	2.50	
	6.32	8.40	6.10	
	6.56	14.50	25.20	
	8.00	40.00	Half-space	
SMT	5.52	0.00	5.86	Stickney, 1997.
	6.12	5.86	12.78	
	6.74	18.64	20.05	
	8.00	38.69	Half-space	
UTAH	3.40	0.00	1.40	Nava et al., 1990.
	5.90	1.40	14.10	
	6.40	15.50	9.90	
	7.50	25.40	16.60	
	7.90	42.00	Half-space	

4. 2004 Earthquake Activity

During 2004, INL recorded more than 2300 independent triggers from earthquakes both within the region and from around the world. Seventeen small to moderate size earthquakes ranging in magnitude between M_L 3.0 and 5.0 occurred outside the 161-km radius. The earthquake activity occurred in areas that have experienced seismic activity in past years including Stanley, Idaho; Yellowstone National Park, Wyoming; Jackson, Wyoming; and southeastern Idaho. 487 earthquakes were located within the 161-km (or 100-mile) radius of INL (Appendix C). Three earthquakes exceeded M_L 3.0, the largest earthquake had a M_L of 4.0. The earthquakes were located in areas that have been seismically active in the past, along the basin and range faults northwest of INL, southwestern Montana, and southeastern Idaho.

4.1 Regional Earthquake Activity

Seventeen earthquakes of M_L 3.0 and greater occurred outside the 100-mile radius of the INL (Figure 4). East of Jackson, Wyoming a M_L 5.0 occurred on January 7, 2005, which was followed by numerous aftershocks occurring over six months. Local residents in nearby towns felt the mainshock. Ten aftershocks having magnitudes that range from 3.0 to 4.1 followed the mainshock. Eight aftershocks M_L from 3.0 to 4.1 occurred in January, one of M_L 3.6 occurred in February, another aftershock of M_L 4.0 occurred in April, and finally, one M_L 3.1 occurred in July. Local residents felt several of the larger aftershocks.

In southeastern Idaho two earthquakes occurred, a M_L 3.3 southwest of Afton, Wyoming and the other a M_L 3.0 east of Preston, Idaho. Nearby residents felt the earthquake that occurred near Preston, Idaho. Three earthquakes occurred near Yellowstone, Wyoming (east and north of Island Park, Idaho) that ranged from M_L 3.0 to 3.2, the largest was reported felt in nearby towns. An M_L 3.0 earthquake occurred near Stanley, Idaho, and was not reported felt.

4.2 Local Earthquake Activity

Epicenters for 487 earthquakes were located within a 161-km radius of the INL (Figure 5). Three of these earthquakes had magnitudes greater than M_L 3.0. In June, an earthquake was located northwest of Mackay, Idaho and had a M_L 3.3. It was not reported felt. In August, an earthquake of M_L 3.6 occurred near Palisades Reservoir, located north of Afton, Wyoming. This earthquake was not reported felt by local residents. In November a swarm of earthquakes began southeast of Challis, Idaho. The largest earthquake had a M_L 4.0 and was felt by local residents. The earthquake activity continued throughout December, 2004. Other seismically active areas included southwestern Montana and southeastern Idaho. Both areas experienced earthquakes throughout the year. One earthquake of magnitude 1.0, occurring in October, was located within the ESRP boundaries northeast of Idaho Falls, Idaho. No earthquakes were located within the INL Site boundaries during 2004.

5. 1972-2004 Earthquake Activity

Since earthquake monitoring began at INL in 1972, only small magnitude microearthquakes of $M_L \leq 1.5$ have occurred within the ESRP. Figure 6 shows that the earthquakes in 2004 occurred in areas within and around the ESRP that have been active in the past. Even though microearthquakes ($M_L \leq 1.5$) have occurred within the ESRP, earthquake monitoring by the INL Seismic Network for the last 32 years indicates that the ESRP has been seismically inactive relative to the surrounding Basin and Range Province (Jackson et al., 1993b).

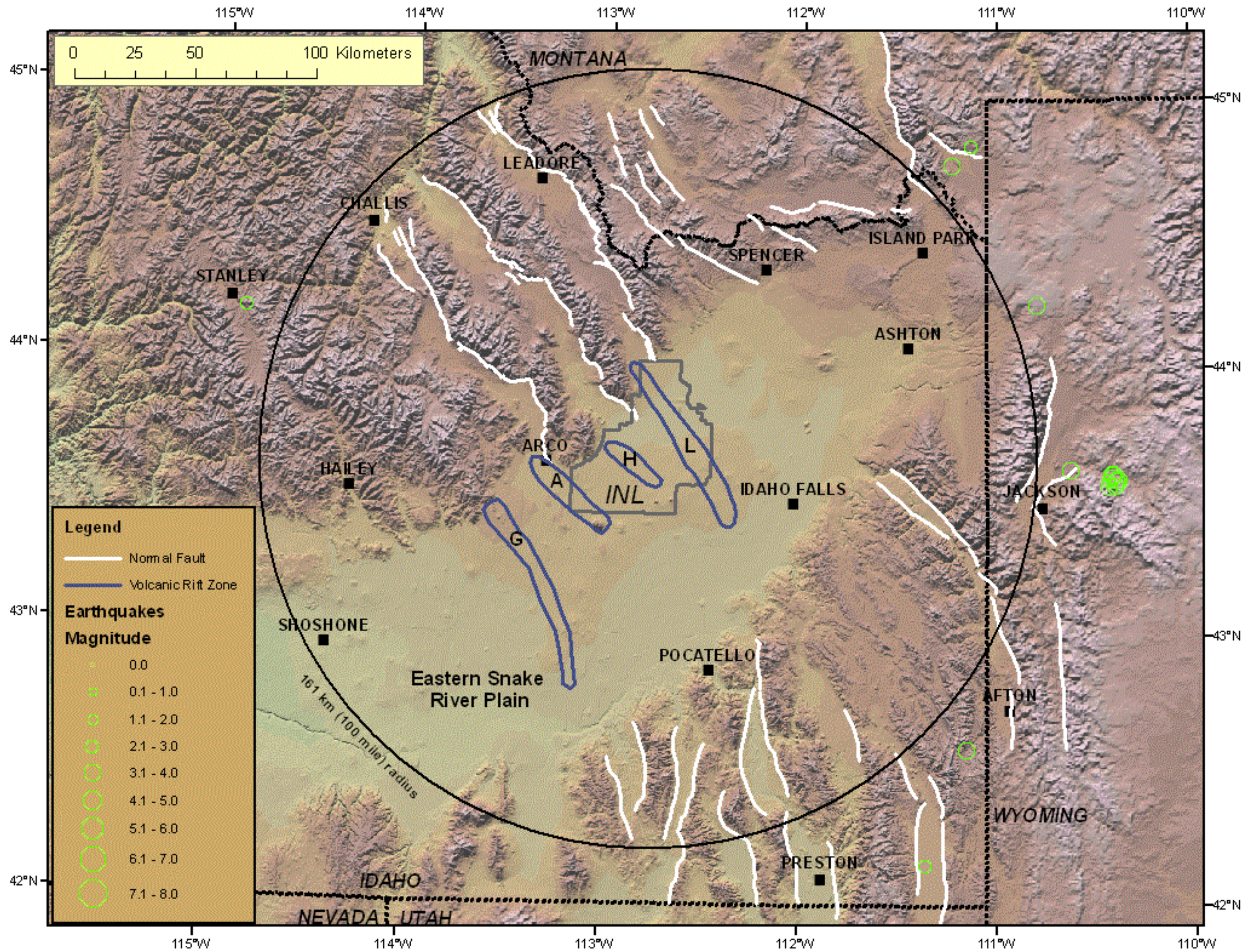

Figure 4. Map shows locations of earthquakes with magnitudes greater than 3.0 outside of the 161-km radius of INL. Volcanic rift zones: G – Great Rift, A – Arco, H – Howe-East Butte, and L – Lava Ridge-Hell's Half Acre.

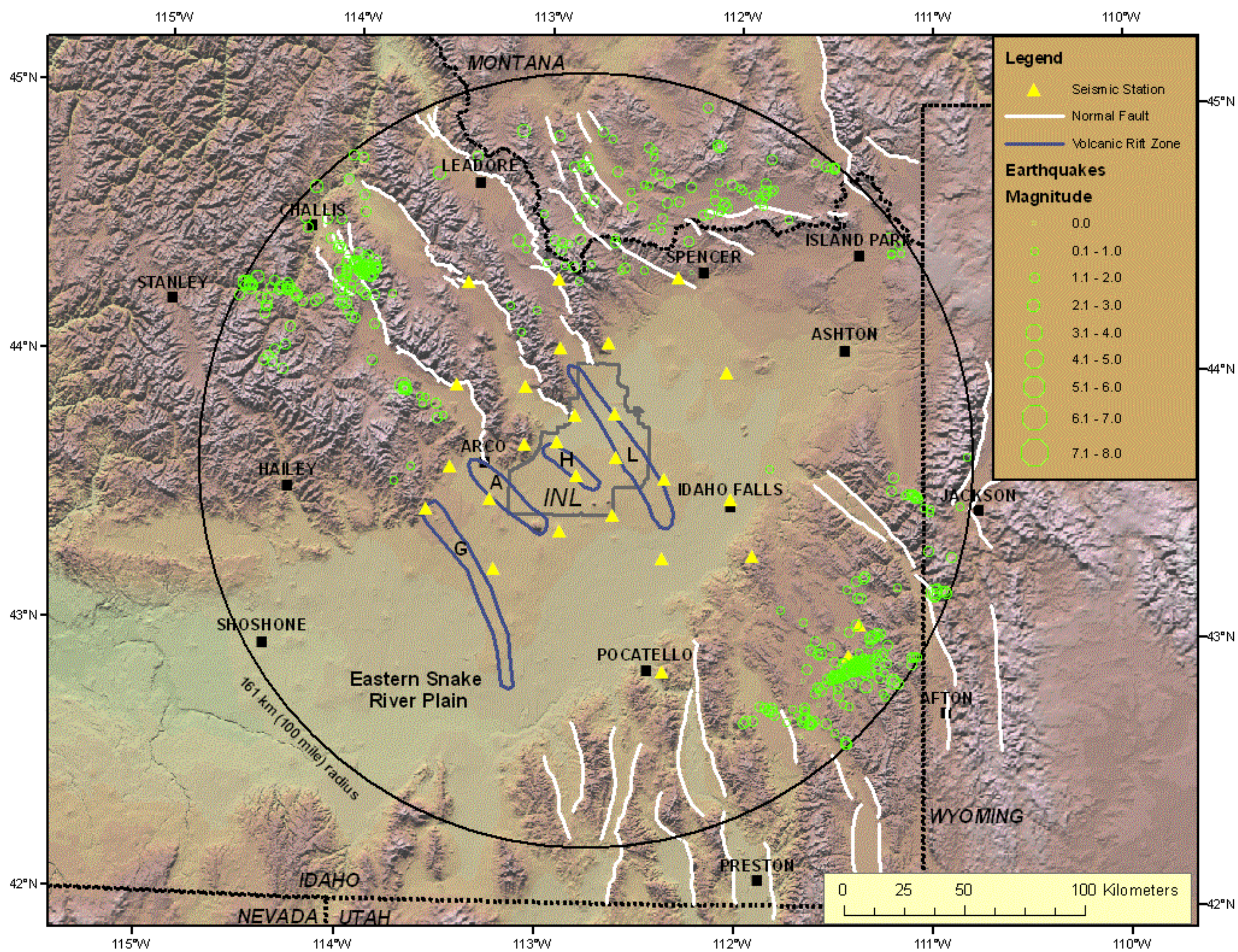

Figure 5. Map shows locations of earthquakes within 161-km radius of INL. Volcanic rift zones: G – Great Rift, A – Arco, H – Howe-East Butte, and L – Lava Ridge-Hell's Half Acre.

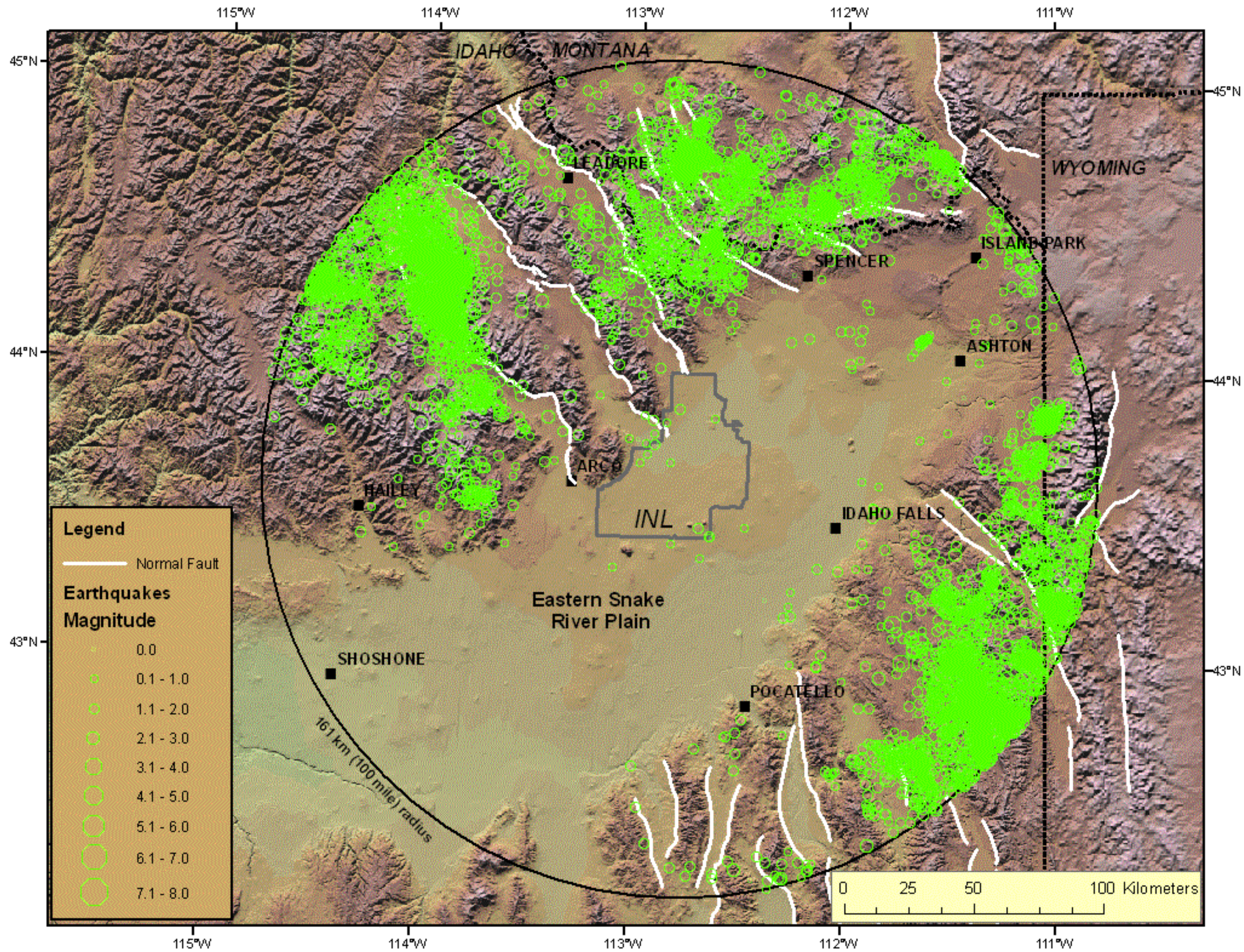

Figure 6. Map shows locations of earthquakes from 1972 to 2004 within the 161-km radius of INL.

