ANNUAL TECHNICAL REPORT: 2001

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ABSTRACT and NONTECHNICAL SUMMARY

This is the annual technical report for USGS Joint Operating Agreement 01HQAG0011 "*Pacific Northwest Seismograph Network (PNSN) Operations*". This agreement covered network operations in western Washington and Oregon, routine data processing, and preparation of bulletins and reports. The objective of our work under this operating agreement was to gather seismic data, and to analyze and interpret them for use in evaluation of seismic and volcanic hazards in Washington and Oregon. This report includes an update on recent changes in our data acquisition and processing system, a review of station operations during 2001, an overview of our public information program, and a summary of 2001 seismicity.

During 2001 there were 23 earthquakes reported felt west of the Cascades in Washington, ranging in magnitude from 1.7 to 6.8. Only one Oregon earthquake was reported felt this year; magnitude 1.9.

By far the most interesting event during the reporting period was the moment-magnitude 6.8 Nisqually earthquake of Feb. 28, 2001. It occurred at a depth of about 52 km, about 18 km northeast of Olympia, WA. Extensive information is available on the Nisqually Earthquake Clearinghouse:

http://maximus.ce.washington.edu/~nisqually/index.html

A great deal has been and will be written about the Nisqually earthquake, which caused significant damages. Only four small aftershocks were recorded in the two weeks following the mainshock, but a possible late aftershock of magnitude 4.3 occurred nearby about six months later.

East of the Cascades in Washington, more than 70 earthquakes were felt during 2001. Many of these were tiny events in the Spokane urban area, where a vigorous sequence of earthquakes began in May. Activity continued in bursts, with the largest earthquake M 4.0 on November 11. No comparable sequence is known in the history of Spokane. For additional details see the quarterly reports, or the PNSN web page "The 2001 Spokane Earthquake Sequence":

http://www.ess.washington.edu/SEIS/EQ_Special/WEBDIR_01062514151n/overview.html

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"PACIFIC NORTHWEST SEISMOGRAPH NETWORK (PNSN) OPERATIONS"

SUMMARY

This is the 2001 annual technical report for USGS Joint Operating Agreement 01HQAG0011 *"Pacific Northwest Seismograph Network (PNSN) Operations"*. This agreement covered network operations in western Washington and northern Oregon, routine data processing, and preparation of bulletins and reports. PNSN stations in southern and central Oregon are maintained by the University of Oregon under Cooperative Agreement 01HQAG0012 and this report also covers the work undertaken under that agreement. The objective of our work under this operating agreement was to gather seismic data, and to analyze and interpret them for use in evaluation of seismic and volcanic hazards in Washington and Oregon. This report includes an update on recent changes in our data acquisition and processing system, a review of station operations during 2001, an overview of our public information program, and a summary of 2001 seismicity.

Since 1984, we have issued quarterly bulletins for all of Washington and Oregon. These include catalogs of earthquakes and blasts located in Washington and Oregon, providing up-to-date coverage of seismic and volcanic activity. Appendix 1 contains quarterly bulletins covering 2001.

CURRENT INITIATIVES

Introduction

The PNSN is continuing the long process of upgrading operations. Upgrades include enhancement of the emergency information distribution system, installation of seismic sensors that can accurately capture the full range of earthquake amplitudes and frequencies, implementation of a data recording system that fully supports multi-component data, and near-real-time data exchange with neighboring networks.

CREST Stations

The USGS/NOAA CREST (Consolidated Reporting of EarthquakeS and Tsunamis) project is designed to improve NOAA's ability to assess the likelihood of a tsunami and issue timely warnings in the event of a west coast subduction earthquake. CREST calls for upgrades to regional networks to enable them to provide very rapid and reliable information to the Alaska and Pacific Tsunami Warning Centers. Installation of CREST stations began in 1998. In 2001, CREST Oregon stations were installed in Eugene, Tahkenitch, and Toledo. In Washington, stations were installed in Port Angeles, and near Forks, Washington. Two additional sites; at Megler, Washington and Mt. Hebo, Oregon; were installed during 2001 but telemetry was not yet functioning.

PNSN Strong Motion Program

Since 1996, the PNSN has installed digital strong-motion instruments. Most of these are in the Puget Sound Area, but stations are also being sited in other urban areas. In 2001, 23 new permanent (and 2 temporary) instruments were installed, bringing the total number of PNSN real-time strong-motion instruments to 70. Continuous data from these stations are sent to the PNSN via Internet or lease-line modem. Most of the strong-motion instruments (except CREST stations) also have internal memory and are configured to record internally if ground motions exceed a specified threshold. If continuous data transmission fails, the internally recorded data are still available via dial-up retrieval or site visit. Three additional dial-up stations in the Portland area are operated by the USGS.

PNSN RACE (Rapid Alerts for Cascadia Earthquakes) System

RACE is an earthquake notification system for emergency managers and others who need very rapid pager-based notification of earthquake activity. The RACE system is based on the CUBE system developed at Caltech for the Southern California Seismic Network. The RACE system is operating in approximately 10 emergency management and state agencies in Washington and Oregon.

EARTHWORM Progress Report

In 2001, *scossa* became our primary EARTHWORM computer, and *milli* was demoted to primary backup computer, while *verme* remained the secondary backup computer.

When one of our SUNWORM digitizers began to have problems in early 2001, we obtained an official EARTHWORM digitizer from the central EARTHWORM team. By the end of 2001, the complex wiring for *pigia*, the new Intel-based EARTHWORM digitizer running under Windows NT, was completed and *pigia* began digitizing data. *Pigia* will operate as an EARTHWORM node, exporting digitized data to *verme*. We are currently configuring the files that associate channel numbers with station and component names. Full integration of *pigia* into our data acquisition process is expected in the first quarter of 2002.

In mid-February a new earthquake magnitude calculator, *localmag*, was implemented as part of our routine earthworm system. It had been tested by its developer, Pete Lombard, using previously recorded PNSN data but calibration had not been completed. Thus, PNSN staff had only very brief training and minimal experience with *localmag* when the Nisqually earthquake occurred on Feb. 28. The initial magnitude estimates from *localmag* were available less than 15 minutes after the earthquake, and were very close to the final magnitude of 6.8. We continue to gather information on how *localmag* performs over a wider magnitude range.

During January and early February, Steve Malone gave a 6-week class on the PNSN EARTHWORM implementation. This class brought PNSN staff up-to-date on most of the critical features of our data acquisition system, and improved our ability to deal with operational problems, which worked out well in the Nisqually earthquake.

OPERATIONS

Seismometer Locations and Network Maintenance

Figure 1 shows seismograph stations operated by the PNSN at the end of 2001, when the PNSN EARTHWORM SYSTEM was digitally recording 439 channels of real-time or near-real-time seismic data. Stations available include a total of 149 short-period stations, 30 broad-band, and 73 strong-motion stations.

This contract (JOA 01HQAG0011) supports 99 short-period sites (some with multiple components) and operation of 70 strong motion and 18 broad-band stations. The supported stations cover much of western Washington and Oregon, including the volcanos of the central Cascades.

Additional stations funded by other contracts, or telemetered in real or near-real time from adjacent networks, are also used in event locations. Station Tables 1A-1C list the locations of various types of stations. Quarterly reports provide additional details of station operation. Quarterly reports from January 1, 2001 through December, 2001 are included as Appendix 1.

Aside from station outages, normal maintenance includes a visit to each site at least once every two years to replace batteries and do preventive maintenance. In addition seismometers must be replaced every 4-6 years. More than 30 radio telemetry relay sites are also maintained independently of the seismograph stations.

Table 1A lists short-period, mostly vertical-component stations used in locating seismic events in Washington and Oregon. The first column in the table gives the 3-letter station designator, followed by a symbol designating the funding agency; stations marked by a percent sign (%) were supported by USGS joint operating agreement 01-HQ-AG-0011. A plus (+) indicates support under Pacific Northwest National Laboratory, Battelle contract 259116-A-B3. Stations designated "#" are USGS-maintained stations recorded at the PNSN. Stations designated by letters are operated by other networks, and telemetered to the PNSN. "M" stations are received from the Montana Bureau of Mines and Geology, "C" stations from the Canadian Pacific Geoscience Center, "U" stations from the US Geological Survey (usually USNSN stations), "N" stations from the USGS Northern California Network, and "H" stations from the Hanford Reservation via the Pacific Northwest National Labs. Other designation indicate support from other sources. Additional columns give station north latitude and west longitude (in degrees, minutes and seconds), station elevation in km, and comments indicating landmarks for which stations were named.

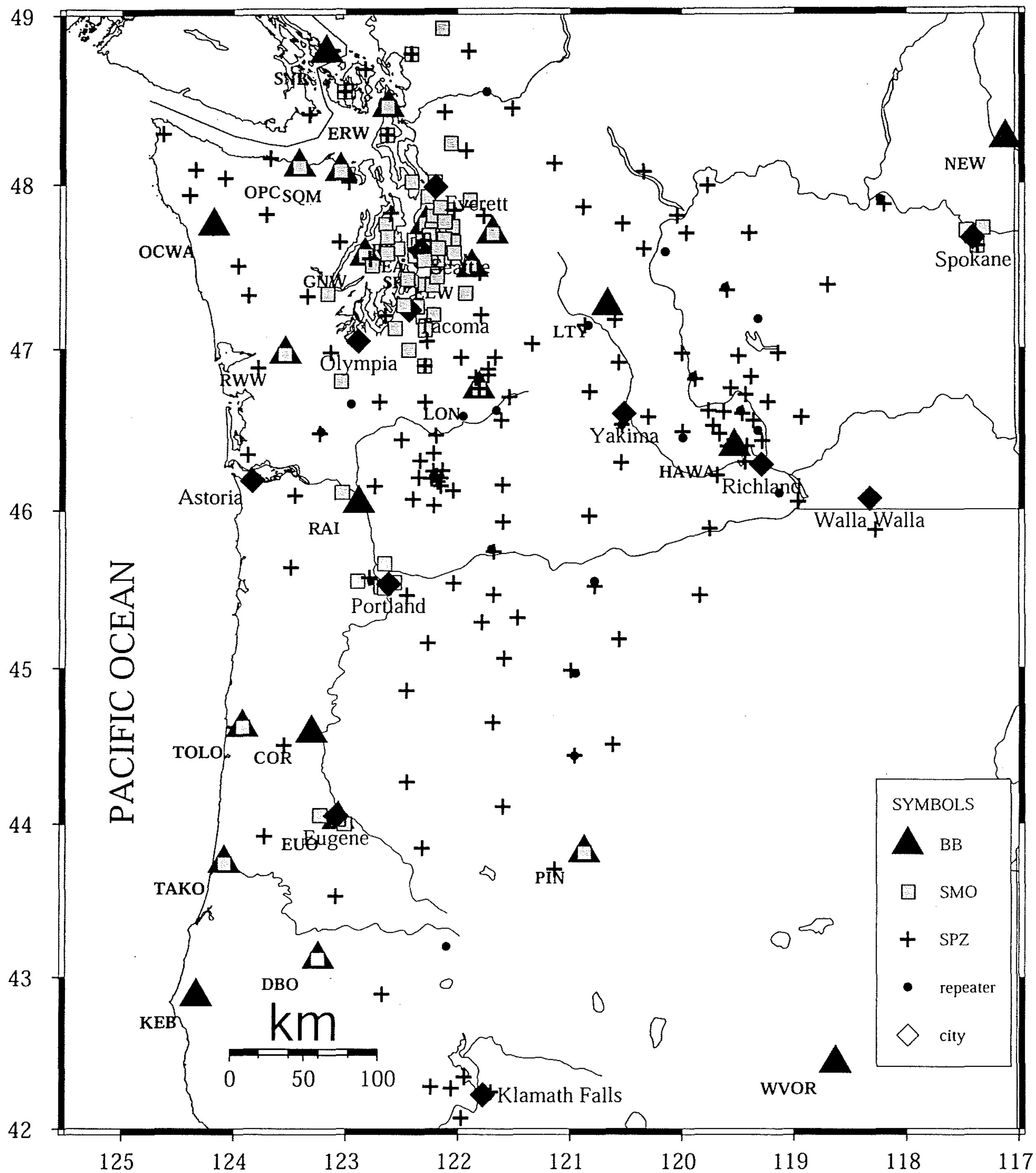

Figure 1A. Stations operating at the end of 4th quarter, 2001. Stations shown are short period vertical (SPZ), 3-component broadband (BB), or strong motion (SMO). City locations are shown by black diamond symbols.