6. References

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Appendix A

Seismic Station Telemetry

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Appendix A

Seismic Network Telemetry

Digital radios, Internet, or DSL links transmit seismic data from INL seismic station to the IRC. Some seismic stations are used as relay links to transmit several seismic stations to a DSL drop point or directly to the IRC. Figure A-1 shows the telemetry layout during 2004.

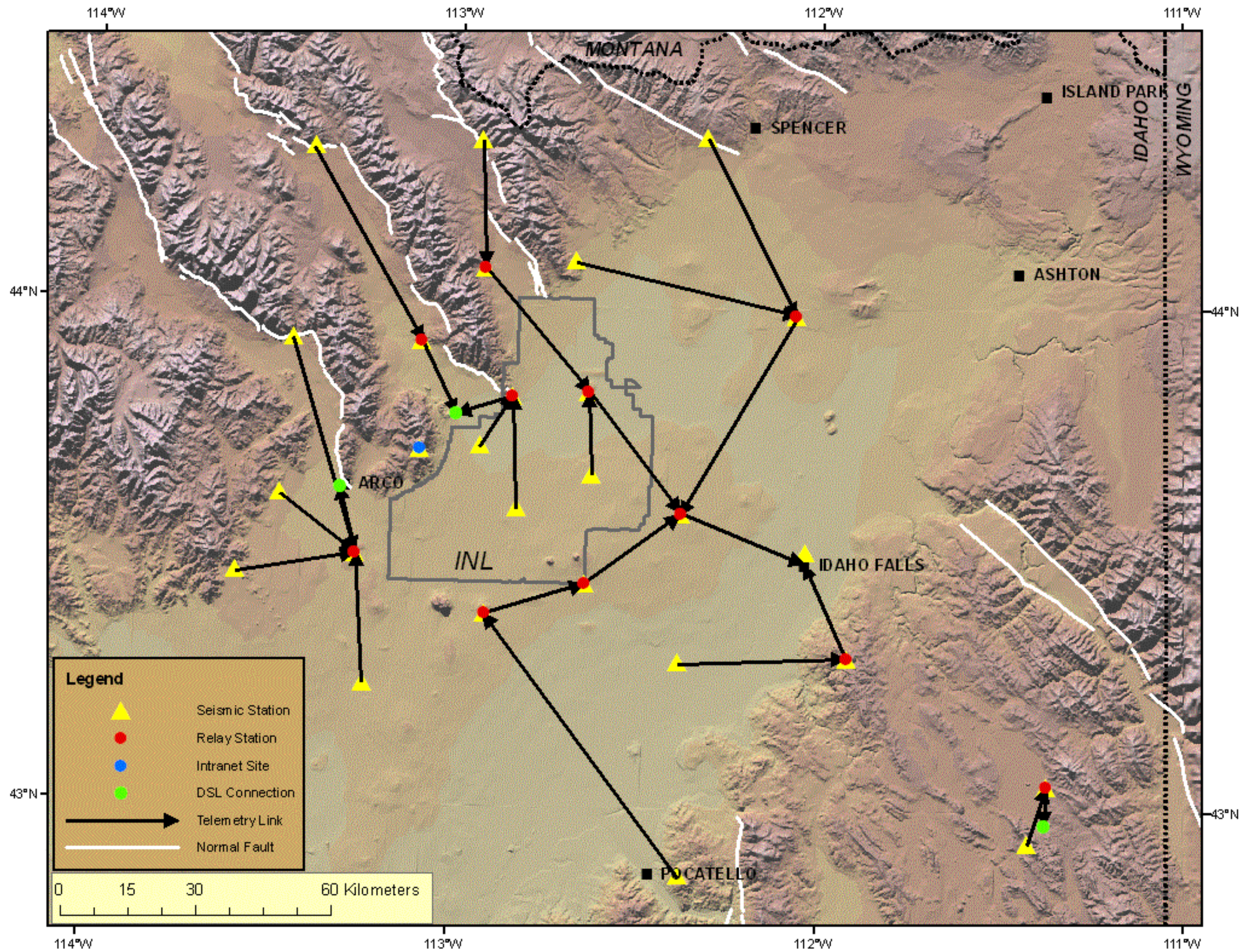

Figure A-1. Telemetry layout for INL seismic stations during 2004.

Appendix B

Instrument Response of NetDAS SMAs

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Appendix B

Instrument Response of NetDAS SMAs

B.1 Method for Determining Amplitude Response

The instrument response of the NetDAS-SMA is used to convert the measured counts of ground motion amplitude to units of g. The NetDAS units that have accelerometers mounted within the unit are calibrated by conducting 1-g (acceleration of gravity) tilt tests. These tests are done on a leveled pad at the IRC seismic lab or on the actual leveled pad at their physical location listed in Table 3. These 1-g tilt tests provide a relationship of the number of digitizer counts equivalent to 1-g offset. From this relationship, the number of counts per g is established. Equation B-1 provides the conversion from the measured count level to actual g level for the recorded motion. Trigger threshold accelerations and counts/g are listed for NetDAS units with SMAs in Table B-1 using equation:

$$\text{Equivalent acceleration (g)} = \text{Counts}_{\text{(Measured or target)}} / \text{(counts/g)} \qquad \text{[B-1]}$$

Equation B-1 cannot be used to convert waveform data collected by the NetDAS units without accelerometers installed in them. For a NetDAS unit without accelerometers there is a frequency dependent amplitude response, which is discussed further in Appendix C. The frequency response information for the NetDAS-4CH should be applied to the acceleration data recorded by accelerometers external to these units. Table B-2 lists the instrument response for these accelerometers using the methods discussed in Appendix C.

Tables B-1 and B-2 list the beginning and ending dates for the time periods that the instrument responses are applicable. If changes occurred to SMA or seismic station instrumentation (such as accelerometer or NetDAS unit) during the year, then more than one range of dates are listed for a location. Also, note that the building numbers and locations for the SMA codes are listed in Table 3.

Table B-1. Instrument response for strong-motion accelerographs.

		Instrument Response			Accelerometer					
INL Site Facility Area	SMA Code	Begin Date	End Date	NetDAS Serial #	Model	Serial #	Orientation	Positive Direction	Counts/g	Trigger Level (g)
MFC	EBR	6/2/2003	12/31/2004	1095	SF2500A	46	Vertical	Down	547675	0.0046
							North	0	554219	0.0045
							East	270	547920	0.0046
	FCF	6/2/2003	12/31/2004	1079	SF2500A	61	Vertical	Down	549212	0.0046
							North	0	559404	0.0045
							East	270	558307	0.0045
CFA	CFAF	12/23/2002	5/6/2004	1097	SF2500A	37	Vertical	Down	561680	0.0045
							North	0	548224	0.0046
							East	270	557569	0.0045
	CFAF	5/6/2004	12/31/2004	1097	SF2500A	37	Vertical	Down	547045	0.0046
							North	0	551038	0.0045
							East	270	558177	0.0045
	EFSF	1/15/2003	5/6/2004	1096	SF2500A	49	Vertical	Down	560732	0.0045
							North	0	530609	0.0047
							East	270	551837	0.0045
	EFSF	5/6/2004	12/31/2004	1096	SF2500A	49	Vertical	Down	553390	0.0045
							North	0	526189	0.0048
							East	270	549747	0.0045

Table B-1. Continued.

		Instrument Response			Accelerometer					
INL Site Facility Area	SMA Code	Begin Date	End Date	NetDAS Serial #	Model	Serial #	Orientation	Positive Direction	Counts/g	Trigger Level (g)
INTEC	CPPF	7/3/2003	5/20/2004	2000	SF2500A	42	Vertical	Down	559054	0.0045
							North	0	548498	0.0046
							East	270	571191	0.0044
	CPPF	5/20/2004	12/31/2004	2000	SF2500A	42	Vertical	Down	552940	0.0045
							North	0	569846	0.0044
							East	270	557651	0.0045
	CPP1	7/3/2003	5/19/2004	2001	SF2500A	50	Vertical	Down	556716	0.0045
							North	0	552755	0.0045
							East	270	559099	0.0045
	CPP1	5/19/2004	12/31/2004	1099	SF2500A	43	Vertical	Down	522025	0.0048
							North	0	563402	0.0044
							East	270	569090	0.0044
	CPP2	7/3/2003	5/19/2004	1078	SF2500A	NA	Vertical	Down	620512	0.0040
							North	0	641121	0.0039
							East	270	621048	0.0040
	CPP2	5/19/2004	12/31/2004	1078	SF2500A	NA	Vertical	Down	615499	0.0041
							North	0	647203	0.0039
							East	270	628378	0.0040
	FAS1	8/21/2003	5/19/2004	1084	SF2500A	48	Vertical	Down	563563	0.0044
							North	0	570173	0.0044
							East	270	558739	0.0045

Table B-1. Continued.

		Instrument Response			Accelerometer					
INL Site Facility Area	SMA Code	Begin Date	End Date	NetDAS Serial #	Model	Serial #	Orientation	Positive Direction	Counts/g	Trigger Level (g)
	FAS1	5/19/2004	12/31/2004	1084	SF2500A	48	Vertical	Down	568601	0.0044
							North	0	572126	0.0044
							East	270	549907	0.0045
	FAS2	8/21/2003	5/19/2004	1083	SF2500A	52	Vertical	Down	545580	0.0046
							North	0	557400	0.0045
							East	270	553412	0.0045
	FAS2	5/19/2004	12/31/2004	1083	SF2500A	52	Vertical	Down	545469	0.0046
							North	0	550078	0.0045
							East	270	562316	0.0044
NRF	NRFF	12/23/2002	12/31/2004	1098	SF2500A	55	Vertical	Down	539329	0.0046
							North	0	552724	0.0045
							East	270	555587	0.0045
	A1W	1/22/2003	12/31/2004	1091	SF2500A	53	Vertical	Down	556354	0.0045
							North	0	564152	0.0044
							East	270	563802	0.0044
	S1W	1/22/2003	12/31/2004	1088	SF2500A	45	Vertical	Down	563302	0.0044
							North	0	557091	0.0045
							East	270	556344	0.0045
PBF	PBFF	12/23/2002	5/19/2004	1099	SF2500A	43	Vertical	Down	533000	0.0047
							North	0	559653	0.0045
							East	270	560023	0.0045

Table B-1. Continued.

		Instrument Response			Accelerometer					
INL Site Facility Area	SMA Code	Begin Date	End Date	NetDAS Serial #	Model	Serial #	Orientation	Positive Direction	Counts/g	Trigger Level (g)
	PBF1	3/11/2003	5/19/2004	1090	SF2500A	56	Vertical	Down	554402	0.0045
							North	180	568899	0.0044
							East	90	601708	0.0042
	PBF2	1/22/2003	5/19/2004	1088	SF2500A	54	Vertical	Down	559395	0.0045
							North	180	569543	0.0044
							East	90	570840	0.0044
RWMC	RWMC	12/23/2002	5/6/2004	1081	SF2500A	58	Vertical	Down	560806	0.0045
							North	0	572612	0.0044
							East	270	525834	0.0048
	RWMC	5/6/2004	11/9/2004	1081	SF2500A	58	Vertical	Down	559481	0.0045
							North	0	576670	0.0043
							East	270	519859	0.0048
RTC	TRAF	8/27/2003	5/6/2004	1094	SF2500A	41	Vertical	Down	535459	0.0047
							North	0	570005	0.0044
							East	270	556635	0.0045
	TRAF	5/6/2004	12/31/2004	1094	SF2500A	41	Vertical	Down	525195	0.0048
							North	0	577435	0.0043
							East	270	554469	0.0045
	TRA1	12/23/2002	5/6/2004	1092	SF2500A	44	Vertical	Down	543796	0.0046
							North	0	562488	0.0044
							East	270	502760	0.0050

Table B-1. Continued.

		Instrument Response			Accelerometer					
INL Site Facility Area	SMA Code	Begin Date	End Date	NetDAS Serial #	Model	Serial #	Orientation	Positive Direction	Counts/g	Trigger Level (g)
	TRA1	5/6/2004	12/31/2004	1092	SF2500A	44	Vertical	Down	539986	0.0046
							North	0	570784	0.0044
							East	270	549115	0.0046
	TRA2	12/23/2002	5/6/2004	1085	SF2500A	57	Vertical	Down	547538	0.0046
							North	0	571192	0.0044
							East	270	558993	0.0045
	TRA2	5/6/2004	12/31/2004	1085	SF2500A	38	Vertical	Down	543172	0.0046
							North	0	556212	0.0045
							East	270	568860	0.0044
STC	IRC	12/16/2002	8/21/2003	1086	SF2500A	52	Vertical	Down	557263	0.0045
							North	0	572415	0.0044
							East	270	566145	0.0044
TAN	TANF	12/23/2002	5/4/2004	1077	SF2500A	40	Vertical	Down	569439	0.0044
							North	0	564102	0.0044
							East	270	556065	0.0045
	TANF	5/4/2004	12/31/2004	1077	SF2500A	40	Vertical	Down	561267	0.0045
							North	0	556232	0.0045
							East	270	564429	0.0044
	TAN1	12/23/2002	5/4/2004	1093	SF2500A	35	Vertical	Down	520982	0.0048
							North	0	568150	0.0044
							East	270	544379	0.0046

Table B-1. Continued.

		Instrument Response			Accelerometer					
INL Site Facility Area	SMA Code	Begin Date	End Date	NetDAS Serial #	Model	Serial #	Orientation	Positive Direction	Counts/g	Trigger Level (g)
	TAN1	5/4/2004	12/31/2004	1093	SF2500A	47	Vertical	Down	575282	0.0043
							North	0	576494	0.0043
							East	270	541081	0.0046
	TAN2	12/23/2002	5/4/2004	1087	SF2500A	39	Vertical	Down	570300	0.0044
							North	0	590686	0.0042
							East	270	552705	0.0045
	TAN2	5/4/2004	12/31/2004	1087	SF2500A	39	Vertical	Down	573037	0.0044
							North	0	598256	0.0042
							East	270	553210	0.0045
	TAN3	12/23/2002	5/4/2004	1080	SF2500A	NA	Vertical	Down	547380	0.0046
							North	0	567920	0.0044
							East	270	548995	0.0046
	TAN3	5/4/2004	12/31/2004	1080	SF2500A	NA	Vertical	Down	534052	0.0047
							North	0	543777	0.0046
							East	270	561958	0.0044

Table B-2. Instrument response of accelerometers located at seismic stations.

Seismic Station	Instrument Response Begin Date	End Date	NetDAS Serial #	Accelerometer Model #	Serial #	Orientation	Counts/V	Positive Direction	V/g	Counts/g
BCYI	1/1/2004	10/28/2004	1071	SF3000L	185	Vertical	805430	Up	1.220	982625
						North	804125	0	1.200	964950
						East	805875	90	1.220	983168
BCYI	10/28/2004	12/31/2004	1071	SF3000L	185	Vertical	839515	Up	1.220	1024208
						North	837795	0	1.200	1005354
						East	839496	90	1.220	1024185
GRRI	1/1/2004	11/9/2004	1031	SF1500A	INL1	Vertical	452004	Up	1.395	630546
						North	486771	37	1.341	652760
						East	445053	127	1.410	627525
GRRI	11/9/2004	12/31/2004	1013	SF2500A	57	Vertical	818908	Up	1.396	1143196
						North	800256	37	1.345	1076344
						East	804890	127	1.412	1136505
HWFI	1/1/2004	6/9/2004	1069	SF2500A	62	Vertical	834003	Up	1.378	1149256
						North	833441	37	1.371	1142648
						East	838237	127	1.352	1133296
HWFI	6/9/2004	12/31/2004	1069	SF2500A	62	Vertical	804926	Up	1.378	1109188
						North	804787	37	1.371	1103363
						East	809507	127	1.352	1094453
NPRI	1/1/2004	10/7/2004	1065	SF2500A	36	Vertical	839342	Up	1.427	1197741
						North	831454	37	1.376	1144081
						East	837778	127	1.371	1148594
NPRI	10/7/2004	12/31/2004	1065	SF2500A	36	Vertical	837440	Up	1.427	1195027
						North	829229	37	1.376	1141019
						East	835391	127	1.371	1145321

Table B-2. Continued.

	Instrument Response			Accelerometer						
Seismic Station	Begin Date	End Date	NetDAS Serial #	Model #	Serial #	Orientation	Counts/V	Positive Direction	V/g	Counts/g
PTI	1/1/2004	11/10/2004	1071	SF3000L	188	Vertical	832903	Up	1.230	1024471
						North	833615	37	1.194	995336
						East	833939	127	1.244	1037420
PTI	11/10/2004	12/31/2004	1071	SF3000L	188	Vertical	837309	Up	1.230	1029890
						North	837818	37	1.194	1000355
						East	838386	127	1.244	1042952
SPCI	1/1/2004	10/6/2004	1070	SF3000L	187	Vertical	806336	Up	1.216	980505
						North	806668	37	1.237	997848
						East	809144	127	1.215	983110
SPCI	10/6/2004	12/31/2004	1070	SF3000L	187	Vertical	828767	Up	1.216	1007781
						North	827770	37	1.237	1023951
						East	829629	127	1.215	1007999
TCSI	1/1/2004	6/9/2004	1067	SF3000L	187	Vertical	829037	Up	1.216	1008109
						North	828765	37	1.237	1025182
						East	830243	127	1.215	1008745
TCSI	6/9/2004	12/31/2004	1067	SF3000L	187	Vertical	806652	Up	1.216	980889
						North	804646	37	1.237	995347
						East	804796	127	1.215	977827

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Appendix C

Instrument Response of Seismic Stations

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Appendix C

Instrument Response of Seismic Stations

C.1 Method for Determining Amplitude Response

The INL calibrated both the NetDAS four (4CH) and eight channel (8CH) NetDAS units. The INL establishes a DC counts/volt level by measuring a known voltage level for a specified duration of time for each channel on the NetDAS units and recording the mean and standard deviation in counts for this duration. The signal polarity is often reversed in order to obtain a greater measurement range. The mean provides the method to produce the DC counts/volt level (Equation C-1a and C-1b) and the standard deviation provides an idea of the measurement uncertainty and system noise.

Single ended:

$$\text{Counts/Volt} = \mu / v_i \qquad \text{[C-1a]}$$

Reversed Polarity:

$$\text{Counts/Volt} = (\mu^{+} - \mu^{-}) / (v_i^{+} - v_i^{-}) \qquad \text{[C-1b]}$$

Where:

μ is mean counts

v_i is input voltage

Subscript "+" is positive polarity

Subscript "– " is negative polarity

C.2 NetDAS-4CH Frequency Response

The response of the Symmetric Research PAR4CH (4CH) digitizer used in the NetDAS-4CH was based on vendor provided information, but calculated at the INL to establish the instrument response of NetDAS units. The vendor DAQSystems, Inc. of the NetDAS units reviewed INL's frequency response results and methods. These methods and results for the response information are provided in the following discussion.

The NetDAS-4CH frequency response was determined empirically by measuring a signal generating a constant amplitude sine wave and changing the frequency of the sine wave and at each step measuring the associated counts reported by the digitizer and NetDAS. This was done for representative frequencies of 0.1, 5, 10, 15, 20, 25, 30, and 35 Hz. This frequency sweep was done twice. The averages of the measured counts at each frequency was then converted into decibel response relative to the average 0.1 value since vendor supplied data states the gain at this frequency should be 1. A 2nd order polynomial was then fit to the data creating a simple amplitude response in frequency. The perfectly matched response (R-squared of one) is shown here as described by Equations C-2 and C-3 (conversion to decibels).

$$Y_{dB} = -0.0045f^2 + 0.0074f - 0.014 \qquad \text{[C-2]}$$

$$dB = 20 \log (E_2/E_1) \quad [C\text{-}3]$$

Where:

E_1 – original signal level

E_2 - modified signal level

E_2/E_1 – commonly referred to as gain

This relationship was then used to calculate the gains to extend the gain frequency information out to the Nyquist frequency (1/2 the sample rate). The INL samples all data at 100 samples per second or Hz. The information was then entered into MATLAB, which has a function to determine poles and zeros. Poles and zeros notations are the form that many seismic applications use to remove the instrument response. The NetDAS-4CH frequency response in dB and poles and zeros are shown in Figure C-1.

Equations C-2 and C-3 can be used in conjunction with the DC counts/volt measurement to generate a count based frequency response for short hand calculations or spectral deconvolution to remove the frequency response.

$$Ycounts = Counts/Volt \times 10\text{^}((-0.0045f^2 + 0.0074f - 0.014)/20) \quad [C\text{-}4]$$

Where:

^ - Indicates 10 to the power of the number calculated in parentheses.

However, the preferred method for removing the frequency response from a recorded waveform is to use a seismic analysis package, such as SEISAN. This program recognizes the poles and zeros representation of instrument response, which quickly and accurately corrects recorded waveforms to actual ground motions.

C.3 NetDAS-8CH Frequency Response

The response of the Symmetric Research PAR24B (8CH) digitizer used in the NetDAS-8CH was based on vendor provided information, and calculated in the same method as described above for the PAR4CH. A 2nd order polynomial was fit to the data creating a simple amplitude response in frequency that matched the amplitude response (R-squared of 0.999). Equation C-5, listed below, is similar to Equation C-3 used for the response of the NetDAS-4CH. The NetDAS-8CH frequency response in dB and poles and zeros are shown in Figure C-2.

$$Y_{dB} = -0.0045f^2 + 0.0071f - 0.0158 \quad [C\text{-}5]$$

C.4 Short-period high-gain seismic stations

In the fall of 2002, INL seismic personnel began tracking instrument response of the seismic stations. Table C-1 lists the measured responses and amplification information for the seismic stations that have been measured for instrument responses.

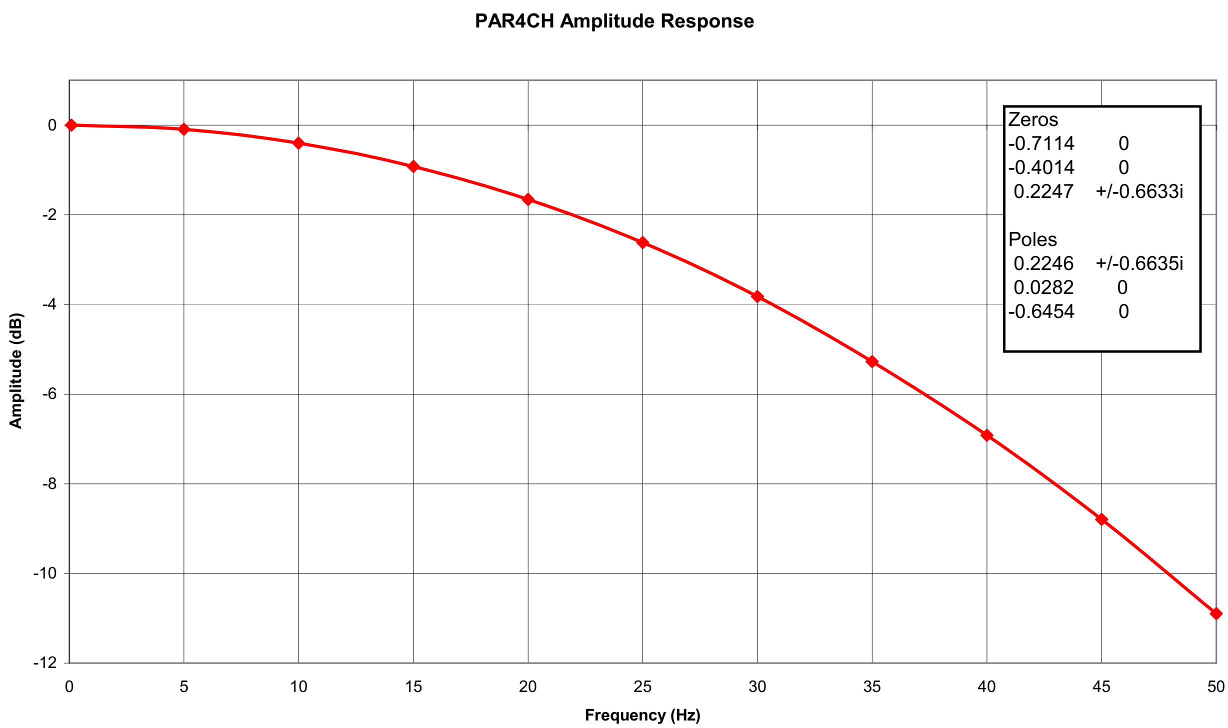

Figure C-1. Amplitude verses frequency system response of the Symmetric Research PAR4CH digitizer used in the NetDAS-4CH.

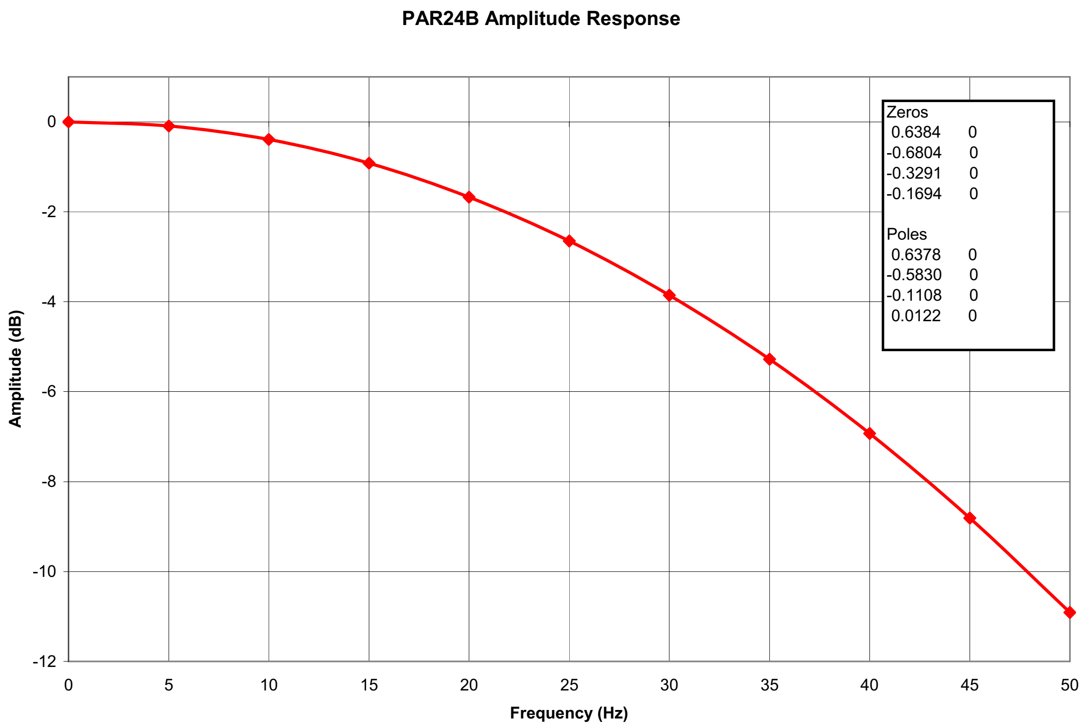

Figure C-2. Amplitude verses frequency system response of the Symmetric Research PAR24B digitizer used in the NetDAS-8CH.

Table C-1. Instrument response of seismometers located at seismic stations.

Seismic Station	Instrument Response Begin Date	End Date	NetDAS Serial #	Digitizer Model	Orientation	Counts/volt	Amplifier Type	Gain	Seismomter Model
Single-component stations									
ARNI	1/1/2004	12/31/2004	1017	4CH	Vertical	NA	4CH	100	S13J
BCYI	11/21/2002	10/28/2004	1068	8CH	Vertical	862,205	4CH	100	S13J
BCYI	10/28/2004	12/31/2004	1068	8CH	Vertical	839,401	4CH	100	S13J
CBTI	10/6/2004	12/31/2004	1029	4CH	Vertical	480,777	4CH	100	S13J
COMI	9/2/2003	10/6/2004	2005	4CH	Vertical	386,801	INL18	90.2	S13
COMI	10/6/2004	12/31/2004	2005	4CH	Vertical	387,088	INL18	90.2	S13
CNCI	10/7/2004	12/31/2004	1066	4CH	Vertical	476,017	4CH	100	L4C
CRBI	12/16/2002	10/27/2004	1015	4CH	Vertical	473,531	4CH	100	S13J
CRBI	10/27/2004	12/31/2004	1027	4CH	Vertical	443,124	None	1	S13J
ECRI	6/6/2003	1/20/2004	1021	4CH	Vertical	477,670	4CH	100	S13
ECRI	1/20/2004	11/11/2004	1051	4CH	Vertical	476,410	4CH	100	S13
ECRI	11/11/2004	12/31/2004	1051	4CH	Vertical	434,299	None	1	S13
EMI	10/27/2004	12/31/2004	1019	4CH	Vertical	476,105	4CH	100	L4C
GBI	10/24/2003	10/26/2004	1026	4CH	Vertical	NA	None	1	S13J
GBI	10/26/2004	12/31/2004	1026	4CH	Vertical	424,375	None	1	S13J
GRRI	6/5/2003	1/20/2004	1022	4CH	Vertical	479,225	4CH	100	S13J
GRRI	1/20/2004	11/9/2004	1012	4CH	Vertical	444,665	INL9	108	S13J
GTRI	1/1/2004	12/31/2004	1021	4CH	Vertical	NA	INL16	90.2	S13J
HHAI	1/1/2004	12/31/2004	1019	4CH	Vertical	NA	4CH	100	S13J

Table C-1. Continued.