TABLE 1A - Short-period Stations operated by the PNSN during the fourth quarter 2001

STA	F	LAT	LONG	EL	NAME
ASR	%	46 09 09.9	121 36 01.6	1.357	Mt. Adams - Stagman Ridge
AUG	%	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BBO	%	42 53 12.6	122 40 46.6	1.671	Butler Butte, Oregon
BEN	1	46 31 12.0	119 43 18.0	0.335	W PNNL station
BHW	%	47 50 12.6	122 01 55.8	0.198	Bald Hill
BLN	%	48 00 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	%	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
BPO	%	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
BRO	%	44 16 02.5	122 27 07.1	0.135	Big Rock Lookout, Oregon
BRV	+	46 29 07.2	119 59 28.2	0.920	Black Rock Valley
BSMT	M	47 51 04.8	114 47 13.2	1.950	Bassoo Peak, MT
BUO	%	42 16 42.5	122 14 43.1	1.797	Burton Butte, Oregon
BVW	+	46 48 39.5	119 52 56.4	0.670	Beverly
CBS	+	47 48 17.4	120 02 30.0	1.067	Chelan Butte, South
CDF	%	46 07 01.4	122 02 42.1	0.756	Cedar Flats
CHMT	M	46 54 51.0	113 15 07.0	-	Chamberlain Mtn, MT
CMM	%	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.
CMW	%	48 25 25.3	122 07 08.4	1.190	Cultus Mtns.
CPW	%	46 58 25.8	123 08 10.8	0.792	Capitol Peak
CRF		46 49 30.0	119 23 13.2	0.189	Corfu
DPW	+	47 52 14.3	118 12 10.2	0.892	Davenport
DY2	+	47 59 06.6	119 46 16.8	0.890	Dyer Hill 2
EDM	%	46 11 50.4	122 09 00.0	1.609	East Dome, Mt. St. Helens
ELK	%	46 18 20.0	122 20 27.0	1.270	Elk Rock
ELL	+	46 54 34.8	120 33 58.8	0.789	Ellensburg
EPH	+	47 21 22.8	119 35 45.6	0.661	Ephrata
ET3	+	46 34 38.4	118 56 15.0	0.286	Eltopia (replaces ET2)
ETW	+	47 36 15.6	120 19 56.4	1.477	Entiat
FHE	+	46 57 06.9	119 29 49.0	0.455	Frenchman Hills East
FL2	%	46 11 47.0	122 21 01.0	1.378	Flat Top 2
FMW	%	46 56 29.6	121 40 11.3	1.859	Mt. Fremont
GBB	H	46 36 31.8	119 37 40.2	0.185	PNNL Station
GBL	+	46 35 54.0	119 27 35.4	0.330	Gable Mountain
GHW	%	47 02 30.0	122 16 21.0	0.268	Garrison Hill
GL2	+	45 57 35.0	120 49 22.5	1.000	New Goldendale
GLK	%	46 33 27.6	121 36 34.3	1.305	Glacier Lake
GMO	%	44 26 20.8	120 57 22.3	1.689	Grizzly Mountain, Oregon
GMW	%	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GPW	%	48 07 05.0	121 08 12.0	2.354	Glacier Peak
GSM	%	47 12 11.4	121 47 40.2	1.305	Grass Mt.
GUL	%	45 55 27.0	121 35 44.0	1.189	Guler Mt.
H2O	H	46 23 45.0	119 25 22.0	-	Water PNNL Station
HAM	%	42 04 08.3	121 58 16.0	1.999	Hamaker Mt., Oregon
HBO	%	43 50 39.5	122 19 11.9	1.615	Huckleberry Mt., Oregon
HDW	%	47 38 54.6	123 03 15.2	1.006	Hoodsport
HOG	%	42 14 32.7	121 42 20.5	1.887	Hogback Mtn., Oregon
HSO	%	43 31 33.0	123 05 24.0	1.020	Harness Mountain, Oregon
HSR	%	46 10 28.0	122 10 46.0	1.720	South Ridge, Mt. St. Helens
HTW	%	47 48 14.2	121 46 03.5	0.833	Haystack Lookout
HUO	%	44 07 10.9	121 50 53.5	2.037	Husband OR (UO)
JBO	+	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JCW	%	48 11 42.7	121 55 31.1	0.792	Jim Creek
JUN	%	46 08 50.0	122 09 04.4	1.049	June Lake
KMO	%	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	%	46 27 46.7	122 11 41.3	0.610	Kosmos
KTR	N	41 54 31.2	123 22 35.4	1.378	CAL-NET
LAB	%	42 16 03.3	122 03 48.7	1.774	Little Aspen Butte, Oregon
LAM	N	41 36 35.2	122 37 32.1	1.769	CAL-NET
LCCM	M	45 50 16.8	111 52 40.8	1.669	Lewis and Clark Caverns, MT
LCW	%	46 40 14.4	122 42 02.8	0.396	Lucas Creek
LMW	%	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
LNO	+	45 52 18.6	118 17 06.6	0.771	Lincton Mt., Oregon
LO2	%	46 45 00.0	121 48 36.0	0.853	Longmire
LOC	+	46 43 01.2	119 25 51.0	0.210	Locke Island
LVP	%	46 03 59.4	122 24 10.2	1.134	Lakeview Peak
MBW	%	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCMT	M	44 49 39.6	112 50 55.8	2.323	McKenzie Canyon, MT
MCW	%	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MDW	+	46 36 47.4	119 45 39.6	0.330	Midway
MEW	%	47 12 07.0	122 38 45.0	0.097	McNeil Island
MJ2	+	46 33 27.0	119 21 32.4	0.146	May Junction 2
MOX	+	46 34 38.4	120 17 53.4	0.501	Moxie City
MPO	%	44 30 17.4	123 33 00.6	1.249	Mary's Peak, Oregon
MTM	%	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
NAC	+	46 43 59.4	120 49 25.2	0.728	Naches
NCO	%	43 42 14.4	121 08 18.0	1.908	Newberry Crater, Oregon
NEL	+	48 04 12.6	120 20 24.6	1.500	Nelson Butte
NLO	%	46 05 21.9	123 27 01.8	0.826	Nicolai Mt., Oregon

STA	F	LAT	LONG	EL	NAME
OBC	%	48 02 07.1	124 04 39.0	0.938	Olympics - Bonidu Creek
OBH	%	47 19 34.5	123 51 57.0	0.383	Olympics - Burnt Hill
OCP	%	48 17 53.5	124 37 30.0	0.487	Olympics - Cheeka Peak
OD2	+	47 23 15.6	118 42 34.8	0.553	Odessa site 2
OFR	%	47 56 00.0	124 23 41.0	0.152	Olympics - Forest Resource Cen
OHW	%	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ON2	%	46 52 50.8	123 46 51.8	0.257	Olympics - North River
OOW	%	47 44 03.6	124 11 10.2	0.561	Octopus West
OSD	%	47 48 59.2	123 42 13.7	2.008	Olympics - Snow Dome
OSR	%	47 30 20.3	123 57 42.0	0.815	Olympics Salmon Ridge
OT3	+	46 40 08.4	119 13 58.8	0.322	New Othello (replaces OT2 8/26
OTR	%	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PAT	+	45 52 55.2	119 45 08.4	0.262	Paterson
PCMD	%	46 53 20.9	122 18 00.9	0.239	PC Mountain Detachment ANSS-SM
PGO	%	45 27 42.6	122 27 11.5	0.253	Gresham, Oregon
PGW	%	47 49 18.8	122 35 57.7	0.122	Port Gamble
PRO	+	46 12 45.6	119 41 08.4	0.553	Prosser
RCM	%	46 50 08.9	121 43 54.4	3.085	Mt. Rainier, Camp Muir
RCS	%	46 52 15.6	121 43 52.0	2.877	Mt. Rainier, Camp Schurman
RED	H	46 17 51.0	119 26 15.6	0.330	Red Mountain PNNL Station
RER	%	46 49 09.2	121 50 27.3	1.756	Mt. Rainier, Emerald Ridge
RMW	%	47 27 35.0	121 48 19.2	1.024	Rattlesnake Mt. (West)
RNO	%	43 54 58.9	123 43 25.5	0.850	Roman Nose, Oregon
RPW	%	48 26 54.0	121 30 49.0	0.850	Rockport
RRHS	%	46 47 58.6	123 02 25.4	0.047	Rochester HS ANSS-SMO
RSW	+	46 23 40.2	119 35 28.8	1.045	Rattlesnake Mt. (East)
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
RVN	%	47 01 38.6	121 20 11.9	1.885	Raven Roost (former NEHRP temp
RVW	%	46 08 53.2	122 44 32.1	0.460	Rose Valley
SAW	+	47 42 06.0	119 24 01.8	0.701	St. Andrews
SBES	%	48 46 05.9	122 24 54.2	0.119	Silver Beach ES SMO
SEA	%	47 39 15.8	122 18 29.3	0.030	UW, Seattle (Wood Anderson BB
SEP	#	46 12 00.7	122 11 28.1	2.116	September lobe, Mt. St. Helens
SFER	%	47 37 10.4	117 21 55.7	-	Spokane Schools, Ferris High S
SHW	%	46 11 37.1	122 14 06.5	1.425	Mt. St. Helens
SLF	%	47 45 32.0	120 31 40.0	1.750	Sugar Loaf
SMW	%	47 19 10.7	123 20 35.4	0.877	South Mtn.
SNI	H	46 27 80.0	119 39 50.0	-	PNNL station
SOS	%	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
SSO	%	44 51 21.6	122 27 37.8	1.242	Sweet Springs, Oregon
STD	%	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	%	48 09 03.1	123 40 11.1	0.308	Striped Peak
SVOH	%	48 17 21.8	122 37 54.8	0.010	Skagit Valley CC ANSS-SMO
TBM	+	47 10 12.0	120 35 52.8	1.006	Table Mt.
TCO	%	44 06 27.6	121 36 02.1	1.975	Three Creek Meadows, Oregon.
TDH	%	45 17 23.4	121 47 25.2	1.541	Tom,Dick,Harry Mt., Oregon
TDL	%	46 21 03.0	122 12 57.0	1.400	Tradedollar Lake
TRW	+	46 17 32.0	120 32 31.0	0.723	Toppenish Ridge
TWW	+	47 08 17.4	120 52 06.0	1.027	Teanaway
UWFH	%	48 32 46.0	123 00 43.0	0.010	UW Friday Harbor ANSS-SMO
VBE	%	45 03 37.2	121 35 12.6	1.544	Beaver Butte, Oregon
VCR	%	44 58 58.2	120 59 17.4	1.015	Criterion Ridge, Oregon
VDB	C	49 01 34.0	122 06 10.1	0.404	Canada
VFP	%	45 19 05.0	121 27 54.3	1.716	Flag Point, Oregon
VG2	%	45 09 20.0	122 16 15.0	0.823	Goat Mt., Oregon
VGB	+	45 30 56.4	120 46 39.0	0.729	Gordon Butte, Oregon
VGZ	C	48 24 50.0	123 19 27.8	0.067	Canada
VIP	%	44 30 29.4	120 37 07.8	1.731	Ingram Pt., Oregon
VLL	%	45 27 48.0	121 40 45.0	1.195	Laurance Lk., Oregon
VLM	%	45 32 18.6	122 02 21.0	1.150	Little Larch, Oregon
VSP	%	42 20 30.0	121 57 00.0	1.539	Spence Mtn, Oregon
VT2	+	46 58 02.4	119 59 57.0	1.270	Vantage2
VTH	%	45 10 52.2	120 33 40.8	0.773	The Trough, Oregon
WA2	+	46 45 19.2	119 33 56.4	0.244	Wahluke Slope
WAT	+	47 41 55.2	119 57 14.4	0.821	Waterville
WIB	%	46 20 34.8	123 52 30.6	0.503	Willapa Bay
WIW	+	46 25 45.6	119 17 15.6	0.128	Wooded Island
WPO	%	45 34 24.0	122 47 22.4	0.334	West Portland, Oregon
WPW	%	46 41 55.7	121 32 10.1	1.280	White Pass
WRD	+	46 58 12.0	119 08 41.4	0.375	Warden
WRW	%	47 51 26.0	120 52 52.0	1.189	Wenatchee Ridge
YA2	+	46 31 36.0	120 31 48.0	0.652	Yakima
YEL	#	46 12 35.0	122 11 16.0	1.750	Yellow Rock, Mt. St. Helens
YPT	+	46 02 55.8	118 57 44.0	0.325	Yellepit

Table 1B lists broad-band stations used in locating seismic events in Washington and Oregon.