Seismic Station	Instrument Response Begin Date	End Date	NetDAS Serial #	Digitizer Model	Orientation	Counts/volt	Amplifier Type	Gain	Seismomter Model
HPI	8/16/2004	12/31/2004	1015	4CH	Vertical	472,446	4CH	100	L4C
KBI	1/1/2004	12/31/2004	1018	4CH	EHZ	NA	INL2	103	S13J
LJI	2/24/2004	12/31/2004	1052	4CH	EHZ	477,522	4CH	100	S13J
ICI	10/27/2004	12/31/2004	1020	4CH	EHZ	477,973	4CH	100	L4C
PZCI	10/28/2003	12/31/2004	1023	4CH	Vertical	400,842	INL13	106	S13J
PTI	4/15/2003	11/10/2004	1071	8CH	Vertical	832,511	4CH	100	S13
PTI	11/10/2004	12/31/2004	1071	8CH	Vertical	836,826	4CH	100	S13
SMBI	8/24/2004	12/31/2004	1063	4CH	Vertical	447,541	None	1	S13J
Three-component stations									
HWFI	6/9/2004	12/31/2004	1069	8CH	Vertical	856,855	4CH	100	S13
					North	857,467	4CH	100	S13
					East	856,426	4CH	100	S13
JGI	11/11/2003	5/11/2004	1010	4CH	Vertical	457,824	4CH	100	S13
					North	464,730	4CH	100	S13
					East	474,780	4CH	100	S13
JGI	5/11/2004	12/31/2004	1010	4CH	Vertical	459,068	4CH	100	S13
					North	463,310	4CH	100	S13
					East	474,627	4CH	100	S13
LLRI	7/21/2003	10/7/2004	1029	4CH	Vertical	472,855	4CH	100	S13J
					North	476,101	4CH	100	S13
					East	472,371	4CH	100	S13

Table C-1. Continued.

Seismic Station	Instrument Response Begin Date	End Date	NetDAS Serial #	Digitizer Model	Orientation	Counts/volt	Amplifier Type	Gain	Seismomter Model
LLRI	10/7/2004	12/31/2004	1029	4CH	Vertical	479,710	4CH	100	S13J
					North	485,322	4CH	100	S13
					East	483,647	4CH	100	S13
NPRI	10/7/2004	12/31/2004	1065	8CH	Vertical	856,746	4CH	100	S13J
					North	857,992	4CH	100	S13
					East	861,760	4CH	100	S13
SPCI	11/24/2003	10/6/2004	1070	8CH	Vertical	804,778	None	1	S13J
					North	821,280	INL22	102	S13
					East	821,786	INL17	102	S13
SPCI	10/6/2004	12/31/2004	1070	8CH	Vertical	826,710	None	1	S13J
					North	827,449	INL22	102	S13
					East	828,404	INL17	102	S13
TCSI	9/3/2003	6/9/2004	1067	8CH	North	804,602	INL99	94.5	S13
					East	805,305	INL12	91	S13
TCSI	6/9/2004	12/31/2004	1067	8CH	Vertical	804,178	INL16	90.2	S13
					North	804,672	INL99	94.5	S13
					East	805,572	INL12	91	S13
TMI	8/10/2004	10/21/2004	1012	4CH	Vertical	484284	4CH	100	S13
					North	450,572	4CH	100	S13
					East	401,864	4CH	100	S13

Table C-1. Continued.

	Instrument Response								
Seismic Station	Begin Date	End Date	NetDAS Serial #	Digitizer Model	Orientation	Counts/volt	Amplifier Type	Gain	Seismomter Model
TMI	10/21/2004	12/31/2004	2004	4CH	Vertical	477351	4CH	100	S13
					North	470,004	4CH	100	S13
					East	475,647	4CH	100	S13

Appendix D

2004 Earthquake List

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Appendix D

2004 Earthquake List

The summary list of earthquakes includes those located within a 161-km (100-mile) radius of the INL centered at 43.0° 39.00' N, 112° 47.00' W. Table D-1 provides an explanation of the headings listed in Table D-2 for the earthquake list. The format for this table has been modified from previous years. The earthquake identification number is no longer reported since the SEISAN analysis package identification number is simply the origin data and time.

Table D-1. Explanation of earthquake list headings.

Heading	Example	Explanation
DATE	2004 01 07	Date of the earthquake: year (2003), month (01), day (01)
ORIGIN	12 32 28.11	Origin time of the earthquake: hour (00), minute (08), and seconds (20.67)
LAT N	44 28.03	Latitude of epicenter in degrees and minutes North
LONG W	112 39.28	Longitude of epicenter in degrees and minutes West
Z	2.16	Calculated focal depth in km. Very few earthquakes have been recorded within the 161-km radius with proper seismic station geometry for calculating a reliable focal depth.
MAG	1.42	Coda magnitude (M_c) of the earthquake as determined under Section 4.2 unless otherwise indicated by a B for BUT, N for NEIC, R for U.S. Bureau of Reclamation (USB), E for BSE, S for SLC, or I for INL, a measured local magnitude (M_L).
NO	5	Number of station readings used in locating the earthquake with weights above 0.1. P- and S-wave arrival times for the same station are regarded as two readings.
GAP	219	Largest azimuthal separation in degrees between stations.
DMIN	69.8	Distance in km from the epicenter to the nearest station.
RMS	0.05	Root mean square error of time residuals in second using all weights as calculated by: $RMS=\sqrt{R_i^2}/NO$ Where: R_i is the time residual for the i^{th} station.
ERH	2.4	Standard horizontal error of the epicenter in km.
ERZ	12.8	Standard vertical error of the focal depth in km.

Table D-2. Earthquakes located within 161-km radius of INL in 2004.

DATE	ORIGIN	LAT N	LONG W	Z	MAG	NO	GAP	DMIN	RMS	ERH	ERZ
2004 01 07	12 32 28.11	44 28.03	112 39.28	2.16	1.42	5	219	69.8	0.05	2.4	12.8
2004 01 07	18 33 49.06	44 15.84	114 22.16	0.08	2.21	10	278	101.2	0.23	5.0	5.3
2004 01 08	13 55 50.29	43 10.14	110 55.73	3.20	1.97	11	107	39.6	0.12	0.5	11.7
2004 01 08	19 44 16.64	43 11.32	110 58.56	3.34	1.37	11	183	35.2	0.22	1.2	4.4
2004 01 08	21 11 31.09	43 9.43	110 59.48	4.87	1.14	6	190	36.3	0.11	1.1	14.7
2004 01 09	09 58 28.63	43 10.86	110 56.18	0.04	1.24	11	193	38.4	0.31	0.9	2.0
2004 01 11	11 03 38.08	43 10.87	110 57.10	0.43	1.95	11	185	37.3	0.25	0.7	2.1
2004 01 11	11 15 46.45	43 10.29	110 58.77	4.98	1.12	6	305	36.0	0.12	1.5	14.7
2004 01 11	21 54 30.45	44 41.44	112 2.79	10.74	1.19	14	157	29.6	0.05	0.5	1.4
2004 01 12	23 02 13.79	43 19.65	111 1.35	5.15	1.06	5	273	25.9	0.15	2.5	15.3
2004 01 12	23 57 42.84	42 51.85	111 28.76	2.23	0.00	4	262	32.9	0.02	2.8	12.6
2004 01 14	02 12 4.54	43 37.02	113 41.05	7.74	0.45	5	256	16.6	0.07	2.8	11.2
2004 01 14	07 05 38.67	43 52.29	113 47.77	5.04	0.00	5	283	48.3	0.06	4.6	9.4
2004 01 21	22 59 37.12	42 51.46	111 16.16	5.55	1.31	7	298	72.6	0.07	2.4	1.8
2004 01 21	23 00 57.76	44 16.90	114 21.32	0.09	1.05	8	313	101.8	0.25	5.8	6.0
2004 01 22	02 10 34.79	43 13.93	111 20.80	2.40	1.97	17	279	92.6	0.24	1.1	1.0
2004 01 24	21 58 24.32	42 54.22	111 9.51	4.98	0.00	7	324	140.9	0.17	3.2	3.2
2004 01 26	08 08 9.75	44 38.85	114 13.00	4.69	2.21	8	330	120.1	0.08	8.1	11.3
2004 01 28	20 41 39.76	42 56.77	111 33.78	2.60	1.16	8	159	11.6	0.27	1.9	25.9
2004 01 30	06 07 24.87	43 29.82	110 51.47	4.97	0.89	7	229	41.6	0.12	1.4	12.4
2004 01 31	17 24 47.20	44 41.12	112 30.51	15.90	0.97	7	197	13.7	0.08	2.1	1.3
2004 01 31	20 19 57.32	43 11.58	111 10.64	12.62	0.86	6	159	22.1	0.16	1.7	2.7
2004 01 31	22 21 46.94	42 54.82	111 23.33	0.03	1.15	6	153	15.6	0.12	0.8	3.4
2004 02 01	03 30 53.24	43 18.32	110 54.16	2.14	1.02	7	120	47.2	0.07	0.7	12.6
2004 02 01	09 24 16.23	44 34.86	112 10.10	10.66	1.19	10	161	18.0	0.1	0.7	1.5
2004 02 01	20 12 54.26	44 16.23	113 58.58	1.73	1.86	12	254	80.1	0.17	1.0	2.5
2004 02 01	20 20 1.82	42 54.37	111 23.25	3.19	1.17	6	163	16.4	0.26	0.9	20.3
2004 02 02	10 34 29.40	44 15.97	114 4.69	2.04	2.14	14	261	86.5	0.17	1.1	2.1
2004 02 02	16 08 10.43	44 39.53	112 34.60	6.54	0.90	9	132	16.2	0.24	0.9	8.4
2004 02 03	00 07 57.63	43 51.21	113 37.91	3.74	0.77	11	245	16.7	0.21	1.3	1.0
2004 02 03	03 39 24.74	44 15.38	113 57.51	6.75	1.60	12	252	54.5	0.26	2.3	5.1
2004 02 03	05 53 27.77	43 0.50	111 17.78	8.11	2.20	6	161	7.9	0.05	2.0	1.5
2004 02 03	07 51 31.83	43 1.20	111 15.54	0.82	0.53	6	141	9.8	0.01	0.9	1.7
2004 02 03	08 26 59.42	43 0.25	111 18.34	9.29	2.01	9	170	7.6	0.08	2.3	1.4
2004 02 03	08 46 2.20	42 59.85	111 18.74	8.76	0.84	5	177	7.8	0.04	5.5	1.6
2004 02 03	12 36 29.16	44 22.46	112 51.72	2.94	1.49	7	137	44.4	0.08	0.9	5.6
2004 02 03	13 42 55.19	43 0.64	111 17.71	2.22	0.62	8	133	7.8	0.27	2.6	15.5
2004 02 04	00 41 0.26	44 8.51	113 53.75	5.01	1.45	10	308	42.8	0.21	7.4	15.6
2004 02 04	16 42 33.62	43 0.54	111 16.15	0.03	0.37	6	137	9.6	0.06	0.8	1.6
2004 02 04	21 53 57.42	44 15.82	114 26.37	0.02	1.70	6	281	112.1	0.22	6.6	7.8
2004 02 04	23 55 31.28	42 54.11	111 23.15	0.06	1.58	8	111	5.0	0.21	1.2	1.8
2004 02 05	19 32 36.52	44 31.77	114 16.56	0.02	1.25	7	278	93.8	0.27	4.0	5.2
2004 02 05	22 29 30.05	42 51.74	111 26.39	0.01	1.32	7	157	8.5	0.22	1.4	1.5
2004 02 06	00 45 49.14	44 28.38	112 58.13	6.28	1.02	5	198	40.6	0.06	2.6	3.4
2004 02 06	10 55 21.04	44 35.15	112 6.44	15.77	0.69	12	130	22.8	0.1	0.4	0.6

Table D-2. Continued.

DATE			ORIGIN			LAT N		LONG W		Z	MAG	NO	GAP	DMIN	RMS	ERH	ERZ
2004	02	07	10	11	45.21	44	40.16	111	59.38	6.87	0.67	8	204	33.2	0.17	0.9	17.8
2004	02	07	12	19	35.39	43	1.20	111	17.08	11.80	1.25	5	212	7.9	0.06	2.3	1.7
2004	02	07	21	37	33.56	42	53.59	111	21.79	2.07	1.45	10	124	6.9	0.17	0.7	17.3
2004	02	09	15	50	28.66	44	33.45	113	57.41	1.38	1.57	10	264	80.7	0.27	3.1	3.5
2004	02	09	15	52	50.52	44	31.74	114	9.64	0.04	1.79	13	285	87.5	0.3	3.3	3.8
2004	02	09	20	13	57.99	44	13.38	114	27.42	5.51	1.45	7	291	86.9	0.19	5.6	7.5
2004	02	10	00	00	4.45	42	52.84	111	24.50	0.02	1.16	11	122	6.5	0.32	1.4	1.3
2004	02	10	20	15	42.10	44	47.16	111	50.68	5.31	1.69	8	178	15.5	0.07	0.8	0.7
2004	02	11	16	55	3.23	42	56.56	111	34.88	3.94	1.02	6	181	21.1	0.06	2.1	12.5
2004	02	11	18	06	20.70	44	16.19	114	20.51	0.08	1.39	9	280	80.7	0.2	3.3	3.6
2004	02	11	22	11	1.78	42	57.68	111	37.23	2.50	0.00	6	185	22.8	0.29	3.4	27.3
2004	02	12	20	15	52.50	44	16.00	114	2.20	0.38	0.89	10	269	60.0	0.2	4.2	5.1
2004	02	12	22	10	56.96	42	52.93	111	20.67	13.69	1.16	5	150	19.1	0.22	4.3	4.4
2004	02	12	23	21	26.85	42	54.11	111	22.51	0.02	1.54	8	120	5.5	0.03	0.4	0.8
2004	02	13	00	00	27.46	42	53.71	111	24.40	4.78	1.65	11	117	4.9	0.27	1.2	1.5
2004	02	13	01	03	3.99	42	41.58	111	38.99	0.02	2.10	12	148	45.7	0.21	0.7	1.7
2004	02	13	01	28	45.56	44	7.72	113	53.05	1.39	0.00	12	292	41.2	0.14	2.3	2.3
2004	02	13	05	34	6.47	42	40.70	111	37.53	4.96	1.68	8	154	44.1	0.14	0.7	14.3
2004	02	13	11	59	36.92	42	42.38	111	38.78	5.11	1.31	7	211	45.2	0.06	1.3	11.8
2004	02	13	12	03	52.23	42	41.31	111	37.08	13.24	1.10	8	176	43.3	0.12	0.6	1.4
2004	02	14	03	55	0.89	43	2.11	111	28.81	1.11	0.00	7	200	9.2	0.03	2.1	3.0
2004	02	14	16	55	8.59	44	50.43	112	7.52	6.87	1.33	8	186	34.8	0.06	1.0	11.1
2004	02	14	21	19	25.30	42	54.72	111	20.53	12.86	1.52	6	129	15.9	0.02	1.3	1.4
2004	02	15	21	31	13.34	42	54.66	111	21.08	13.46	1.47	5	152	15.9	0.01	1.6	1.7
2004	02	16	22	18	11.50	42	52.93	111	23.28	2.10	1.28	8	184	19.1	0.08	4.2	14.4
2004	02	16	23	54	24.93	42	54.42	111	20.82	11.28	1.39	8	127	16.4	0.04	1.2	1.5
2004	02	17	00	42	43.60	44	16.85	114	32.70	0.62	0.00	9	286	95.9	0.17	3.6	4.7
2004	02	17	17	17	8.31	43	6.41	111	46.45	3.62	0.83	4	266	33.4	0.04	3.5	7.3
2004	02	17	22	19	2.56	42	44.96	111	34.68	5.02	0.00	4	288	37.8	0.23	5.2	21.8
2004	02	18	00	16	49.30	43	40.90	110	49.48	3.02	0.78	5	229	25.6	0.12	5.8	14.1
2004	02	18	05	52	2.80	44	37.86	112	48.51	9.31	1.60	7	138	22.1	0.05	1.1	6.8
2004	02	18	22	33	55.70	42	57.58	111	37.24	5.05	1.06	4	198	22.9	0.1	2.7	14.9
2004	02	20	00	00	23.08	42	53.83	111	23.79	0.03	1.68	13	103	5.0	0.23	0.7	1.1
2004	02	20	18	39	0.46	44	15.14	113	54.19	3.86	1.23	14	258	51.0	0.24	1.2	3.4
2004	02	20	23	59	55.32	42	57.12	111	22.69	15.25	0.93	5	196	11.3	0.05	0.8	1.3
2004	02	21	17	16	26.33	44	40.78	112	15.65	10.30	1.07	12	153	14.3	0.09	0.4	1.1
2004	02	22	20	18	29.70	42	53.99	111	22.50	0.03	0.95	12	106	5.7	0.25	0.8	1.3
2004	02	23	22	22	44.46	42	52.49	111	19.00	10.38	1.34	8	110	20.3	0.06	0.6	1.3
2004	02	23	23	52	21.58	42	52.95	111	25.33	2.67	1.01	8	108	6.2	0.22	1.3	6.7
2004	02	24	06	00	51.07	42	47.00	111	14.21	12.29	0.68	8	112	11.4	0.11	3.2	3.2
2004	02	24	06	52	56.96	43	36.27	111	11.93	9.33	1.81	18	143	29.1	0.15	0.5	1.5
2004	02	24	18	14	43.43	42	52.89	111	22.37	2.52	0.77	6	198	19.1	0.04	1.1	11.2
2004	02	25	20	01	32.85	44	14.11	114	18.54	10.42	1.20	9	232	75.1	0.09	1.1	1.4
2004	03	01	22	25	27.49	42	52.71	111	18.78	3.10	1.05	6	131	20.0	0.04	0.6	10.8
2004	03	02	00	21	48.97	44	16.17	114	33.35	0.02	1.47	9	253	79.5	0.29	2.0	2.8
2004	03	02	07	10	5.71	42	43.65	111	38.51	8.61	0.67	11	171	42.5	0.29	1.0	11.1

Table D-2. Continued.

DATE			ORIGIN			LAT N		LONG W		Z	MAG	NO	GAP	DMIN	RMS	ERH	ERZ
2004	03	02	21	51	36.43	44	13.04	114	5.22	6.46	0.77	7	215	60.1	0.11	0.9	2.3
2004	03	02	22	08	20.63	42	53.13	111	26.01	5.59	1.82	10	169	5.9	0.23	1.2	1.3
2004	03	02	22	24	1.30	42	50.07	111	23.91	15.28	0.00	4	257	24.4	0	3.9	1.5
2004	03	03	22	29	25.20	42	50.02	111	24.20	18.54	0.78	5	259	24.6	0.02	3.4	3.1
2004	03	04	05	23	26.18	42	43.96	111	38.97	5.00	0.88	7	172	42.3	0.17	0.9	17.0
2004	03	05	10	40	35.59	42	41.04	111	32.46	33.73	1.58	7	164	37.2	0.03	1.5	3.1
2004	03	05	23	51	49.08	42	49.31	111	28.73	2.02	1.70	6	349	13.7	0.3	16.3	6.2
2004	03	07	13	37	8.86	44	47.37	112	27.69	0.24	0.99	9	172	22.4	0.06	1.2	2.5
2004	03	09	22	23	29.35	42	50.55	111	39.29	5.00	0.00	5	323	21.8	0.26	4.6	4.9
2004	03	10	00	16	34.09	44	13.77	114	36.21	4.96	1.72	5	327	135.3	0.01	7.3	10.1
2004	03	10	19	52	13.88	44	51.85	112	57.49	11.46	1.33	5	297	9.5	0.01	1.8	1.0
2004	03	10	22	25	2.50	42	54.87	111	29.76	2.33	1.25	7	166	6.6	0.12	1.8	15.1
2004	03	11	22	32	19.71	42	52.96	111	21.56	9.25	0.34	6	144	19.0	0.04	0.9	2.7
2004	03	12	01	47	23.33	42	51.77	111	29.13	2.14	1.40	7	264	9.8	0.16	1.4	17.2
2004	03	12	02	07	8.12	44	30.14	111	13.72	6.16	0.54	7	134	33.6	0.26	0.9	23.9
2004	03	12	03	42	53.07	42	52.51	111	14.75	2.12	0.44	9	123	17.0	0.28	1.8	26.3
2004	03	12	05	26	59.06	44	47.03	112	48.54	1.88	1.64	12	154	5.8	0.11	1.6	3.2
2004	03	12	18	07	43.96	44	29.13	112	39.22	8.84	0.81	10	124	23.8	0.1	0.5	6.2
2004	03	13	00	32	58.89	43	11.01	111	26.46	11.11	0.56	6	224	15.5	0.06	2.4	1.2
2004	03	13	04	24	53.91	44	50.22	112	6.68	5.84	1.55	12	185	37.2	0.13	0.7	4.2
2004	03	13	23	54	39.77	42	51.78	111	27.49	0.02	0.88	7	259	8.8	0.19	1.3	1.7
2004	03	14	18	09	1.01	42	51.45	111	27.82	2.02	1.16	6	262	9.6	0.09	1.8	14.7
2004	03	14	22	25	38.83	43	31.45	111	5.13	14.06	0.70	6	214	27.2	0.06	2.8	1.1
2004	03	14	22	30	53.38	43	31.66	111	5.11	12.52	1.22	11	189	27.5	0.15	0.7	1.1
2004	03	14	23	13	21.95	43	33.24	111	12.63	10.99	1.19	10	172	57.1	0.07	1.1	2.8
2004	03	14	23	59	50.08	43	32.50	111	7.38	3.32	1.12	8	181	26.4	0.07	1.0	11.8
2004	03	15	01	05	3.93	43	32.15	111	8.50	2.90	0.67	7	178	24.9	0.09	2.0	13.0
2004	03	15	01	27	46.36	43	31.38	111	4.12	8.68	0.44	6	217	28.1	0.07	1.7	4.4
2004	03	15	01	56	6.34	43	29.20	111	0.65	5.07	0.85	5	236	29.8	0.11	2.9	12.4
2004	03	15	03	52	59.32	43	31.94	111	4.90	8.91	1.28	9	189	28.0	0.08	1.2	3.4
2004	03	15	07	40	20.10	43	31.52	111	4.95	13.20	0.98	8	190	27.4	0.11	1.2	0.7
2004	03	15	07	49	4.94	43	32.31	111	6.79	11.45	0.64	6	205	26.7	0.06	1.8	3.9
2004	03	16	00	03	10.25	42	54.44	111	27.27	2.16	1.12	9	160	4.3	0.2	2.6	11.9
2004	03	17	02	22	9.78	43	59.39	114	25.12	8.27	1.99	8	267	47.5	0.1	1.0	3.9
2004	03	17	19	29	43.01	44	40.60	114	3.27	2.74	1.86	15	246	96.0	0.19	0.9	1.7
2004	03	17	23	34	6.86	44	15.71	114	20.54	0.03	1.63	8	237	77.9	0.28	3.9	12.7
2004	03	17	23	47	8.05	42	54.07	111	23.43	0.03	1.19	13	116	4.8	0.24	0.6	1.4
2004	03	18	04	02	44.08	42	54.69	111	13.64	13.42	0.92	5	177	19.3	0.04	1.9	3.2
2004	03	18	15	25	26.70	44	49.96	112	7.36	5.91	1.27	8	184	34.2	0.09	1.0	14.4
2004	03	18	17	48	24.36	44	42.85	113	34.47	0.02	2.30	26	239	87.9	0.24	1.1	1.1
2004	03	19	22	02	54.00	43	52.64	113	38.76	4.82	0.82	8	255	16.6	0.11	1.9	1.0
2004	03	20	00	06	57.53	42	53.19	111	38.24	2.61	1.75	9	181	18.5	0.08	0.7	13.6
2004	03	20	12	26	34.52	44	7.68	113	7.90	7.07	0.19	7	283	17.5	0.09	1.3	12.2
2004	03	20	23	53	13.49	42	54.25	111	24.22	7.17	1.31	9	111	4.0	0.11	0.8	0.4
2004	03	21	02	19	10.60	43	28.32	111	0.96	5.09	0.58	6	205	28.8	0.1	1.6	12.0
2004	03	21	02	26	54.53	43	29.55	111	2.55	4.69	0.85	6	199	27.9	0.06	1.7	12.4

Table D-2. Continued.

DATE	ORIGIN	LAT N	LONG W	Z	MAG	NO	GAP	DMIN	RMS	ERH	ERZ
2004 03 21	09 17 7.96	44 15.61	114 1.41	7.41	1.28	14	213	58.8	0.31	1.6	4.2
2004 03 22	15 54 49.41	42 52.00	111 26.12	2.84	0.52	4	174	21.4	0.01	0.7	12.3
2004 03 22	17 24 5.02	42 54.69	111 23.24	7.39	1.30	8	116	4.1	0.11	1.1	0.9
2004 03 24	06 23 29.91	44 22.39	112 36.12	4.59	1.29	16	104	23.0	0.17	0.4	1.1
2004 03 24	18 45 4.09	42 51.72	111 30.27	2.47	1.52	5	266	10.8	0.14	1.5	15.3
2004 03 24	23 08 2.44	42 44.76	111 25.44	2.19	0.96	5	353	21.3	0.26	12.9	25.0
2004 03 25	21 46 2.65	42 50.72	111 30.41	4.40	0.91	5	269	12.4	0.08	2.7	10.8
2004 03 27	00 09 2.00	42 48.51	111 29.13	2.10	0.73	6	351	15.3	0.27	8.3	26.0
2004 03 29	14 09 12.65	44 18.08	114 3.92	1.40	1.78	11	219	86.5	0.16	1.0	1.5
2004 03 31	02 56 12.25	44 12.82	114 4.00	2.75	1.98	12	213	58.6	0.09	0.7	1.5
2004 03 31	22 09 24.19	44 33.88	111 44.92	4.97	0.72	4	297	61.4	0.05	6.5	11.6
2004 04 01	21 26 59.60	42 51.26	111 30.01	0.01	0.00	6	267	11.3	0.22	1.8	2.0
2004 04 01	23 53 4.31	42 51.46	111 29.47	2.00	1.39	6	265	10.6	0.2	2.6	21.0
2004 04 04	22 03 43.64	42 51.11	111 31.94	2.40	1.10	6	270	13.2	0.2	2.8	19.5
2004 04 05	02 22 14.01	44 11.37	114 2.12	2.97	1.48	10	208	52.1	0.16	0.9	2.8
2004 04 06	02 15 48.58	44 49.67	112 29.30	6.48	1.30	6	188	28.5	0.04	0.7	12.9
2004 04 08	22 53 55.66	42 51.54	111 29.89	0.01	1.26	4	338	10.8	0.15	8.4	2.5
2004 04 11	21 18 53.28	42 51.36	111 27.97	0.02	1.16	6	262	9.8	0.23	1.9	2.4
2004 04 13	21 57 52.45	42 51.17	111 29.81	2.00	1.13	6	266	11.3	0.23	2.9	22.7
2004 04 14	18 11 41.57	42 38.99	111 29.65	4.96	0.88	6	150	34.7	0.1	0.8	14.0
2004 04 15	07 40 47.51	44 20.04	113 57.77	7.21	1.27	9	214	60.8	0.04	1.1	13.0
2004 04 15	18 17 9.77	44 41.73	112 22.67	14.29	1.36	15	153	11.4	0.07	0.4	0.7
2004 04 16	20 12 53.72	42 54.08	111 25.94	5.62	1.09	8	157	4.2	0.3	1.1	1.6
2004 04 19	21 02 49.15	42 48.31	111 33.91	2.31	1.24	6	280	18.8	0.2	2.0	20.5
2004 04 20	22 31 41.76	44 26.22	112 56.26	6.70	1.08	6	190	40.3	0.04	1.2	2.9
2004 04 22	22 58 50.35	42 47.76	111 35.83	2.62	1.11	6	284	21.3	0.18	1.9	18.8
2004 04 23	22 37 21.73	44 19.26	112 50.14	7.53	0.53	7	164	28.4	0.12	1.1	14.6
2004 04 24	18 30 5.66	42 56.01	111 34.49	2.36	0.90	8	192	21.3	0.23	1.3	22.3
2004 04 26	03 21 36.02	44 45.62	111 32.18	10.26	0.74	5	263	10.8	0.07	2.8	4.9
2004 04 28	21 35 34.54	42 58.84	111 19.10	4.55	0.66	7	164	9.1	0.23	1.4	3.0
2004 04 30	17 28 57.88	44 2.09	114 24.49	0.04	1.92	19	281	77.6	0.25	2.9	3.2
2004 05 02	14 50 48.95	44 35.88	112 6.06	13.52	0.88	6	154	23.3	0.05	0.6	1.4
2004 05 02	17 12 48.29	42 55.88	111 6.07	4.96	0.96	7	200	18.4	0.07	1.0	5.1
2004 05 02	19 18 3.16	42 56.15	111 5.33	3.65	0.60	5	206	19.0	0.03	1.3	9.2
2004 05 02	23 22 28.41	42 55.90	111 6.24	7.63	1.04	6	200	18.5	0.05	1.1	2.2
2004 05 03	03 39 42.94	42 42.93	111 41.00	5.04	0.80	7	175	45.4	0.11	0.9	14.3
2004 05 03	15 47 3.02	42 56.11	111 5.41	5.67	0.51	5	205	18.9	0.06	1.3	7.0
2004 05 03	21 57 11.10	42 41.78	111 39.07	0.02	1.48	12	148	45.8	0.35	1.2	2.9
2004 05 03	22 57 41.30	42 50.96	111 31.14	1.83	0.68	6	269	12.7	0.22	6.7	9.3
2004 05 05	17 45 54.18	44 41.93	112 7.00	4.61	0.79	7	160	25.0	0.03	0.7	1.1
2004 05 05	23 03 41.04	42 52.57	111 26.51	5.97	1.28	8	156	7.1	0.22	1.2	2.0
2004 05 06	11 39 34.73	44 20.43	113 58.54	7.45	1.13	6	216	62.1	0.13	1.1	16.7
2004 05 07	05 24 30.64	44 33.48	112 50.95	0.02	1.37	8	145	30.0	0.18	1.1	1.9
2004 05 08	05 26 27.93	42 56.05	111 4.60	7.82	0.75	5	209	18.9	0.08	1.9	2.7
2004 05 09	02 35 41.06	44 27.41	114 8.08	0.02	1.48	11	234	80.2	0.3	1.8	3.8
2004 05 10	11 25 51.29	44 21.85	114 0.32	14.58	1.40	9	219	65.6	0.12	0.8	1.2