TABLE 1B

Broad-band three-component stations operating at the end of the fourth quarter 2001. Symbols are as in Table 1A.

STA	F	LAT	LONG	EL	NAME
BRKS	%	47 45 19.1	122 17 17.9	0.020	Brookside ANSS-SMO
COR	U	44 35 08.5	123 18 11.5	0.121	Corvallis, Oregon (OSU BB)
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon (UO CREST
ELW	%	47 29 39.4	121 52 17.2	0.267	EchoLakeBPA BB-SMO-IDS20
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie SMO-IDS24 BB
EUO	%	44 01 45.7	123 04 08.2	0.160	Eugene,OR U0 CREST BB SMO
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mt CREST BB SMO
HAWA	U	46 23 32.3	119 31 57.2	0.367	Hanford Nike USNSN BB
HLID	U	43 33 45.0	114 24 49.3	1.772	Hailey, ID USNSN BB
KSXB	N	41 49 51.0	123 52 33.0	-	Camp Six, OR CREST BB
KEB	N	42 52 20.0	124 20 03.0	0.818	Edson Butte, OR CREST BB
KRMB	N	41 31 23.0	123 54 29.0	1.265	Red Mtn, OR CREST BB
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire CREST BB LONLZ SMO
LTY	%	47 15 21.2	120 39 53.3	0.970	Liberty (BB)
NEW	U	48 15 50.0	117 07 13.0	0.760	Newport Observatory USNSN BB
OCWA	U	47 44 56.0	124 10 41.2	0.671	Octopus Mtn. USNSN BB
OFR	%	47 56 00.0	124 23 41.0	0.152	Olympics - Forest Resource Cen
OPC	%	48 06 01.0	123 24 41.8	0.090	Olympic Penn College CREST BB
PIN	%	43 48 40.0	120 52 19.0	1.865	Pine Mt., Oregon (U0 CREST, B
PNT	C	49 18 57.6	119 36 57.6	0.550	Canada, BB
RAI		46 02 25.1	122 53 06.4	1.520	Trojan Plant, Oregon (OSU BB)
RWW	%	46 57 53.7	123 32 31.7	0.015	Ranney Well CREST BB SMO
SEA	%	47 39 15.8	122 18 29.3	0.030	UW, Seattle (Wood Anderson BB
SNB	C	48 46 33.6	123 10 16.3	0.408	Canada BB
SP2	%	47 33 23.3	122 14 52.8	0.030	Seward Park, Seattle SMO-IDS24
SQM	%	48 04 39.0	123 02 44.0	0.030	Sequim, WA (CREST BB SMO)
TAKO	%	43 44 36.0	124 04 56.0	0.100	Tahkenitch, OR CREST BB SMO
TOLO	%	44 37 19.0	123 55 21.0	0.100	Toledo BPA, OR CREST BB SMO
TTW	%	47 41 40.7	121 41 20.0	0.542	Tolt Res, WA CREST BB SMO
WVOR	U	42 26 02.0	118 38 13.0	1.344	Wildhorse Valley, Oregon (USNS

Table 1C lists strong-motion, three-component stations operating in Washington and Oregon that provide data in real or near-real time to the PNSN. Several of these stations also have broad-band instruments, as noted. The "SENSOR" field designates what type of seismic sensor is used;

- A = Terra-Tech SSA-320 SLN triaxial accelerometer/Terra-Tech IDS24
- A20 = Terra-Tech SSA-320 triaxial accelerometer/Terra-Tech IDS20 recording system,
- FBA23 = Kinemetrics FBA23 accelerometers and Reftek recording system,
- EPI = Kinemetrics Episensor accelerometers and Reftek recording system.
- BB = Guralp CMG-40T 3-D broadband velocity sensor.
- BB3 = Guralp CMG3T 3-D broadband velocity sensor.
- BBZ = Broad Band sensor, PMD 2024, vertical component only.
- K2 = Kinemetrics Episensor accelerometers and K2 Recording System

The "TELEMETRY" field indicates the type of telemetry used to recover the data.

- D = dial-up,
- E = continuously telemetered via Internet from a remote EARTHWORM system
- I = continuously telemetered via Internet,
- L = continuously telemetered via dedicated lease-line telephone lines,
- L-PPP = continuously telemetered via dedicated lease-line telephone lines using PPP protocol
- M = continuously telemetered via BPA microwave
- R = continuously telemetered via spread-spectrum radio

TABLE 1C

Strong-motion three-component stations operating at the end of the fourth quarter 2001. Symbols are as in Table 1A.

STA	F	LAT	LONG	EL	NAME	SENSORS	TELEMETRY
ALCT	%	47 38 48.8	122 2 15.7	0.055	Alcott Elementary	K2	I
ALST	%	46 6 32.3	123 1 58.5	0.198	Alston	A20	E,M
ALVY	%	43 59 53.2	123 0 57.0	0.155	Alvey	K2	E,M
ATES	%	48 14 10.9	122 3 33.0	0.010	Trafton Elementary	K2	I
BABE	%	47 36 21.0	122 32 7.0	0.010	Blakely Elementary	K2	I
BEVT	%	47 55 12.0	122 16 12.0	0.170	Boeing Plant Everett	K2	I
BRKS	%	47 45 19.1	122 17 17.9	0.020	Brookside Elementary	K2,BBZ	I
CSEN	%	47 48 4.5	122 13 6.5	0.055	Crystal Springs Elementary	K2	I
CSO	#	45 31 1.0	122 41 22.5	0.036	Canyon	FBA23	D
DBO	%	43 7 9.0	123 14 34.0	0.984	Dodson Butte (CREST)	EPI,BB3	E,L-PPP
EARN	%	47 44 27.2	122 2 37.7	0.159	East Ridge Elementary	K2	I
EGRN	%	47 4 24.0	122 58 41.0	0.010	Evergreen State College	K2	None
ELW	%	47 29 39.4	121 52 17.2	0.267	Echo Lake	A,BB	D,M,L
ERW	%	48 27 14.4	122 37 30.2	0.389	Mount Erie	A,BB	D,L,M
EUO	%	44 1 45.7	123 4 8.2	0.160	Eugene Golf Course (CREST)	EPI,BB	E,L-PPP
EVCC	%	48 0 27.0	122 12 15.3	0.000	Everett Community College	K2	None
EVGW	%	47 51 15.8	122 9 12.2	0.010	Gateway Middle School	K2	I
FINN	%	47 43 10.2	122 13 55.9	0.121	Finn Hill Junior High	K2	I
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mountain (CREST)	EPI,BB3	L-PPP
HAO	#	45 30 33.1	122 39 24.0	0.018	Harrison	FBA23	D
HICC	%	47 23 24.4	122 17 52.4	0.115	Highline Community College	K2	I
HOLY	%	47 33 55.4	122 23 1.0	0.106	Holy Rosary School	K2	I
KDK	%	47 35 42.7	122 19 56.0	0.004	King Dome	K2	None
KEEL	%	45 33 0.8	122 53 42.4	0.067	Keeler	A20	D,E,M
KICC	%	47 34 37.9	122 37 52.4	0.010	Kitsap County Central Communications	K2	None
KIMB	%	47 34 29.3	122 18 10.1	0.069	Kimball Elementary	K2	I
KIMR	%	47 30 11.0	122 46 2.0	0.123	Moderate Risk Waste Collection Facility	K2	I
KINR	%	47 45 6.0	122 38 35.0	0.010	North Road Shed	K2	I
KITP	%	47 40 30.0	122 37 47.0	0.076	Wastewater Treatment Plant	K2	I
KNJH	%	47 23 5.0	122 13 42.0	0.010	Kent Junior High	K2	I
LANE	%	44 3 6.5	123 13 54.8	0.120	Lane	K2	E,M
LAWT	%	47 39 23.4	122 23 21.9	0.050	Lawton Elementary	A20	I
LEOT	%	47 46 4.4	122 6 56.2	0.115	Leota Junior High	K2	I
LON	%	46 45 0.0	121 48 36.0	0.853	Longmire Springs (CREST)	EPI,BB3	L-PPP
LTY	%	47 15 21.2	120 39 53.4	0.970	Liberty Heights Mine (CREST)	BB3	I
MARY	%	47 39 45.7	122 7 11.6	0.011	Marymoor Park	K2	I
MBKE	%	48 55 2.0	122 8 29.0	1.010	Kendall Elementary	K2	I
MBPA	%	47 53 54.7	121 53 20.2	0.186	Monroe	A20	D,M,L
MPL	%	47 28 7.0	122 11 4.5	0.122	Maple Valley	A	D,M,L
MURR	%	47 7 12.0	122 33 36.0	0.100	Camp Murray	K2	None
NOWS	%	47 41 12.0	122 15 21.2	0.002	NOAA Sand Point	A20	I
OHC	%	47 20 2.0	123 9 29.0	0.010	Hood Canal Junior High	K2	I
OPC	%	48 6 1.0	123 24 41.8	0.090	Peninsula College (CREST)	EPI,BB	I
PAYL	%	47 11 34.0	122 18 46.0	0.010	Aylen Junior High	K2	I
PCEP	%	47 6 41.8	122 17 24.0	0.160	Puyallup East Sheriff Precinct	K2	I
PCFR	%	46 59 23.3	122 26 27.4	0.137	Roy Training Center	K2	I
PCMD	%	46 53 20.9	122 18 0.9	0.239	Mountain Detachment	K2	I
PIN	%	43 48 40.0	120 52 19.0	1.865	Pine Mtn. (CREST)	EPI,BB3	E,L-PPP
PNLK	%	47 34 54.5	122 2 1.0	0.128	Pine Lake Middle School	K2	I
QAW	%	47 37 54.3	122 21 15.5	0.140	Queen Anne	A20	L
RAW	%	47 20 14.0	121 55 53.2	0.208	Raver	A20	M,L
RBEN	%	47 26 6.7	122 11 10.0	0.152	Benson Hill Elementary	K2	I
RBO	#	45 32 27.0	122 33 51.5	0.158	Rocky Butte	FBA23	D
RHAZ	%	47 32 24.7	122 11 1.3	0.108	Hazelwood Elementary	A20	I
ROSS	%	45 39 43.0	122 39 25.0	0.061	Ross	A20	E
RRHS	%	46 47 58.6	123 2 25.4	0.047	Rochester High School	K2	I
RWW	%	46 57 53.7	123 32 31.7	0.015	Ranney Well (CREST)	EPI,BB3	L-PPP
SBES	%	48 46 5.9	122 24 54.2	0.119	Silver Beach Elementary School	K2	I
SEA	%	47 39 15.8	122 18 29.3	0.030	University of Washington	A20,PMD2023	L
SFER	%	47 37 10.4	117 21 55.7	0.000	Ferris High School	K2	I
SGAR	%	47 40 37.8	117 24 50.3	0.579	Garfield Elementary	K2	I
SMNR	%	47 12 16.6	122 12 53.4	0.010	Sumner High School	K2	I
SP2	%	47 33 23.3	122 14 52.8	0.030	Seward Park	A,BB	L
SQM	%	48 4 39.0	123 2 44.0	0.030	Sequim Battelle Properties (CREST)	EPI,BB	I,R
SVOH	%	48 17 21.8	122 37 54.8	0.010	Skagit Valley College Oak Harbor	K2	I
SWES	%	47 42 51.0	117 27 53.2	0.623	Westview Elementary	K2	I
SWID	%	48 0 31.0	122 24 42.0	0.010	South Whidbey Primary School	K2	I
TAKO	%	43 44 36.0	124 4 56.0	0.100	Tahkenitch (CREST)	EPI,BB	M,E
TBPA	%	47 15 29.0	122 22 1.0	0.002	Tacoma	A20	M,L,D
TKCO	%	47 32 12.7	122 18 1.5	0.005	King County Airport	A20	I
TOLO	%	44 37 19.0	123 55 21.0	0.100	Toledo (CREST)	EPI,BB	ME
TTW	%	47 41 40.7	121 41 20.0	0.542	Tolt Reservoir (CREST)	EPI,BB3	I
UPS	%	47 15 50.2	122 29 1.1	0.113	University of Puget Sound	K2	I
UWFH	%	48 32 46.0	123 0 43.0	0.010	Friday Harbor Laboratories	K2	I
VVHS	%	47 25 25.1	122 27 13.1	0.095	Vashon High School	K2	I
WISC	%	47 36 32.0	122 10 27.8	0.056	Wilburton Instructional Services Center	K2	I