Table D-2. Continued.

DATE			ORIGIN			LAT N		LONG W		Z	MAG	NO	GAP	DMIN	RMS	ERH	ERZ
2004	05	11	12	40	23.99	44	36.43	112	34.39	3.25	1.01	4	137	14.3	0.05	5.2	10.7
2004	05	12	11	55	42.26	42	54.76	111	27.09	0.21	0.62	5	263	3.7	0.02	1.0	1.4
2004	05	12	12	22	38.15	42	41.42	111	56.89	4.34	1.49	11	92	65.2	0.24	0.9	7.1
2004	05	12	12	31	7.50	42	41.37	111	54.71	13.50	1.07	8	131	59.9	0.16	0.9	1.4
2004	05	12	13	31	33.31	42	40.87	111	57.38	7.42	1.88	14	83	63.3	0.1	0.4	2.0
2004	05	13	13	41	6.61	44	23.06	112	46.70	11.38	0.72	6	191	49.6	0.13	2.2	6.9
2004	05	13	19	39	53.63	44	40.55	111	49.54	4.38	0.64	7	147	14.0	0.07	0.7	1.2
2004	05	14	12	12	37.96	42	44.79	111	52.31	5.03	1.09	8	173	53.3	0.05	1.2	11.9
2004	05	14	18	56	18.91	44	28.74	112	16.34	5.05	1.15	10	104	16.0	0.12	0.7	1.2
2004	05	14	21	10	24.06	44	40.20	111	52.51	5.94	1.88	8	144	17.9	0.09	0.5	13.3
2004	05	14	22	58	34.82	42	51.26	111	28.89	2.43	1.16	6	264	10.5	0.16	1.7	16.3
2004	05	14	23	39	33.62	44	16.07	114	3.90	5.60	1.95	13	216	61.9	0.16	0.8	2.4
2004	05	15	04	21	59.28	42	43.68	111	49.85	5.48	1.92	15	75	52.2	0.11	0.4	3.0
2004	05	15	04	48	4.45	42	43.90	111	50.02	3.44	1.86	17	75	52.1	0.11	0.4	2.4
2004	05	15	05	13	42.79	42	44.72	111	51.18	2.50	1.00	9	171	52.2	0.2	1.2	20.8
2004	05	15	05	42	39.03	42	43.48	111	48.84	9.80	1.93	11	91	51.4	0.19	0.9	3.4
2004	05	15	07	12	51.92	42	44.42	111	51.18	3.06	1.11	9	127	52.6	0.15	0.9	16.5
2004	05	15	10	36	49.41	42	42.94	111	47.98	4.99	1.18	9	163	51.4	0.07	0.7	11.8
2004	05	15	11	07	44.22	42	44.51	111	48.73	2.50	1.25	5	143	50.0	0.11	1.1	15.4
2004	05	15	12	04	11.99	44	44.88	112	52.67	3.67	1.67	7	183	9.1	0.01	5.0	9.0
2004	05	15	14	50	54.44	44	7.25	114	19.71	3.28	1.24	5	275	62.3	0.07	3.3	7.2
2004	05	15	20	13	8.58	42	53.96	111	23.05	0.03	0.00	10	118	5.3	0.28	1.0	1.9
2004	05	16	04	30	41.95	44	45.72	111	33.26	11.77	1.12	6	276	9.5	0.1	1.7	0.9
2004	05	17	21	53	6.15	42	50.62	111	30.75	2.45	1.29	6	269	12.8	0.11	2.2	14.8
2004	05	17	22	03	4.45	44	37.48	112	5.23	5.07	1.08	10	139	24.6	0.1	0.8	2.3
2004	05	20	22	06	49.86	42	47.37	111	28.79	3.78	1.15	4	276	30.7	0.06	2.5	13.1
2004	05	21	13	43	35.77	42	41.11	111	44.51	5.00	0.44	6	168	50.9	0.12	0.9	14.7
2004	05	21	15	20	27.90	44	34.27	113	1.69	6.34	0.79	7	180	27.7	0.26	2.0	4.0
2004	05	21	21	15	4.50	42	53.29	111	23.73	0.02	1.46	8	138	5.9	0.18	1.3	2.0
2004	05	23	18	49	6.38	43	31.49	111	5.00	3.50	0.90	7	190	27.4	0.06	1.6	11.2
2004	05	24	21	10	14.07	42	53.20	111	16.89	14.20	1.05	5	207	19.9	0.03	2.4	1.2
2004	05	25	18	36	2.23	42	53.16	111	21.02	11.57	1.11	4	140	18.7	0.02	7.6	9.8
2004	05	25	21	36	36.82	42	52.50	111	19.13	2.51	1.22	7	109	10.9	0.1	0.9	11.4
2004	05	25	23	31	43.53	42	53.81	111	24.48	2.00	1.25	10	154	4.7	0.17	1.2	19.2
2004	05	26	08	09	48.31	44	43.44	112	25.78	2.47	1.02	6	239	14.8	0.1	3.4	3.4
2004	05	26	21	31	40.90	42	52.53	111	24.30	0.01	1.35	10	120	7.1	0.2	0.8	1.5
2004	05	29	11	30	47.79	42	44.26	111	42.46	4.94	0.97	7	197	44.6	0.11	0.8	14.1
2004	05	31	21	38	0.88	42	50.79	111	31.06	2.49	1.06	7	270	12.8	0.17	1.3	16.9
2004	06	02	17	27	34.82	42	42.32	111	38.69	5.03	1.62	5	109	45.1	0.04	0.6	11.4
2004	06	03	14	37	20.14	43	13.57	111	21.04	0.02	1.28	9	178	15.2	0.21	2.2	1.5
2004	06	03	22	20	37.92	44	38.90	111	52.71	0.08	0.86	5	160	19.1	0.27	2.4	9.2
2004	06	04	17	06	24.21	43	32.25	111	5.62	2.99	1.35	8	186	27.7	0.08	1.4	10.3
2004	06	04	17	58	48.49	43	32.29	111	6.48	1.76	1.33	9	161	26.9	0.11	1.0	1.4
2004	06	04	20	54	10.54	42	59.40	111	35.64	5.65	1.25	9	127	19.5	0.07	0.5	2.9
2004	06	05	03	44	19.70	44	37.35	112	46.21	0.36	1.07	7	142	23.6	0.03	0.8	2.3
2004	06	05	03	48	29.57	43	32.27	111	6.14	2.68	1.30	8	185	27.2	0.1	1.2	12.0

Table D-2. Continued.

DATE			ORIGIN			LAT N		LONG W		Z	MAG	NO	GAP	DMIN	RMS	ERH	ERZ
2004	06	05	22	48	6.05	42	51.58	111	30.24	0.06	1.27	8	177	11.0	0.06	0.6	0.9
2004	06	07	02	02	31.16	44	46.48	111	36.76	7.95	0.96	8	198	6.5	0.19	1.1	2.3
2004	06	09	01	54	20.01	44	10.05	114	27.94	0.02	1.54	10	244	67.4	0.08	1.8	2.8
2004	06	09	02	29	49.33	44	14.84	113	56.56	0.31	1.35	11	251	43.5	0.09	1.7	1.0
2004	06	10	05	01	31.04	44	21.83	113	59.21	18.24	1.02	10	218	83.5	0.09	0.8	14.5
2004	06	10	05	39	4.82	44	20.43	113	57.62	7.67	1.32	11	215	44.4	0.21	1.1	20.6
2004	06	10	22	55	10.90	42	52.08	111	27.14	0.03	1.37	8	170	8.2	0.28	1.5	1.4
2004	06	11	03	11	35.47	44	17.36	114	33.79	1.25	0.93	5	254	81.7	0.18	2.2	3.0
2004	06	12	17	12	44.67	42	37.97	111	39.47	4.99	0.00	10	143	48.0	0.12	0.5	12.2
2004	06	13	23	38	51.56	42	53.81	111	25.55	6.42	1.12	6	185	4.6	0.18	4.8	1.1
2004	06	14	18	43	13.88	42	41.08	111	36.84	5.00	1.86	6	144	45.6	0.13	1.5	15.1
2004	06	15	14	23	35.26	42	49.00	111	34.52	6.72	0.64	4	294	31.2	0.1	2.6	14.6
2004	06	16	21	52	56.75	42	55.22	111	19.03	11.70	0.10	5	177	15.4	0.02	4.7	2.0
2004	06	17	13	04	34.23	44	0.49	113	54.18	6.83	1.78	22	182	52.1	0.29	0.7	2.5
2004	06	17	22	55	15.52	42	54.34	111	23.98	8.88	0.00	9	117	4.0	0.2	0.9	0.8
2004	06	17	23	38	28.13	44	13.46	113	11.56	12.64	0.90	11	133	19.5	0.08	0.4	2.1
2004	06	18	01	18	25.21	44	26.29	111	9.94	2.58	0.41	8	103	27.6	0.09	0.5	11.7
2004	06	18	06	44	14.30	43	54.79	113	44.06	6.88	3.30 N	16	155	51.2	0.18	0.6	3.5
2004	06	18	07	05	30.44	43	54.70	113	44.01	6.43	1.88	15	155	51.1	0.16	0.6	3.3
2004	06	18	07	12	51.76	43	54.31	113	43.50	6.46	1.08	11	157	50.4	0.15	0.7	2.8
2004	06	18	09	23	24.42	43	54.30	113	43.92	7.92	1.32	11	154	50.5	0.16	0.7	17.1
2004	06	18	11	50	36.73	43	54.02	113	43.08	6.96	1.13	7	175	49.7	0.1	0.8	10.9
2004	06	18	12	54	24.69	43	54.34	113	43.59	4.69	1.16	11	158	50.5	0.13	0.7	3.2
2004	06	19	05	29	35.56	44	18.93	114	3.40	6.63	1.20	13	219	52.0	0.18	1.1	3.6
2004	06	20	03	38	53.70	43	54.61	113	43.18	11.42	1.96	8	176	66.2	0.06	1.2	2.2
2004	06	21	11	30	42.31	43	54.76	113	43.69	5.18	1.55	9	159	66.8	0.13	1.5	3.5
2004	06	22	23	10	40.27	42	52.17	111	28.23	0.36	1.23	7	173	8.6	0.2	1.3	2.1
2004	06	25	01	44	10.30	44	46.70	113	23.02	9.12	1.40	7	288	42.7	0.02	1.5	3.6
2004	06	25	15	48	16.53	44	37.31	113	58.23	0.11	1.64	18	238	56.7	0.34	3.0	4.5
2004	06	26	22	48	44.99	42	55.04	111	21.53	0.04	0.00	8	127	5.6	0.28	0.8	1.4
2004	06	27	08	18	46.04	42	49.44	111	20.03	9.34	2.03	11	108	14.5	0.09	0.4	1.0
2004	07	01	19	01	13.72	44	27.93	112	55.90	0.10	1.57	14	123	15.2	0.12	0.4	1.6
2004	07	02	12	07	0.33	44	45.43	112	50.36	3.24	0.88	7	146	7.9	0.07	5.0	10.6
2004	07	02	12	20	28.38	44	26.91	112	56.14	5.15	0.00	16	153	13.3	0.11	0.5	0.8
2004	07	03	23	00	7.07	42	56.76	111	15.02	4.71	1.12	4	173	15.4	0.03	3.2	11.8
2004	07	04	19	39	35.61	42	53.83	111	21.78	16.27	1.25	5	122	17.4	0.02	0.9	0.8
2004	07	05	23	49	55.39	44	15.69	114	32.25	0.02	2.39	14	252	78.4	0.2	1.1	1.6
2004	07	06	23	59	21.40	44	12.97	114	2.46	4.29	1.41	4	210	57.0	0.01	1.5	8.8
2004	07	07	17	35	24.87	44	45.45	111	30.85	12.03	0.69	6	174	12.4	0.04	0.7	2.3
2004	07	08	23	43	24.93	42	53.94	111	23.68	16.57	1.16	6	164	17.3	0.06	1.2	0.6
2004	07	09	08	35	57.45	44	37.66	112	19.47	7.92	1.85	18	138	6.7	0.08	0.4	0.9
2004	07	09	23	37	44.38	44	16.12	114	32.21	0.04	0.00	8	274	79.2	0.2	2.8	3.8
2004	07	10	08	03	10.83	44	24.93	112	36.34	8.10	0.00	5	177	25.9	0.07	0.9	12.4
2004	07	10	14	26	10.55	44	36.94	112	5.46	13.83	1.59	13	137	24.2	0.2	0.8	1.6
2004	07	10	18	56	48.02	42	51.77	111	28.26	16.57	1.19	5	172	22.7	0.04	2.0	0.8
2004	07	11	12	02	57.69	44	31.09	112	24.92	3.11	0.68	4	158	8.5	0.05	9.0	9.8

Table D-2. Continued.

DATE			ORIGIN			LAT N		LONG W		Z	MAG	NO	GAP	DMIN	RMS	ERH	ERZ
2004	07	12	11	33	37.15	44	37.13	112	23.44	5.75	1.09	8	134	2.8	0.06	0.7	0.4
2004	07	13	13	24	7.92	44	22.74	112	54.88	4.68	0.44	4	164	5.9	0.21	17.4	12.7
2004	07	17	22	46	58.59	42	51.64	111	28.70	5.06	1.14	4	174	32.7	0.1	1.1	14.1
2004	07	19	03	02	5.56	44	44.11	112	27.73	11.66	0.89	6	232	16.7	0.08	2.3	1.8
2004	07	19	09	49	47.37	42	50.44	111	13.15	5.19	0.00	5	255	12.8	0.01	3.2	7.7
2004	07	19	10	14	35.30	42	49.39	111	13.34	8.73	0.00	15	89	91.0	0.21	0.6	1.7
2004	07	19	12	51	3.47	44	28.14	113	9.03	11.09	2.03	18	160	22.8	0.11	0.5	1.5
2004	07	20	21	11	18.04	42	54.19	111	19.90	9.64	0.00	6	258	24.3	0.07	5.7	8.5
2004	07	21	23	53	30.40	44	16.05	114	33.07	0.02	1.93	14	253	79.2	0.25	3.1	2.9
2004	07	22	19	25	54.10	44	16.38	114	32.57	0.02	2.02	9	252	79.7	0.14	2.1	2.6
2004	07	23	23	36	41.08	44	16.06	114	31.85	0.04	1.62	8	252	79.0	0.16	1.6	2.8
2004	07	26	01	03	54.02	44	52.76	113	8.30	0.16	2.30	21	237	63.1	0.23	3.6	4.2
2004	07	28	22	26	28.32	44	14.95	114	18.93	1.99	1.19	7	258	73.0	0.08	1.9	3.1
2004	08	02	12	23	26.29	44	37.89	112	8.06	11.44	1.58	11	141	21.1	0.08	0.4	1.8
2004	08	03	11	46	9.38	43	33.70	113	46.23	4.74	0.97	7	144	18.1	0.04	0.9	1.8
2004	08	03	19	43	39.22	42	54.96	111	22.67	0.07	0.00	5	123	28.2	0.28	1.2	5.0
2004	08	04	03	23	41.42	44	45.65	111	30.69	12.04	1.04	9	175	12.7	0.07	0.6	1.6
2004	08	05	02	48	28.74	44	26.28	111	12.90	2.31	0.54	7	112	27.6	0.05	0.5	11.3
2004	08	06	11	35	6.31	44	20.15	114	4.31	5.18	2.04	19	222	53.3	0.18	0.8	2.5
2004	08	06	22	46	46.07	42	55.01	111	21.15	13.80	1.65	8	128	26.6	0.14	1.6	2.6
2004	08	08	14	25	7.86	44	45.26	111	30.92	5.41	1.75	10	174	12.2	0.22	1.0	1.3
2004	08	09	22	49	45.90	42	54.66	111	22.36	3.02	1.56	10	122	27.5	0.09	0.5	13.8
2004	08	12	08	42	51.01	44	41.99	111	52.49	10.86	1.32	10	157	16.9	0.11	0.6	2.0
2004	08	12	17	41	45.24	42	40.75	111	37.50	7.93	1.39	9	175	63.8	0.09	0.6	3.8
2004	08	12	21	18	46.04	42	49.79	111	25.66	4.98	0.00	6	140	27.7	0.11	0.8	11.3
2004	08	13	07	53	50.40	44	44.57	112	47.75	5.78	1.39	5	140	10.3	0.02	3.5	6.0
2004	08	13	20	41	46.03	42	53.57	111	22.48	2.21	0.86	6	121	17.9	0.05	1.1	13.2
2004	08	14	01	56	47.12	44	23.28	113	0.64	11.05	0.76	9	186	8.6	0.13	2.8	1.9
2004	08	14	20	14	43.46	43	10.30	110	59.49	11.05	3.60 N	6	199	33.5	0.01	0.8	1.5
2004	08	14	20	30	4.75	43	10.13	110	59.63	9.61	1.65	9	199	33.2	0.07	0.7	2.1
2004	08	15	17	26	18.01	42	53.71	111	24.01	14.75	1.13	7	149	17.7	0.06	3.3	4.1
2004	08	15	18	44	15.83	42	55.77	111	16.96	14.81	1.21	9	167	15.5	0.15	3.2	1.3
2004	08	18	21	23	13.55	42	55.07	111	23.49	10.13	1.29	9	119	15.2	0.1	1.3	1.9
2004	08	19	21	43	41.67	42	55.01	111	19.87	15.73	1.06	9	131	15.5	0.09	1.5	1.0
2004	08	20	09	48	12.36	44	13.16	114	12.16	7.28	1.38	9	224	74.8	0.13	1.6	3.0
2004	08	23	19	30	39.40	42	51.75	111	26.34	5.66	0.93	5	211	21.9	0.11	2.7	14.0
2004	08	26	21	39	58.91	44	13.55	114	4.28	9.36	1.50	6	214	54.0	0.26	3.1	8.0
2004	08	26	22	12	39.32	42	53.69	111	15.06	20.88	0.00	5	172	18.9	0.12	2.7	1.4
2004	08	27	11	44	31.26	44	31.88	114	5.11	0.72	1.90	19	252	84.0	0.31	2.4	2.6
2004	08	27	16	58	57.28	44	21.99	112	29.94	4.86	0.57	5	196	14.8	0.24	8.9	19.8
2004	08	30	20	42	0.19	42	40.82	111	37.01	21.98	1.87	7	125	43.3	0.17	1.6	7.9
2004	08	30	22	52	35.00	42	50.69	111	29.54	4.07	0.82	4	267	25.2	0.05	2.4	13.0
2004	08	31	06	15	53.21	42	45.27	111	27.14	4.99	0.47	4	127	28.8	0	0.9	12.4
2004	08	31	06	21	6.00	43	52.37	113	37.25	3.72	0.71	5	268	14.9	0.05	2.2	1.1
2004	08	31	22	43	9.59	43	1.52	111	25.33	11.36	1.45	8	105	5.2	0.05	2.5	2.1
2004	08	31	22	53	43.93	43	3.22	111	23.12	12.74	1.61	10	145	1.2	0.08	2.9	1.0

Table D-2. Continued.

DATE			ORIGIN			LAT N		LONG W		Z	MAG	NO	GAP	DMIN	RMS	ERH	ERZ
2004	09	01	05	40	21.61	44	22.00	112	37.05	4.64	0.63	13	85	24.1	0.11	0.4	1.0
2004	09	03	20	29	38.59	44	21.63	112	14.89	9.49	0.00	5	295	5.9	0.01	2.1	1.1
2004	09	05	08	09	50.21	44	10.07	114	0.90	7.36	1.43	15	205	74.3	0.13	0.9	1.2
2004	09	06	19	45	23.32	44	27.56	112	53.79	0.02	0.55	7	171	14.9	0.21	1.4	2.5
2004	09	08	22	24	10.31	44	15.46	114	21.04	3.08	1.61	9	237	75.7	0.24	2.5	4.8
2004	09	09	18	32	31.03	42	54.57	111	23.51	5.00	1.02	7	119	28.7	0.25	1.3	6.4
2004	09	10	13	24	4.47	44	15.47	113	48.44	2.87	1.00	7	349	67.8	0.06	3.3	4.7
2004	09	10	16	03	29.88	42	52.77	111	23.42	3.81	1.51	8	114	19.4	0.12	0.9	12.1
2004	09	10	22	53	30.41	42	55.77	111	18.38	19.43	0.75	6	157	14.7	0.16	3.9	2.4
2004	09	11	14	17	44.75	44	45.63	113	58.98	0.02	1.62	13	249	90.1	0.24	2.4	3.6
2004	09	11	14	33	26.64	44	46.22	114	2.10	6.66	1.16	13	252	94.1	0.27	2.7	4.4
2004	09	11	20	05	58.12	44	15.99	114	34.41	1.42	1.37	13	276	79.4	0.24	2.8	3.4
2004	09	11	20	45	52.30	44	14.50	114	17.91	0.01	1.42	5	233	71.7	0.03	2.1	2.1
2004	09	12	19	58	28.76	42	53.57	111	21.81	7.23	1.56	6	124	17.9	0.03	2.2	7.0
2004	09	13	22	15	0.01	42	41.36	111	37.52	4.13	1.48	7	114	43.8	0.12	0.6	16.0
2004	09	14	01	22	32.08	44	26.30	113	6.92	7.70	0.97	7	179	18.4	0.07	1.3	10.1
2004	09	14	01	27	21.13	44	39.21	111	56.06	0.04	1.02	7	142	22.9	0.07	1.0	2.4
2004	09	14	17	16	49.30	42	58.38	111	31.05	5.06	0.74	7	175	15.0	0.06	2.4	12.0
2004	09	14	22	51	26.76	42	58.65	111	13.85	20.70	1.18	5	208	14.2	0.06	5.0	1.0
2004	09	15	22	38	38.75	44	15.55	114	21.57	0.81	1.29	8	238	77.5	0.09	1.1	2.2
2004	09	16	08	32	19.92	44	58.59	112	10.82	6.19	1.40	9	230	45.8	0.11	0.8	14.8
2004	09	16	15	17	2.22	44	13.77	114	11.13	5.49	1.28	18	223	63.0	0.27	1.2	2.5
2004	09	16	22	29	21.42	44	51.39	112	40.77	6.50	0.97	5	245	13.8	0.06	2.6	3.1
2004	09	17	01	24	54.08	44	37.75	111	53.93	0.04	1.69	14	153	21.6	0.12	0.3	1.1
2004	09	17	17	57	25.06	42	51.41	111	28.96	2.85	1.45	4	264	23.7	0.14	3.9	16.9
2004	09	17	23	21	26.94	42	56.60	111	17.07	16.48	0.46	7	167	14.1	0.29	3.1	1.1
2004	09	19	21	47	25.09	42	55.59	111	21.42	16.35	1.00	8	129	14.2	0.29	2.2	1.2
2004	09	20	16	43	22.51	43	47.97	113	33.34	1.70	1.75	23	121	16.6	0.2	0.5	1.1
2004	09	21	03	53	52.68	43	51.07	113	33.83	10.36	1.33	9	160	12.4	0.16	2.1	2.7
2004	09	21	08	20	51.16	44	38.48	111	54.71	0.95	0.96	9	137	21.8	0.1	0.5	1.8
2004	09	21	18	13	24.27	42	53.19	111	22.52	2.53	0.90	6	119	18.6	0.03	0.8	12.6
2004	09	21	21	59	59.53	44	36.77	111	52.90	6.31	0.94	7	152	21.5	0.04	0.8	9.9
2004	09	22	09	16	51.14	42	50.36	111	11.58	9.84	2.11	12	148	11.2	0.12	1.2	1.1
2004	09	22	22	39	21.67	44	15.39	114	23.61	0.02	1.61	7	241	77.1	0.05	1.4	3.0
2004	09	23	16	46	1.12	42	41.66	111	35.86	16.26	1.80	9	81	41.5	0.09	0.9	1.2
2004	09	23	20	19	37.23	42	54.23	111	6.34	2.71	1.06	8	198	15.4	0.05	1.0	11.6
2004	09	24	19	12	21.72	42	53.94	111	21.57	15.20	1.17	5	191	17.2	0.06	4.2	2.5
2004	09	24	22	11	22.18	42	53.76	111	23.79	2.51	1.34	6	114	17.6	0.15	1.4	16.4
2004	09	25	12	16	53.06	43	9.08	111	21.91	1.63	1.15	10	146	10.9	0.11	0.4	1.6
2004	09	25	12	45	5.89	43	9.26	111	22.90	2.00	1.09	11	143	11.2	0.08	0.4	14.3
2004	09	26	19	42	21.04	42	54.33	111	22.09	5.15	0.54	10	123	16.5	0.15	0.8	2.5
2004	09	27	05	40	23.90	44	17.51	114	5.61	7.00	2.00	21	220	65.3	0.28	0.9	2.4
2004	09	28	20	03	46.74	42	47.72	111	15.24	7.24	0.63	5	213	13.0	0.03	2.9	4.8
2004	09	28	20	06	21.11	42	51.00	111	11.93	2.24	1.33	7	173	12.4	0.1	1.0	12.0
2004	09	29	02	16	2.65	42	50.08	111	10.33	11.96	1.87	6	154	9.7	0.04	1.4	1.9
2004	09	29	17	50	20.74	42	55.37	111	19.15	12.54	1.48	9	135	15.1	0.05	0.7	0.9

Table D-2. Continued.