Data Processing

The PNSN seismic recording system uses real-time telemetry, and operates in an 'event triggered' mode. Analog and strong-motion digital data are recorded at 100 samples per sec., while broad-band digital data are digitized at 40 or 50 samples per sec. Arrival times, first motion polarities, signal durations, signal amplitudes, locations and focal mechanisms (when possible) are determined in post-processing. Digital data are processed for all locatable teleseisms, regional events, and local events. Each trace data file has an associated 'pickfile' which includes arrival times, polarities, coda lengths, and other data.

EARTHWORM is our main PNSN data-acquisition system. The old SUNWORM system operates as a digitizer for the analog stations. Analog stations, and most digital stations, are continuously telemetered in real time. Only one broadband stations (LTY) and three USGS strong-motion stations in Portland record only on-site. Data are retrieved via dial-up modem, if needed. All of the real-time data are continuously recorded into temporary storage areas called "wave tanks" which can accommodate about 24 hours of continuous data for the entire network. Triggering algorithms create individual event files.

Continuous data are archived for a small subset of stations, usually about 20, mostly on volcanoes. We continue to use the UW2 pickfile and data formats, and analysis tools which have been in place for the past several years.

Unedited network-trigger trace data are stored on ongoing "network-archive" backup tapes. Edited "Master Event" trace data files are kept for all seismic events. These "Master Event" files are also translated to IRIS-SEED format and submitted to the IRIS Data Management Center for archive and distribution.

Through EARTHWORM, we exchange real-time data with the University of Oregon, The Battelle Pacific Northwest National Labs, the Pacific Geoscience Centre, the Montana Bureau of Mines, and CALNET. In addition, we send real-time data to the Alaska Tsunami Warning Center, the Pacific Tsunami Warning Center, the Cascade Volcano Observatory, and the National Earthquake Information Center,

The entire PNSN catalog has been contributed to the CNSS composite catalog located at the Northern California Earthquake Data Center. The PNSN section of the CNSS catalog is updated daily.

Starting in the fall of 2001, we started shipping a large portion of our waveform data to the IRIS DMC in near real time. This was done by running the *ew2seed* program at IRIS whcih connects to our EARTHWORM waveservers and extracts 1/2 hour of data at a time. Sevral months of testing proved sucessful. At the end of the year we started sending all PNSN traces from all wave servers so that IRIS has a complete copy of all our continuous data in the BUD (Buffer of Uniform Data) system.

Publications

Publications wholly or partly supported under this operating agreement are listed in Appendix 2.

SEISMICITY, EMERGENCY NOTIFICATION, AND OUTREACH

Seismicity

Figure 2 shows earthquakes of magnitude 2.0 or larger located in Washington and Oregon during this reporting period. Table 2 lists earthquakes recorded by the PNSN during 2001 which were reported felt. Table 3 gives information on seismic activity recorded at the PNSN annually since 1980. During this reporting period there were 23 earthquakes reported felt west of the Cascades in Washington, ranging in magnitude from 1.7 to 6.8. Only one Oregon earthquake was reported felt this year; a magnitude 1.9 event.

By far the most interesting event during the reporting period was the moment-magnitude 6.8 Nisqually earthquake of Feb. 28, 2001. It occurred at a depth of about 52 km, about 18 km northeast of Olympia, WA. Extensive information is available on the Nisqually Earthquake Clearinghouse:

http://maximus.ce.washington.edu/~nisqually/index.html

A great deal has been and will be written about the Nisqually earthquake, which caused significant damages. Only four small aftershocks were recorded in the two weeks following the mainshock, but a possible late aftershock of magnitude 4.3 occurred nearby about six months later. Appendix 3 is a reprint of the PNSN's

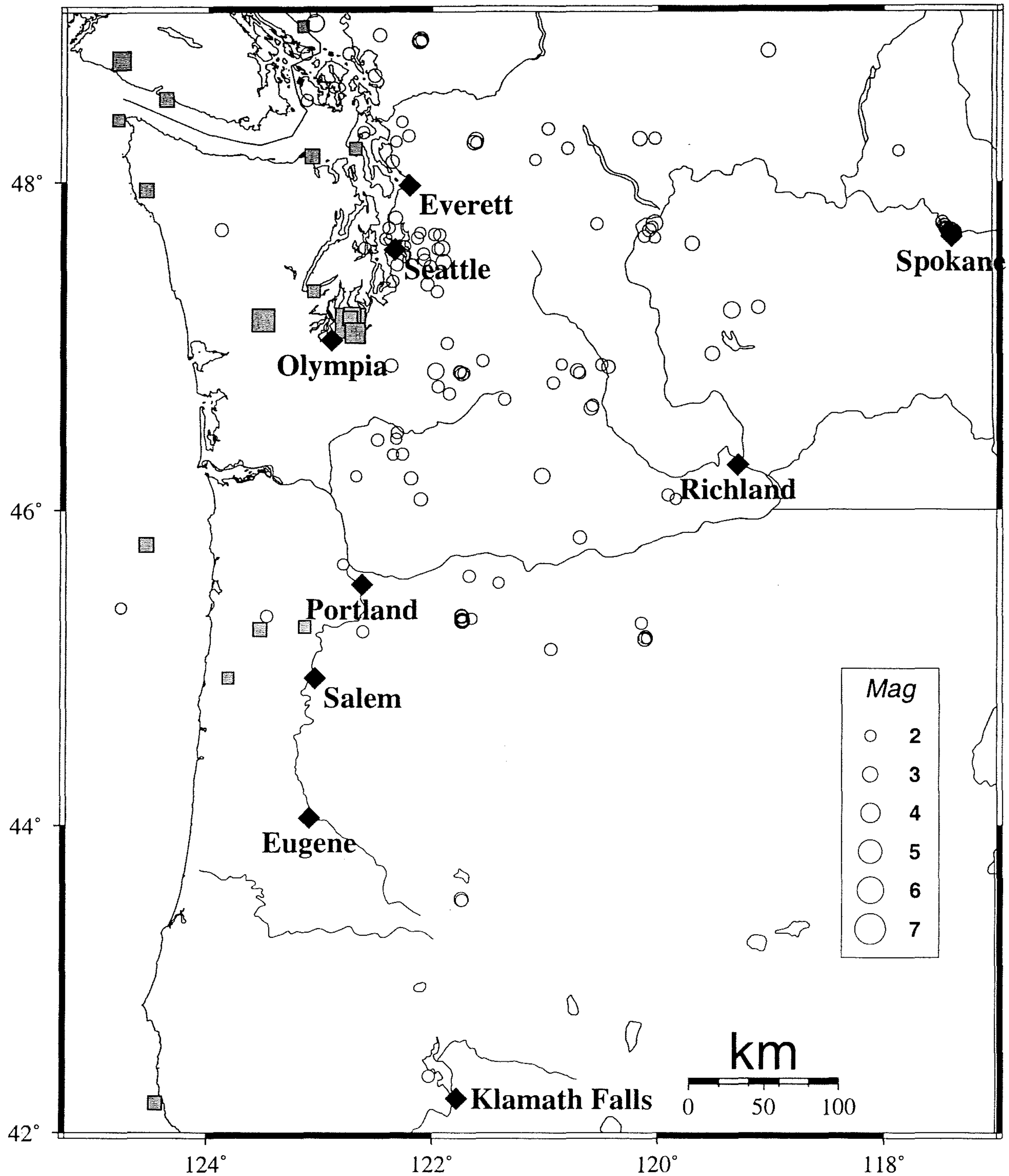

Figure 2. Year 2001 located earthquakes, magnitude >= 2.0. Grey squares indicate earthquakes with depth greater than 30km. Unfilled circles indicate earthquakes with depth <= 30km. Black diamonds indicate cities. Area covered is 117W-125.25W, 42N-49N

"Preliminary Report on the Mw=6.8 Nisqually, Washington Earthquake of 28, February 2001", from Seismological Research Letters, V. 72, N. 3, pp. 352-361.

The 2001 Nisqually earthquake was the largest of a unusual series of Benioff zone earthquakes that began in July 1999 with a M 5.8 earthquake at about 41 km depth beneath Satsop WA. The Nisqually earthquake, in Feb. 2001, was east of the Satsop earthquake and, at 52 km, deeper. A M 5.0 earthquake on June 10, 2001 was near the location and depth of the 1999 Satsop earthquake, and a M 4.3 earthquake on July 22 (UTC) was close to the location and depth of the Nisqually event.

East of the Cascades in Washington, more than 70 earthquakes were felt during 2001. Many of these were tiny events in the Spokane urban area, where a vigorous sequence of earthquakes began in May. Activity continued in bursts, with the largest earthquake M 4.0 on November 11. No comparable sequence is known in the history of Spokane. For additional details see the quarterly reports, or the PNSN web page "The 2001 Spokane Earthquake Sequence":

http://www.ess.washington.edu/SEIS/EQ_Special/WEBDIR_01062514151n/overview.html

Magnitudes of the Spokane felt earthquakes ranged from -0.9 to 4.0. Network coverage was initially sparse, and in addition to the 98 locatable earthquakes, there were many additional felt events early in the sequence too small to locate.

TABLE 2

Felt Earthquakes during 2001

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEPTH km	MAG	COMMENTS
01/02/14 03:54:54	48.75N	123.12W	20.9	2.3	26.0 km NNW of Friday Harbor, WA
01/02/14 22:03:58	47.51N	121.89W	6.6	3.1	5.4 km S of Fall City, WA
01/02/24 07:40:50	47.53N	122.06W	22.6	2.2	13.2 km SE of Bellevue, WA
01/02/28 07:16:13	47.75N	120.03W	0.6	3.2	10.2 km S of Chelan, WA
01/02/28 18:54:32	47.14N	122.72W	51.9	6.8	17.0 km NE of Olympia, WA
01/03/01 09:10:20	47.19N	122.71W	54.3	3.4	21.6 km NE of Olympia, WA
01/03/01 14:23:34	47.18N	122.72W	51.4	2.7	19.4 km NE of Olympia, WA
01/03/10 06:26:05	47.48N	122.79W	19.3	1.7	15.9 km SW of Bremerton, WA
01/03/11 17:08:54	47.60N	121.91W	21.6	2.9	4.4 km NNW of Fall City, WA
01/03/16 02:41:11	47.56N	122.07W	18.1	2.2	10.2 km ESE of Bellevue, WA
01/03/21 10:31:05	46.21N	121.02W	0.9	2.9	35.4 km E of Mt Adams, WA
01/04/07 16:02:35	48.72N	124.76W	41.8	3.9	90.6 km NNW of Forks, WA
01/06/10 13:19:11	47.16N	123.50W	40.7	5.0	18.3 km N of Satsop, WA
01/06/25 14:15:22	47.68N	117.39W	10.5	3.9	1.5 km NE of Spokane, WA (Mission & N Division)
01/06/25 15:01:27	47.70N	117.41W	11.1	3.4	3.3 km N of Spokane, WA (Mission & N Division)
01/06/25 16:49:16	47.73N	117.47W	0.0	2.3	8.7 km NNW of Spokane, WA (Mission & N Division)
01/06/25 22:58:13	47.72N	117.46W	0.0	2.3	6.8 km NNW of Spokane, WA (Mission & N Division)
01/06/26 01:21:21	47.75N	117.48W	0.0	2.1	11.1 km NNW of Spokane, WA (Mission & N Division)
01/06/26 05:52:26	47.75N	117.48W	8.0	2.4	10.6 km NNW of Spokane, WA (Mission & N Division)
01/06/27 09:07:45	47.72N	117.45W	0.4	2.4	6.5 km NNW of Spokane, WA (Mission & N Division)
01/06/27 14:45:37	47.70N	117.41W	7.3	2.9	4.2 km N of Spokane, WA (Mission & N Division)
01/06/28 07:51:42	47.67N	117.39W	0.4	2.3	1.4 km NE of Spokane, WA (Mission & N Division)
01/06/28 11:47:48	47.67N	117.41W	0.5	0.7	0.4 km WNW of Spokane, WA (Mission & N Division)
01/06/29 01:13:27	47.68N	117.42W	0.5	2.4	1.7 km NNW of Spokane, WA (Mission & N Division)
01/06/30 01:23:31	46.85N	121.97W	7.7	3.3	16.2 km W of Mt Rainier, WA
01/07/01 05:44:13	47.67N	117.41W	0.5	2.9	0.5 km N of Spokane, WA (Mission & N Division)
01/07/01 05:45:43	47.68N	117.40W	0.8	2.9	1.8 km NNE of Spokane, WA (Mission & N Division)
01/07/01 06:07:13	47.68N	117.41W	0.4	2.3	1.0 km NNW of Spokane, WA (Mission & N Division)
01/07/02 17:48:29	47.67N	117.42W	0.4	0.8	1.1 km NW of Spokane, WA (Mission & N Division)
01/07/03 21:20:27	47.67N	117.41W	0.5	2.2	0.7 km NNW of Spokane, WA (Mission & N Division)
01/07/08 11:16:32	47.68N	117.41W	0.5	1.5	1.5 km NNW of Spokane, WA (Mission & N Division)
01/07/16 11:37:35	45.11N	122.51W	13.1	1.9	21.4 km SE of Canby, OR
01/07/22 15:13:52	47.08N	122.68W	52.4	4.3	16.3 km ENE of Olympia, WA
01/07/24 13:31:06	47.49N	122.02W	16.4	2.2	9.3 km N of Maple Valley, WA
01/07/29 06:26:53	47.68N	117.41W	0.4	2.3	1.1 km NNW of Spokane, WA (Mission & N Division)
01/07/29 06:37:58	47.68N	117.41W	0.2	1.3	1.6 km NNW of Spokane, WA (Mission & N Division)
01/07/29 07:04:24	47.66N	117.39W	0.3	1.2	1.5 km SE of Spokane, WA (Mission & N Division)
01/07/30 20:35:08	47.67N	117.42W	0.3	1.8	1.4 km NW of Spokane, WA (Mission & N Division)
01/07/31 01:38:10	47.68N	117.40W	0.5	3.2	1.8 km NNE of Spokane, WA (Mission & N Division)
01/07/31 05:07:31	47.68N	117.41W	0.4	2.2	1.3 km NNW of Spokane, WA (Mission & N Division)
01/07/31 05:24:33	47.69N	117.42W	0.5	1.5	2.4 km NNW of Spokane, WA (Mission & N Division)
01/07/31 06:48:11	47.71N	117.47W	0.5	1.8	6.9 km NW of Spokane, WA (Mission & N Division)
01/07/31 08:51:55	47.72N	117.45W	2.1	1.6	7.1 km NNW of Spokane, WA (Mission & N Division)
01/07/31 16:27:42	47.68N	117.42W	0.5	1.8	1.5 km NW of Spokane, WA (Mission & N Division)
01/08/01 14:29:48	47.67N	117.42W	0.5	2.2	0.9 km WNW of Spokane, WA (Mission & N Division)
01/08/09 13:31:23	47.68N	117.42W	0.8	1.5	1.7 km NW of Spokane, WA (Mission & N Division)
01/08/14 13:28:27	44.28N	125.46W	10.0	1.5	119.1 km WSW of Newport, OR

TABLE 2 (continued)

Felt Earthquakes during 2001

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEPTH km	MAG	COMMENTS
01/08/19 06:17:32	48.25N	121.61W	1.7	3.0	1.0 km WSW of Darrington, WA
01/08/25 17:52:34	48.23N	121.60W	2.7	2.1	2.1 km S of Darrington, WA
01/08/30 03:47:31	48.23N	121.62W	4.8	2.7	2.9 km SW of Darrington, WA
01/09/28 18:34:53	47.68N	117.38W	1.8	2.8	2.1 km NE of Spokane, WA (Mission & N Division)
01/09/28 18:37:53	47.66N	117.37W	0.3	1.9	2.7 km ESE of Spokane, WA (Mission & N Division)
01/09/28 18:38:37	47.67N	117.40W	0.6	2.6	0.7 km NNE of Spokane, WA (Mission & N Division)
01/09/28 18:41:40	47.67N	117.39W	0.0	1.6	1.0 km ENE of Spokane, WA (Mission & N Division)
01/10/05 02:26:41	48.82N	122.11W	12.1	3.0	7.6 km E of Deming, WA
01/10/06 10:52:09	48.83N	122.10W	13.2	3.0	8.2 km E of Deming, WA
01/10/15 04:57:01	48.15N	123.06W	44.4	2.9	28.6 km E of Port Angeles, WA
01/11/10 18:30:59	48.93N	123.04W	15.4	3.4	21.7 km S of Vancouver,BC
01/11/11 16:00:29	47.68N	117.40W	4.7	4.0	2.0 km NNE of Spokane, WA (Mission & N Division)
01/11/11 17:21:33	47.68N	117.40W	0.6	3.1	1.3 km NNE of Spokane, WA (Mission & N Division)
01/11/12 03:03:02	47.68N	117.40W	0.6	3.3	2.0 km N of Spokane, WA (Mission & N Division)
01/11/12 03:07:40	47.68N	117.41W	0.6	1.9	1.7 km N of Spokane, WA (Mission & N Division)
01/11/12 03:11:15	47.68N	117.41W	0.6	2.4	1.9 km NNW of Spokane, WA (Mission & N Division)
01/11/12 11:44:18	47.68N	117.39W	0.6	1.7	2.4 km NE of Spokane, WA (Mission & N Division)
01/11/12 13:25:59	47.68N	117.40W	0.5	1.9	2.0 km NNE of Spokane, WA (Mission & N Division)
01/11/13 05:41:45	47.69N	117.40W	0.6	2.3	2.4 km N of Spokane, WA (Mission & N Division)
01/11/13 07:39:05	47.68N	117.42W	0.6	2.1	1.4 km NW of Spokane, WA (Mission & N Division)
01/11/13 10:14:01	48.86N	122.46W	22.0	2.5	11.7 km N of Bellingham, WA
01/11/13 20:26:26	47.69N	117.40W	0.6	3.0	2.2 km NNE of Spokane, WA (Mission & N Division)
01/11/14 01:50:51	47.69N	117.38W	0.6	1.2	3.6 km NE of Spokane, WA (Mission & N Division)
01/11/14 16:41:20	47.69N	117.32W	0.6	1.6	7.3 km ENE of Spokane, WA (Mission & N Division)
01/11/15 00:11:46	47.69N	117.39W	0.0	2.1	2.7 km NNE of Spokane, WA (Mission & N Division)
01/11/16 01:42:29	47.68N	117.39W	0.5	1.8	2.2 km NE of Spokane, WA (Mission & N Division)
01/11/17 16:18:49	47.68N	117.42W	0.4	1.4	1.9 km NNW of Spokane, WA (Mission & N Division)
01/11/18 19:51:12	47.68N	117.42W	0.8	1.6	1.5 km NW of Spokane, WA (Mission & N Division)
01/11/19 04:47:06	47.68N	117.41W	2.2	1.2	1.5 km NNW of Spokane, WA (Mission & N Division)
01/11/19 04:47:52	47.69N	117.41W	1.2	0.5	2.9 km NNW of Spokane, WA (Mission & N Division)
01/11/20 06:03:56	47.67N	117.44W	2.6	1.0	2.3 km WNW of Spokane, WA (Mission & N Division)
01/11/20 12:14:42	47.67N	117.44W	0.0	1.4	2.5 km W of Spokane, WA (Mission & N Division)
01/11/22 04:43:01	47.68N	117.42W	2.5	1.4	1.2 km NW of Spokane, WA (Mission & N Division)
01/11/24 00:32:10	47.67N	117.43W	2.1	-0.5	1.6 km WNW of Spokane, WA (Mission & N Division)
01/11/26 04:13:15	47.68N	117.42W	2.2	0.9	1.6 km NNW of Spokane, WA (Mission & N Division)
01/11/26 09:41:37	47.69N	117.40W	0.0	-0.8	3.0 km NNE of Spokane, WA (Mission & N Division)
01/11/26 09:41:53	47.68N	117.43W	2.1	0.0	1.8 km NW of Spokane, WA (Mission & N Division)
01/11/26 09:59:53	47.68N	117.38W	4.7	-1.6	2.3 km NE of Spokane, WA (Mission & N Division)
01/11/26 10:12:11	47.68N	117.40W	2.3	-1.6	1.6 km N of Spokane, WA (Mission & N Division)
01/11/26 11:56:07	47.68N	117.41W	2.2	0.7	1.8 km N of Spokane, WA (Mission & N Division)
01/11/27 08:26:58	47.65N	117.44W	0.5	-0.9	3.4 km SW of Spokane, WA (Mission & N Division)
01/12/06 23:24:08	46.89N	122.36W	20.4	2.4	8.1 km WNW of Eatonville, WA
01/12/19 06:39:26	47.69N	117.38W	0.0	-0.8	3.1 km NNE of Spokane, WA (Mission & N Division)
01/12/19 21:32:17	47.67N	117.44W	2.0	-0.8	2.2 km WNW of Spokane, WA (Mission & N Division)
01/12/20 03:03:20	47.67N	117.44W	2.0	-0.5	2.3 km W of Spokane, WA (Mission & N Division)
01/12/20 08:30:43	47.67N	117.43W	1.8	-0.1	2.1 km W of Spokane, WA (Mission & N Division)
01/12/25 03:58:53	47.68N	117.42W	0.2	-0.7	1.7 km NW of Spokane, WA (Mission & N Division)
01/12/27 22:11:20	47.66N	117.43W	0.0	-0.5	2.0 km W of Spokane, WA (Mission & N Division)
01/12/29 11:57:27	47.67N	117.43W	0.0	-0.8	2.0 km W of Spokane, WA (Mission & N Division)