DATE			ORIGIN			LAT N		LONG W		Z	MAG	NO	GAP	DMIN	RMS	ERH	ERZ
2004	09	29	22	26	6.92	44	12.97	114	16.41	0.08	1.33	4	229	73.4	0.04	3.3	2.3
2004	10	01	19	05	45.52	44	52.99	112	43.83	8.81	1.63	7	300	11.2	0.08	2.4	1.3
2004	10	02	00	31	28.48	44	19.42	114	2.75	5.20	1.21	14	219	64.7	0.16	0.8	4.0
2004	10	02	04	56	26.66	43	57.72	114	21.55	1.93	1.02	6	258	44.5	0.05	5.3	11.5
2004	10	02	13	57	9.96	43	59.44	114	27.77	13.16	1.13	6	271	47.8	0.02	5.8	10.8
2004	10	02	16	16	31.25	44	3.27	114	21.34	0.08	1.23	12	303	81.2	0.29	4.0	5.5
2004	10	02	19	08	52.97	44	0.53	114	26.15	6.11	1.74	7	250	49.7	0.11	1.2	2.6
2004	10	04	18	03	26.02	42	53.62	111	21.17	15.80	0.67	5	192	17.8	0.03	2.3	1.3
2004	10	05	02	24	31.92	43	48.67	113	31.58	6.91	0.42	5	181	14.3	0.07	2.0	13.9
2004	10	05	07	37	38.97	42	44.54	111	39.02	17.53	1.46	12	103	41.4	0.17	0.5	14.6
2004	10	06	11	28	50.18	44	28.33	111	10.51	5.67	0.76	6	104	31.3	0.09	0.6	5.7
2004	10	08	16	08	46.77	44	16.84	114	34.29	0.02	2.17	19	255	80.9	0.23	1.7	1.7
2004	10	12	18	00	38.54	42	56.13	111	16.02	3.66	1.12	4	184	15.6	0.03	2.4	11.1
2004	10	13	17	12	30.91	44	31.78	112	27.85	2.77	0.89	4	168	9.0	0.01	5.9	9.4
2004	10	14	23	10	35.72	44	18.19	114	30.17	0.02	2.05	15	306	87.6	0.29	3.6	5.0
2004	10	15	20	32	5.12	43	38.00	111	50.19	5.00	1.00	9	127	50.3	0.16	0.9	15.8
2004	10	16	16	07	31.40	43	12.91	111	23.38	15.94	1.41	6	161	16.9	0.02	0.6	1.6
2004	10	17	20	58	28.20	44	25.28	114	4.87	5.06	1.93	4	228	98.9	0.18	14.5	12.7
2004	10	18	02	36	40.07	44	21.01	113	58.63	5.44	1.63	4	216	94.0	0.21	18.1	12.1
2004	10	18	21	14	7.50	42	49.19	111	33.69	2.87	0.00	5	278	30.3	0.03	1.5	12.7
2004	10	20	07	00	8.01	44	22.72	113	57.04	0.03	1.99	25	264	44.2	0.27	1.3	1.8
2004	10	20	07	40	17.79	44	23.42	113	57.41	0.08	1.82	20	256	44.9	0.29	1.7	2.1
2004	10	20	12	55	7.99	44	21.77	113	57.05	7.17	1.75	20	256	43.9	0.28	1.1	5.1
2004	10	20	13	54	21.31	44	23.75	113	56.52	0.33	1.60	18	256	43.8	0.16	1.0	1.5
2004	10	20	19	25	8.18	42	54.90	111	22.12	10.34	0.73	8	127	15.4	0.17	4.0	4.4
2004	10	21	04	59	18.77	44	44.04	112	39.06	10.49	1.71	11	204	18.8	0.14	1.0	1.5
2004	10	26	18	56	37.55	44	16.49	114	34.15	0.02	2.08	15	255	80.2	0.2	2.1	2.4
2004	10	27	13	33	13.35	44	25.13	114	5.79	2.59	1.94	18	229	56.4	0.19	0.7	2.2
2004	10	27	23	07	43.31	44	17.48	114	25.29	1.49	1.53	7	244	81.0	0.11	1.8	2.2
2004	10	29	06	15	7.68	44	25.86	114	5.52	7.19	1.57	14	230	56.4	0.14	1.0	8.4
2004	10	29	07	45	56.29	44	9.84	113	59.59	0.03	1.09	13	203	49.7	0.08	0.5	1.7
2004	11	06	00	41	11.56	43	54.29	113	43.14	4.72	1.28	16	153	21.6	0.12	0.5	1.0
2004	11	06	03	15	44.89	44	39.45	111	52.28	5.92	1.55	13	138	18.2	0.16	0.6	17.5
2004	11	08	19	47	57.39	42	54.71	111	23.16	6.36	1.03	10	120	15.8	0.29	1.8	4.6
2004	11	09	04	52	35.17	44	26.10	111	13.04	6.52	0.59	6	139	27.3	0.07	0.7	11.7
2004	11	09	04	53	54.33	44	36.35	112	4.38	0.05	1.04	7	158	25.5	0.08	0.7	2.1
2004	11	09	06	23	2.50	44	26.24	111	13.08	2.46	0.58	7	166	27.6	0.04	0.7	3.5
2004	11	09	08	10	49.82	43	3.74	111	39.62	11.07	0.88	12	91	23.6	0.09	0.6	1.4
2004	11	10	21	57	56.29	42	54.93	111	20.15	12.53	0.68	5	130	15.6	0.06	2.2	2.7
2004	11	11	11	05	10.80	44	40.61	112	0.33	5.58	0.81	6	152	27.6	0.1	0.8	2.6
2004	11	12	22	51	55.47	42	55.85	111	20.88	14.02	0.89	7	132	13.7	0.1	1.7	1.3
2004	11	14	21	21	49.73	42	54.50	111	22.05	14.86	0.80	5	190	16.1	0.08	4.0	2.2
2004	11	15	04	26	36.84	44	29.67	114	15.61	7.04	1.51	9	244	90.1	0.12	0.7	1.3
2004	11	16	23	30	12.76	44	22.95	113	54.20	1.47	1.39	9	292	76.9	0.08	1.6	1.9
2004	11	17	13	21	58.99	44	22.10	114	3.30	1.21	0.77	6	252	93.9	0.07	3.6	9.9
2004	11	19	22	46	37.50	42	49.69	111	32.62	5.22	0.88	4	275	28.7	0.04	3.1	11.4

Table D-2. Continued.

DATE			ORIGIN			LAT N		LONG W		Z	MAG	NO	GAP	DMIN	RMS	ERH	ERZ
2004	11	20	06	42	59.70	44	20.01	114	3.04	5.01	1.31	6	220	51.6	0.06	1.1	13.5
2004	11	20	11	42	48.50	44	19.56	114	2.77	6.75	1.91	16	220	64.9	0.18	0.8	3.0
2004	11	20	11	57	0.44	44	20.35	114	3.02	0.01	1.70	14	220	66.1	0.2	1.3	2.9
2004	11	20	14	25	52.38	44	17.36	114	1.41	0.02	0.99	7	263	60.8	0.13	2.7	4.3
2004	11	21	14	28	0.87	44	21.09	113	59.23	1.93	0.00	10	217	63.6	0.26	1.4	6.4
2004	11	21	14	44	49.17	44	21.57	113	59.41	7.53	1.11	8	218	64.4	0.07	1.1	13.7
2004	11	21	14	59	5.62	44	20.26	113	59.16	2.26	1.75	15	234	62.4	0.18	1.2	3.0
2004	11	21	15	46	28.04	44	19.11	113	58.14	6.66	0.99	5	290	59.9	0.01	3.1	8.5
2004	11	21	15	50	32.60	44	20.38	113	57.82	4.04	4.00 N	23	233	44.7	0.2	0.9	3.3
2004	11	21	15	58	37.16	44	21.71	113	56.22	6.65	1.69	21	254	42.8	0.27	2.0	5.8
2004	11	21	16	01	25.25	44	21.04	113	53.97	7.03	1.06	7	261	39.7	0.08	1.6	4.0
2004	11	21	16	05	14.43	44	18.92	113	55.25	6.75	1.02	13	284	41.1	0.22	3.6	7.9
2004	11	21	16	10	22.93	44	20.77	113	55.41	7.31	1.36	14	262	41.5	0.21	1.1	8.3
2004	11	21	16	13	53.02	44	19.51	113	55.55	7.04	2.03	21	271	41.6	0.2	1.1	2.9
2004	11	21	16	18	23.96	44	21.23	113	55.87	7.26	0.00	7	254	42.2	0.05	1.2	4.6
2004	11	21	16	20	18.50	44	21.13	113	55.59	6.91	0.00	7	253	60.5	0.32	2.6	5.0
2004	11	21	16	23	45.53	44	21.89	113	53.91	2.73	1.34	8	279	39.8	0.09	1.1	1.0
2004	11	21	16	29	8.85	44	21.44	113	55.34	7.26	1.14	12	253	41.6	0.24	1.6	10.4
2004	11	21	16	38	13.75	44	19.60	113	54.61	5.95	1.15	6	251	40.3	0.07	3.2	7.2
2004	11	21	16	48	22.78	44	20.70	113	58.08	7.04	1.48	17	215	45.1	0.26	1.2	2.9
2004	11	21	16	56	59.22	44	20.41	113	57.32	7.40	1.19	13	214	44.0	0.18	0.9	18.2
2004	11	21	16	59	11.71	44	21.68	113	59.15	5.35	1.90	20	218	46.7	0.17	0.9	3.7
2004	11	21	18	08	54.22	44	21.34	113	58.17	7.17	0.93	9	217	45.3	0.21	1.1	21.4
2004	11	21	18	53	13.17	44	19.01	114	0.48	1.95	1.22	5	284	48.1	0.01	1.5	1.6
2004	11	21	19	40	20.46	44	20.79	113	58.64	6.45	1.69	13	235	45.8	0.18	1.1	2.9
2004	11	22	01	39	5.96	44	21.86	113	59.22	5.62	1.79	17	218	46.8	0.16	0.9	3.1
2004	11	22	02	47	24.24	44	20.70	113	58.63	8.51	0.87	11	216	62.5	0.2	1.2	2.1
2004	11	22	02	51	2.75	44	21.07	113	58.93	6.84	1.21	12	217	63.3	0.15	0.9	3.6
2004	11	22	03	10	28.48	44	19.65	113	57.08	5.69	1.10	7	213	59.7	0.08	0.9	3.4
2004	11	22	05	25	15.79	44	21.98	113	59.31	6.72	1.69	18	219	46.9	0.14	0.7	2.7
2004	11	22	06	00	28.97	44	48.78	112	27.66	4.50	0.91	4	253	25.0	0.01	5.4	11.3
2004	11	22	06	21	53.91	44	21.13	113	59.10	9.42	0.00	8	217	63.5	0.06	1.2	2.6
2004	11	22	06	48	53.72	44	21.14	113	58.57	6.81	1.55	15	217	45.8	0.13	0.7	2.8
2004	11	22	11	40	21.25	44	20.47	113	57.37	6.99	0.95	10	215	44.1	0.13	1.1	11.9
2004	11	22	12	25	23.06	44	20.43	113	58.91	0.43	1.58	8	247	62.4	0.06	1.7	2.6
2004	11	22	15	31	29.42	44	40.13	111	50.40	6.11	0.73	6	140	15.4	0.07	0.6	12.2
2004	11	22	16	43	55.64	44	21.35	113	55.85	6.56	1.14	9	254	61.0	0.29	2.2	7.9
2004	11	24	05	11	42.76	44	12.53	113	3.12	6.23	0.58	8	167	16.0	0.08	0.5	0.8
2004	11	24	18	53	5.72	44	21.20	113	55.86	4.93	0.49	6	316	42.2	0.09	5.3	10.9
2004	11	26	08	49	17.31	44	21.11	113	53.72	3.53	1.82	13	312	76.1	0.08	1.3	2.7
2004	11	26	09	46	41.80	44	21.03	113	54.51	6.41	1.64	12	312	77.2	0.09	1.3	2.7
2004	11	27	00	51	24.88	44	20.96	113	53.81	3.30	1.60	11	312	76.2	0.08	1.3	3.5
2004	12	02	06	12	19.95	44	20.91	113	56.41	7.55	1.10	11	279	60.9	0.2	1.3	4.2
2004	12	03	13	32	17.35	44	34.81	112	11.99	11.29	1.14	5	178	15.5	0.01	0.8	1.7
2004	12	04	17	26	26.87	44	21.18	113	57.86	6.92	0.99	8	215	44.8	0.1	0.9	15.0
2004	12	04	21	01	42.59	42	53.16	111	24.46	0.02	1.02	6	108	5.9	0.18	1.1	2.3

Table D-2. Continued.

DATE	ORIGIN	LAT N	LONG W	Z	MAG	NO	GAP	DMIN	RMS	ERH	ERZ
2004 12 05	00 13 6.64	44 40.92	112 29.13	18.38	0.92	8	203	12.2	0.1	2.0	1.3
2004 12 06	13 56 27.58	44 33.69	112 24.60	3.35	1.06	5	148	3.7	0.24	14.6	12.3
2004 12 06	15 56 26.37	44 16.32	114 33.22	0.02	1.52	8	253	79.7	0.04	2.1	1.8
2004 12 08	03 54 17.61	44 20.09	113 56.91	7.06	0.67	5	213	60.1	0.09	0.9	14.8
2004 12 08	17 06 38.82	42 49.17	111 34.84	2.50	1.14	5	295	18.5	0.21	3.1	21.1
2004 12 18	00 30 49.95	42 53.59	111 23.81	0.02	0.90	11	114	5.4	0.25	0.8	1.3
2004 12 19	20 53 59.23	44 28.72	112 50.12	5.56	1.12	6	138	37.3	0.01	0.5	3.2
2004 12 22	06 39 8.98	44 20.86	113 53.54	6.22	1.06	9	259	58.4	0.14	2.3	5.1
2004 12 23	21 07 3.36	44 13.39	114 29.43	6.35	1.90	16	248	73.7	0.15	0.8	1.9
2004 12 24	15 20 46.05	42 36.40	111 26.06	4.98	1.63	10	110	32.6	0.21	0.8	16.0
2004 12 25	16 50 3.43	42 36.47	111 26.50	4.97	1.80	13	109	33.0	0.13	0.5	12.1
2004 12 25	18 36 1.47	44 39.68	112 8.67	12.42	1.00	10	149	21.2	0.12	0.7	1.5
2004 12 26	05 05 17.07	42 36.99	111 26.24	4.96	1.36	9	109	32.2	0.09	0.7	11.7
2004 12 26	07 36 6.41	42 52.02	111 20.83	4.22	1.21	6	303	90.7	0.19	2.5	5.0
2004 12 27	01 58 54.09	44 11.79	114 27.51	0.02	1.83	13	266	70.6	0.21	2.3	2.5
2004 12 27	07 41 51.12	44 11.64	114 27.14	0.11	1.67	9	267	70.3	0.17	2.5	2.9
2004 12 28	03 39 21.25	44 20.92	113 57.47	7.07	1.33	8	215	61.8	0.08	0.6	14.2
2004 12 28	03 44 12.79	44 22.62	114 2.56	9.25	1.22	8	223	68.7	0.07	0.9	1.8
2004 12 28	03 48 0.05	44 22.11	113 59.72	6.41	2.21	18	219	47.5	0.18	0.8	2.9
2004 12 28	03 55 25.71	44 21.54	113 59.83	0.91	1.48	8	218	64.7	0.1	0.8	2.1
2004 12 28	04 00 6.22	44 22.29	114 0.64	7.01	1.25	9	220	66.5	0.29	1.6	7.0
2004 12 28	14 41 39.20	44 24.46	113 59.26	6.25	1.25	5	301	68.3	0.05	4.1	9.4
2004 12 29	06 01 20.47	44 20.58	113 59.38	8.15	1.31	10	247	63.0	0.1	1.2	1.9
2004 12 29	16 32 35.75	44 22.24	114 0.62	6.98	1.97	15	220	66.4	0.23	1.0	1.7
2004 12 29	16 39 13.81	44 45.04	112 49.75	2.69	1.97	7	141	8.7	0.04	0.9	2.3
2004 12 29	20 46 51.39	44 15.96	114 23.87	0.08	1.24	7	279	84.5	0.11	3.6	3.4
2004 12 31	10 29 14.47	44 19.67	113 55.75	0.05	2.10	13	285	58.6	0.16	2.7	3.5