TABLE 3

Annual counts of events recorded by the PNSN, 1980-2001

Year	Total #	Out of Net	Inside Net			
			Unlocated	Located		
				Total	EQs(#felt)	Blasts
80	4576	253	1075	3246	2874(18)	372
81	5155	291	1474	3385	2672(29)	713
82	4452	329	1824	2297	1948(20)	349
83	4489	405	2338	1745	1356(15)	389
84	3144	267	1095	1780	1409(16)	371
85	3560	266	1168	2122	1890(16)	232
86	2554	318	452	1776	1594(21)	182
87	1981	537	127	1304	966(22)	338
88	2249	507	114	1624	1263(19)	361
89	2781	501	137	2136	1835(38)	301
90	3433	717	204	2505	2096(26)	409
91	3083	675	315	2085	1687(26)	398
92	3522	891	235	2381	1993(22)	388
93	5594	731	626	4224	3877(35)	347
94	6243	900	1518	3816	3424(28)	392
95	5354	959	1462	2915	2539(16)	376
96	4741	911	1192	2628	2214(39)	414
97	3881	728	904	2239	1992(35)	247
98	7463	831	2174	4430	4176(11)	254
99	4505	803	1483	2187	1965(30)	222
00	5625	1121	1686	2818	2482(18)	341
01	5945	1090	2106	2730	2258(95)	472

Emergency Notification

The RACE system, discussed earlier, is a pager-based alarm system that updates earthquake locations on a map displayed on a PC screen. When a "significant" event (magnitude 2.9 or larger) is located by the PNSN automatic systems, a preliminary location and magnitude is sent within minutes to seismologists and the RACE system via pager. The same information is forwarded via fax and e-mail to others with critical need. A set of web-pages on earthquakes magnitude 3.3 and larger are automatically generated and linked to the PNSN web-site. These preliminary messages are rapidly followed by final processing and update of the RACE systems, faxes, e-mail, and web-site, within 20 minutes to an hour.

Public Information and Outreach

Summary lists for all earthquakes located by the PNSN since 1969 are available via anonymous ftp on **ftp.geophys.washington.edu** in the *pub/seis_net* subdirectory. This information is also available via the PNSN **World-Wide-Web(WWW)** site.

http://www.geophys.washington.edu/SEIS/PNSN/

Our web-server contains text about earthquakes in the Pacific Northwest, maps of stations, catalogs and maps of recent earthquake activity, and maps and text about recent interesting sequences. It also contains links into other sources of earthquake information around the country and world.

The PNSN has an educational outreach program to better inform the public, policy makers, and emergency managers about seismicity and natural hazards. We provide information sheets, lab tours, workshops, and media interviews, and have an audio library with several tapes. We organize and participate in special events in addition to our normal background of informational work; including several thousand calls per quarter to our audio library; tours of the PNSN lab by hundreds of students, teachers, and parents; and outreach talks to numerous groups of all types.

This year was a another very busy one for the PNSN!

- The M 6.8 Nisqually earthquake on February 28th was followed by intense national media attention, with a high demand for interviews and information. FEMA funding was obtained for The Nisqually Earthquake Clearinghouse (hosted by the PNSN) to collect and organize data related to the earthquake. The Clearinghouse operated through the end of September.

- High demand for public information continued as additional western Washington Benioff zone earthquakes (M 5.0 and M 4.3) occurred in June and July, and a swarm of small earthquakes, in sporadic bursts from June through December, were felt by many in downtown Spokane.
- PNSN staff met with numerous state and county officials, representatives of utility and private companies, and engineering and emergency management groups regarding rapid earthquake notification and long-term network and strong-motion development plans. The PNSN installed a RACE System at the WSDOT Seattle Operations Center.
- Many presentations were given; to professional groups such as the Washington State Emergency Managers Association (WSEMA), the Western States Seismic Policy Council (WSSPC), the Contingency Planners And Recovery Managers (CPARM), the Western Washington Emergency Network conference, the Oregon Seismic Safety Policy Advisory Committee, and the the Washington Seismic Safety Committee; and to general audiences at functions including Disaster Saturday, the Burke Museum, the Olympic Peninsula Intertribal Cultural Advisory Committee, the Association of Geo-science Educators, the Seattle Middle Schools Science Fair.
- The PNSN hosted meetings of the ANSS Technical Integration Committee (see report at http://www.anss.org/ticplan/) and the ANNS Pacific Northwest Region Siting Advisory Committee Meeting (see http://www.ess.washington.edu/SEIS/ANSS/), as well as several meetings of Cascadia Regional Earthquake Workgroup (CREW) subcommittees.
- PNSN representatives participated in national level ANSS committees and activiites throughout the year, and attended a wide variety of other meetings related to earthquake hazards, preparedness, and related information and outreach.
- The PNSN was especially well represented at the April meeting of the Seismological Society of America, with individual or shared authorship of numerous posters and presentations.
- Tony Qamar, Washington State Seismologist, has been appointed to the newly reconstituted Seismic Safety Committee of the Washington State Emergency Management Council. Dr. Qamar has been appointed chairman of the Information and Technology Subcommittee.

ACKNOWLEDGMENTS

Seismic stations, telemetry links, and data acquisition equipment were maintained by Jim Ramey and Allen Strelow at the UW, Patrick McChesney (stationed at CVO in Vancouver, Washington), Pat Ryan (of the University of Oregon in Eugene, Oregon), and Don Hartshorn (of Pacific Northwest National Labs in Richland, WA). Bill Steele provided information to the public, while Amy Wright handled routine data analysis and archiving of digital trace data in UW2 format. George Thomas, Amy Lindemuth, Lynn Hultgrien and Sue Sweet worked on strong motion instrumentation and software. Ruth Ludwin wrote reports, maintained the PNSN web-pages, and handled administrative tasks. The University of Oregon (UO) installed and maintained stations and telemetry links in central Oregon, and operated an earthworm node to transmit data to the University of Washington.

APPENDIX 1

PNSN Quarterly Reports
01-A, 01-B, 01-C, and 01-D

APPENDIX 3

Reprint of:
Preliminary Report on the Mw=6.8 Nisqually, Washington Earthquake of 28, February 2001
2001, SRL V. 72, N. 3, pp. 352-361.

APPENDIX 1

PNSN Quarterly Reports
01-A, 01-B, 01-C, and 01-D

QUARTERLY NETWORK REPORT 2001-A
on
Seismicity of Washington and Oregon

January 1 through March 31, 2001

Pacific Northwest Seismograph Network
Geophysics Program
Box 351650
University of Washington
Seattle, Washington 98195-1650

This report is prepared as a preliminary description of the seismic activity in Washington State and Oregon. Information contained in this report should be considered preliminary, and not cited for publication without checking directly with network staff. The views and conclusions contained in this document should not be interpreted as necessarily representing the official policies, either express or implied, of the U.S. Government.

Seismograph network operation in Washington and Oregon is supported by the following contracts:

U.S. Geological Survey
Joint Operating Agreement 01-HQ-AG-0011

and

Pacific Northwest National Laboratory, operated by Battelle for the U.S. Dept. of Energy
Contract 259116-A-B3

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INTRODUCTION

This is the first quarterly report of 2001 from the University of Washington Geophysics Program *Pacific Northwest Seismograph Network* (PNSN), covering seismicity of Washington and western Oregon.

Comprehensive quarterlies have been produced by the PNSN since the beginning of 1984. Prior to that we published quarterly reports for western Washington in 1983 and for eastern Washington from 1975 to 1983. Annual technical reports covering seismicity in Washington since 1969 are available from the U.W. Geophysics Program. Beginning in 1999, the quarterly PNSN catalog listing changed; earthquakes smaller than magnitude 2.0 are no longer listed in the quarterly reports. The complete PNSN catalog is available on-line, both through our web-site and through the CNSS catalog. We will continue to provide special coverage (figures, counts, listings, etc.) of earthquake swarms, aftershock sequences, etc.

This quarterly report discusses network operations, seismicity of the region, unusual events or findings, and our educational and outreach activities. This report is preliminary, and subject to revision. The PNSN routinely records signals from selected stations in adjoining networks. This improves our ability to locate earthquakes at the edges of our network. However, our earthquake locations may be revised if new data become available, such as P and S readings from Canadian seismograph stations. Findings mentioned in these quarterly reports should not be cited for publication.

NETWORK OPERATIONS

Figure 1a shows a map view of stations operating during the quarter. Figure 1b is a more detailed view of stations in the Puget Sound area. Table 1 gives approximate periods of time when individual stations were inoperable. Data for Table 1 are compiled from weekly plots of network-wide teleseismic arrivals and automated digital signal checks, plus records of maintenance and repair visits.

Data Recording and EARTHWORM Update

At the end of 2000, a full EARTHWORM configuration was implemented on the computer scossa. This quarter, scossa became our main EARTHWORM machine, with milli serving as our primary backup and verme as the secondary backup. Milli and verme still serve as the principal computers for data acquisition for many of the digital stations. We are currently running EARTHWORM-V5.1.

The SUNWORM digitizer for our backup system began to have problems, so we requested an official EARTHWORM digitizer from the central EARTHWORM team. Equipment arrived at the end of the quarter, but it will take some effort to develop the wiring configuration to get it installed as part of our main system.

In mid-February a new earthquake magnitude calculator, *localmag*, was implemented as part of our routine earthworm system. It had been tested by its developer, Pete Lombard, using previously recorded PNSN data but calibration had not been completed, and PNSN staff had only very brief training and minimal experience with *localmag* when the Nisqually earthquake occurred on Feb. 28. The initial magnitude estimates from *localmag* were available less than 15 minutes after the earthquake, and were very close to the final magnitude of 6.8. We have implemented *localmag* routinely on our system, and continue to gather information on how it performs over a wider magnitude range.

During January and early February, Steve Malone gave a 6-week class on the PNSN EARTHWORM implementation. This class brought PNSN staff up-to-date on most of the critical features of our data acquisition system, and improved our ability to deal with operational problems.

Strong Motion Instrumentation and Recording Update

Three new strong-motion stations were installed in the first quarter of 2001. The first was BEVT, a new ANSS (Advanced National Seismic System) station at Boeing-Everett. The other two stations, ALVY and LANE, are new USGS strong motion stations at BPA (Bonneville Power Administration) substations in Eugene, OR.

The ANSS Advisory Committee met on February 21, 2001. George Thomas, Steve Malone, and Bill Steele attended the meeting, the purpose of which was to initiate activities of the Advisory Committee and assist with the development of the ANSS in the Pacific Northwest.

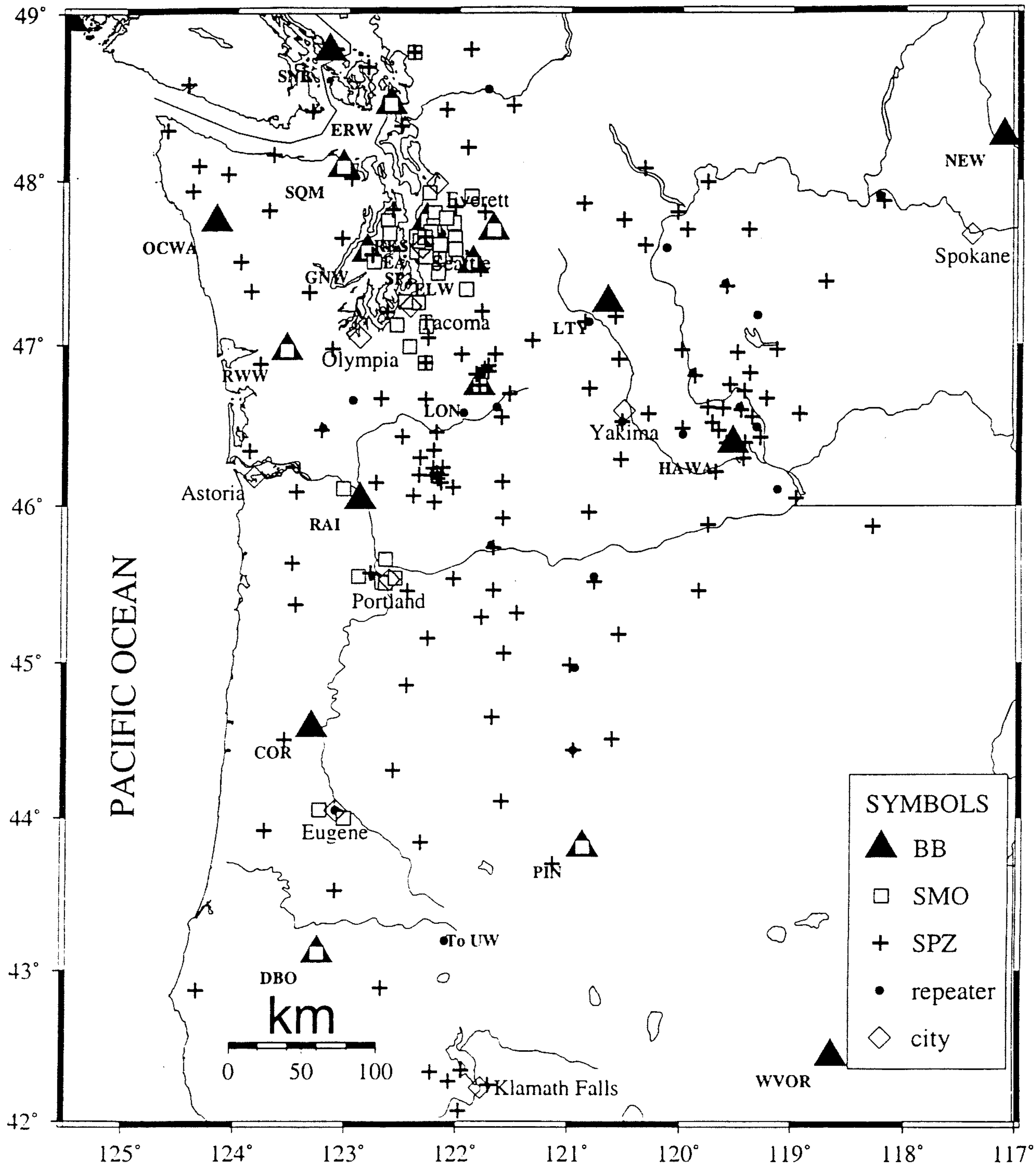

Figure 1A. Stations operating at the end of 1st quarter, 2001. Stations shown are short period vertical (SP), 3-component broadband (BB), or strong motion (SMO).

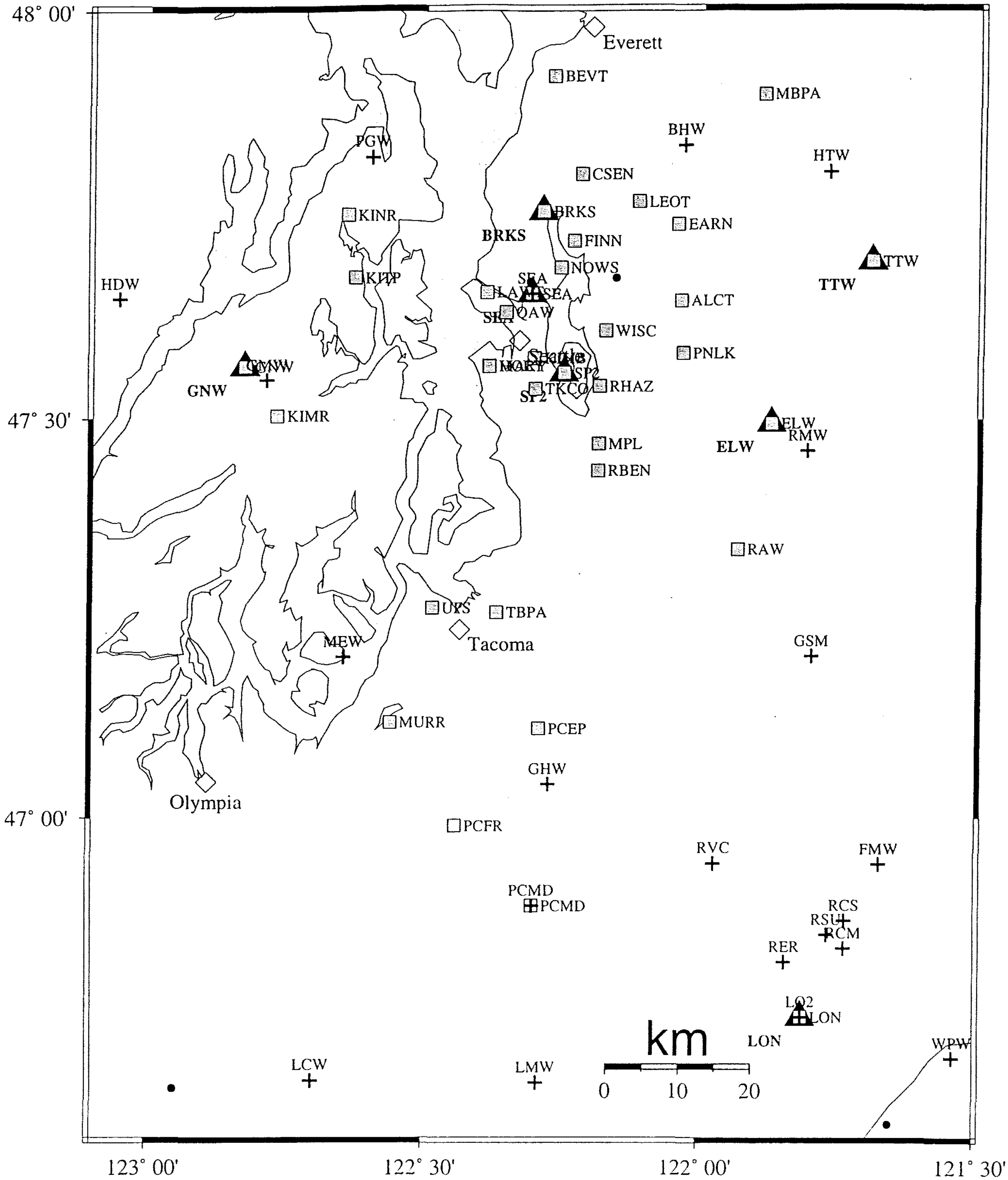

Figure 1B. Stations operating at the end of 1st quarter, 2001. Detail of Figure 1A.

The USGS has authorized funding for the installation of 20 additional ANSS strong motion instruments in the greater Puget Sound Region in calendar year 2001. The siting process for these new instruments was halfway finished by the end of the first quarter.

In the first quarter of 2001, we successfully implemented *ShakeMap*, a map displaying ground shaking produced by an earthquake based on surface geology and data from the strong motion instruments. A *ShakeMap* was made within an hour of a magnitude 3.1 felt earthquake on February 14th and also within a few hours of the magnitude 6.8 Nisqually earthquake.

CREST Instrument Update

CREST (Consolidated Reporting of EarthquakeS and Tsunamis) stations are planned for Eugene Oregon (through UO), and for Longview, Boistfort Peak, Forks, and Tolt Reservoir in Washington. Four additional sites directly on the coast with BPA telemetry have been identified, and permitting discussions are underway.

TABLE 1
Station Outages, Repairs, and Installations 1st quarter 2001

Station	Outage Dates	Comments
ALVY	1/17/01	Installed (SMO)
BBO	2/1/01-3/7/01	Receiver box knocked over, repaired burned wires
BEVT	2/21/01	Installed (SMO)
GLK	3/1/01-3/14/01	Phone off
KOS	2/1/01-3/14/01	Dead - batteries were replaced
LANE	1/17/01	Installed (SMO)
LMW	2/28/01-End	Dead
RSU	9/30/00-End	Dead
SLF	12/1/00-3/1/01	Back on with warmer weather
TKO	1/4/99-End	REMOVED
TTW	1/1/00-End	Bad GPS antenna after switching to ethernet telemetry
TWW	12/1/00-End	Bad time
VRC	10/1/00-End	Dead/VCO was shot with a gun, pulled out 11/2
VSP	1/1/01-1/10/01	Solar cells iced over, replaced batteries
WPW	3/1/01-3/14/01	Phone off

STATIONS USED FOR LOCATION OF EVENTS

Table 2A lists short-period, mostly vertical-component stations used in locating seismic events in Washington and Oregon. The first column in the table gives the 3-letter station designator, followed by a symbol designating the funding agency; stations marked by a percent sign (%) were supported by USGS joint operating agreement 01-HQ-AG-0011. A plus (+) indicates support under Pacific Northwest National Laboratory, Battelle contract 259116-A-B3. Stations designated "#" are USGS-maintained stations recorded at the PNSN. Other stations were supported from other sources. Additional columns give station north latitude and west longitude (in degrees, minutes and seconds), station elevation in km, and comments indicating landmarks for which stations were named.

TABLE 2A - Short-period Stations operated by the PNSN during the first quarter 2001

STA	F	LAT	LONG	EL	NAME
ASR	%	46 09 09.9	121 36 01.6	1.357	Mt. Adams - Stagman Ridge
AUG	%	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BBO	%	42 53 12.6	122 40 46.6	1.671	Butler Butte, Oregon
BHW	%	47 50 12.6	122 01 55.8	0.198	Bald Hill
BLN	%	48 00 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	%	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
BPO	%	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
BRV	+	46 29 07.2	119 59 28.2	0.920	Black Rock Valley
BVW	+	46 48 39.5	119 52 56.4	0.670	Beverly
CBS	+	47 48 17.4	120 02 30.0	1.067	Chelan Butte, South
CDF	%	46 07 01.4	122 02 42.1	0.756	Cedar Flats
CMM	%	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.
CMW	%	48 25 25.3	122 07 08.4	1.190	Cultus Mtns.
CPW	%	46 58 25.8	123 08 10.8	0.792	Capitol Peak
CRF	+	46 49 30.0	119 23 13.2	0.189	Corfu
DPW	+	47 52 14.3	118 12 10.2	0.892	Davenport
DY2	+	47 59 06.6	119 46 16.8	0.890	Dyer Hill 2
EDM	%	46 11 50.4	122 09 00.0	1.609	East Dome, Mt. St. Helens
ELK	%	46 18 20.0	122 20 27.0	1.270	Elk Rock
ELL	+	46 54 34.8	120 33 58.8	0.789	Ellensburg
EPH	+	47 21 22.8	119 35 45.6	0.661	Ephrata
ET3	+	46 34 38.4	118 56 15.0	0.286	Eltopia (replaces ET2)
ETW	+	47 36 15.6	120 19 56.4	1.477	Entiat

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
FBO	%	44 18 35.6	122 34 40.2	1.080	Farmers Butte, Oregon
FHE		46 57 06.9	119 29 49.0	0.455	Frenchman Hills East
FL2	%	46 11 47.0	122 21 01.0	1.378	Flat Top 2
FMW	%	46 56 29.6	121 40 11.3	1.859	Mt. Fremont
GBL	+	46 35 54.0	119 27 35.4	0.330	Gable Mountain
GHW	%	47 02 30.0	122 16 21.0	0.268	Garrison Hill
GL2	+	45 57 35.0	120 49 22.5	1.000	New Goldendale
GLK	%	46 33 27.6	121 36 34.3	1.305	Glacier Lake
GMO	%	44 26 20.8	120 57 22.3	1.689	Grizzly Mountain, Oregon
GMW	%	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GSM	%	47 12 11.4	121 47 40.2	1.305	Grass Mt.
GUL	%	45 55 27.0	121 35 44.0	1.189	Guler Mt.
HAM	%	42 04 08.3	121 58 16.0	1.999	Hamaker Mt., Oregon
HBO	%	43 50 39.5	122 19 11.9	1.615	Huckleberry Mt., Oregon
HDW	%	47 38 54.6	123 03 15.2	1.006	Hoodsport
HOG	%	42 14 32.7	121 42 20.5	1.887	Hogback Mtn., Oregon
HSO	%	43 31 33.0	123 05 24.0	1.020	Harness Mountain, Oregon
HSR	%	46 10 28.0	122 10 46.0	1.720	South Ridge, Mt. St. Helens
HTW	%	47 48 14.2	121 46 03.5	0.833	Haystack Lookout
JBO	+	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JCW	%	48 11 42.7	121 55 31.1	0.792	Jim Creek
JUN	%	46 08 50.0	122 09 04.4	1.049	June Lake
KMO	%	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	%	46 27 46.7	122 11 41.3	0.610	Kosmos
LAB	%	42 16 03.3	122 03 48.7	1.774	Little Aspen Butte, Oregon
LCW	%	46 40 14.4	122 42 02.8	0.396	Lucas Creek
LMW	%	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
LNO	+	45 52 18.6	118 17 06.6	0.771	Linton Mt., Oregon
LO2	%	46 45 00.0	121 48 36.0	0.853	Longmire
LOC	+	46 43 01.2	119 25 51.0	0.210	Locke Island
LVP	%	46 04 06.0	122 24 30.0	1.170	Lakeview Peak
MBW	%	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCW	%	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MDW	+	46 36 47.4	119 45 39.6	0.330	Midway
MEW	%	47 12 07.0	122 38 45.0	0.097	McNeil Island
MJ2	+	46 33 27.0	119 21 32.4	0.146	May Junction 2
MOX	+	46 34 38.4	120 17 53.4	0.501	Moxie City
MPO	%	44 30 17.4	123 33 00.6	1.249	Mary's Peak, Oregon
MTM	%	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
NAC	+	46 43 59.4	120 49 25.2	0.728	Naches
NCO	%	43 42 14.4	121 08 18.0	1.908	Newberry Crater, Oregon
NEL	+	48 04 12.6	120 20 24.6	1.500	Nelson Butte
NLO	%	46 05 21.9	123 27 01.8	0.826	Nicolai Mt., Oregon
OBC	%	48 02 07.1	124 04 39.0	0.938	Olympics - Bonidu Creek
OBH	%	47 19 34.5	123 51 57.0	0.383	Olympics - Burnt Hill
OCP	%	48 17 53.5	124 37 30.0	0.487	Olympics - Cheeka Peak
OD2	+	47 23 15.6	118 42 34.8	0.553	Odessa site 2
OFR	%	47 56 00.0	124 23 41.0	0.152	Olympics - Forest Resource Cen
OHW	%	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ON2	%	46 52 50.8	123 46 51.8	0.257	Olympics - North River
OOW	%	47 44 03.6	124 11 10.2	0.561	Octopus West
OSD	%	47 48 59.2	123 42 13.7	2.008	Olympics - Snow Dome
OSR	%	47 30 20.3	123 57 42.0	0.815	Olympics Salmon Ridge
OT3	+	46 40 08.4	119 13 58.8	0.322	New Othello (replaces OT2 8/26
OTR	%	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PAT	+	45 52 55.2	119 45 08.4	0.262	Paterson
PCMD	%	46 53 20.9	122 18 00.9	0.239	PC Mountain Detachment
PGO	%	45 27 42.6	122 27 11.5	0.253	Gresham, Oregon
PGW	%	47 49 18.8	122 35 57.7	0.122	Port Gamble
PRO	+	46 12 45.6	119 41 08.4	0.553	Prosser
RCM	%	46 50 08.9	121 43 54.4	3.085	Mt. Rainier, Camp Muir
RCS	%	46 52 15.6	121 43 52.0	2.877	Mt. Rainier, Camp Schurman
RER	%	46 49 09.2	121 50 27.3	1.756	Mt. Rainier, Emerald Ridge
RMW	%	47 27 35.0	121 48 19.2	1.024	Rattlesnake Mt. (West)
RNO	%	43 54 58.9	123 43 25.5	0.850	Roman Nose, Oregon
RPW	%	48 26 54.0	121 30 49.0	0.850	Rockport
RSU	%	46 51 12.0	121 45 47.0	4.440	Rainier summit
RSW	+	46 23 40.2	119 35 28.8	1.045	Rattlesnake Mt. (East)
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
RVN	%	47 01 38.6	121 20 11.9	1.885	Raven Roost (former NEHRP temp
RVW	%	46 08 53.2	122 44 32.1	0.460	Rose Valley
SAW	+	47 42 06.0	119 24 01.8	0.701	St. Andrews
SBES	%	48 46 05.9	122 24 54.2	0.000	Silver Beach ES
SEA	%	47 39 15.8	122 18 29.3	0.030	UW, Seattle (Wood Anderson,BB,
SEP	#	46 12 00.7	122 11 28.1	2.116	September lobe, Mt. St. Helens
SHW	%	46 11 37.1	122 14 06.5	1.425	Mt. St. Helens

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
SLF	%	47 45 32.0	120 31 40.0	1.750	Sugar Loaf
SMW	%	47 19 10.7	123 20 35.4	0.877	South Mtn.
SOS	%	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
SSO	%	44 51 21.6	122 27 37.8	1.242	Sweet Springs. Oregon
STD	%	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	%	48 09 03.1	123 40 11.1	0.308	Striped Peak
TBM	+	47 10 12.0	120 35 52.8	1.006	Table Mt.
TCO	%	44 06 27.6	121 36 02.1	1.975	Three Creek Meadows. Oregon.
TDH	%	45 17 23.4	121 47 25.2	1.541	Tom.Dick.Harry Mt.. Oregon
TDL	%	46 21 03.0	122 12 57.0	1.400	Tradedollar Lake
TKO	%	45 22 16.7	123 27 14.0	1.024	Trask Mtn. Oregon
TRW	+	46 17 32.0	120 32 31.0	0.723	Toppenish Ridge
TWW	+	47 08 17.4	120 52 06.0	1.027	Teanaway
VBE	%	45 03 37.2	121 35 12.6	1.544	Beaver Butte. Oregon
VCR	%	44 58 58.2	120 59 17.4	1.015	Criterion Ridge. Oregon
VFP	%	45 19 05.0	121 27 54.3	1.716	Flag Point. Oregon
VG2	%	45 09 20.0	122 16 15.0	0.823	Goat Mt.. Oregon
VGB	+	45 30 56.4	120 46 39.0	0.729	Gordon Butte. Oregon
VIP	%	44 30 29.4	120 37 07.8	1.731	Ingram Pt.. Oregon
VLL	%	45 27 48.0	121 40 45.0	1.195	Laurance Lk.. Oregon
VLM	%	45 32 18.6	122 02 21.0	1.150	Little Larch. Oregon
VRC	%	42 19 47.2	122 13 34.9	1.682	Rainbow Creek. Oregon
VSP	%	42 20 30.0	121 57 00.0	1.539	Spence Mtn. Oregon
VT2	+	46 58 02.4	119 59 57.0	1.270	Vantage2
VTH	%	45 10 52.2	120 33 40.8	0.773	The Trough. Oregon
WA2	+	46 45 19.2	119 33 56.4	0.244	Wahluke Slope
WAT	+	47 41 55.2	119 57 14.4	0.821	Waterville
WG4	+	46 01 49.2	118 51 21.0	0.511	Wallula Gap
WIB	%	46 20 34.8	123 52 30.6	0.503	Willapa Bay
WIW	+	46 25 45.6	119 17 15.6	0.128	Wooded Island
WPO	%	45 34 24.0	122 47 22.4	0.334	West Portland. Oregon
WPW	%	46 41 55.7	121 32 10.1	1.280	White Pass
WRD	+	46 58 12.0	119 08 41.4	0.375	Warden
WRW	%	47 51 26.0	120 52 52.0	1.189	Wenatchee Ridge
YA2	+	46 31 36.0	120 31 48.0	0.652	Yakima
YEL	#	46 12 35.0	122 11 16.0	1.750	Yellow Rock. Mt. St. Helens

Table 2B lists broad-band. three-component stations operating in Washington and Oregon that provide data to the PNSN.

TABLE 2B

Broad-band three-component stations operating at the end of the first quarter 2001. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME
COR		44 35 08.5	123 18 11.5	0.121	Corvallis. Oregon (IRIS station. Operated by OSU)
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte. Oregon (CREST - operated by UO)
ELW	%	47 29 38.8	121 52 21.6	0.267	Echo Lake. WA (operated by UW)
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie. WA (operated by UW)
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mountain. WA (CREST - operated by UW)
HAWA		46 23 32.3	119 31 57.2	0.367	Hanford Nike (USGS-USNSN)
HLID		43 33 45.0	114 24 49.3	1.772	Hailey. ID (USGS-USNSN)
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire (CREST - operated by UW)
LTY	%	47 15 21.2	120 39 53.3	0.970	Liberty. WA (operated by UW)
NEW		48 15 50.0	117 07 13 0	0.760	Newport Observatory (USGS-USNSN)
OCWA		47 44 56.0	124 10 41.2	0.671	Octopus Mtn. (USGS-USNSN)
PIN		43 48 40.0	120 52 19.0	1.865	Pine Mt. Oregon (CREST - operated by UO)
RAI		46 02 25.1	122 53 06.4	1.520	Trojan Plant. Oregon (OSU)
RWW	%	46 57 50.1	123 32 35.9	0.015	Ranney Well (CREST - operated by UW)
SP2	%	47 33 23.3	122 14 52.8	0.030	Seward Park. Seattle (operated by UW)
SQM	%	48 04 39.0	123 02 44.0	0.030	Sequim (operated by UW. telemetered by Battelle)
TTW	%	47 41 40.7	121 41 20.0	0.542	Tolt Reservoir. WA (operated by UW)
WVOR		42 26 02.0	118 38 13.0	1.344	Wildhorse Valley. Oregon (USGS-USNSN)

Table 2C lists strong-motion, three-component stations operating in Washington and Oregon that provide data in real or near-real time to the PNSN. Several of these stations also have broad-band instruments, as noted. The "SENSOR" field designates what type of seismic sensor is used;

- A = Terra-Tech SSA-320 SLN triaxial accelerometer/Terra-Tech IDS24 recording system,
- A20 = Terra-Tech SSA-320 triaxial accelerometer/Terra-Tech IDS20 recording system,
- FBA23 = Kinemetrics FBA23 accelerometers and Reftek recording system,
- EPI = Kinemetrics Episensor accelerometers and Reftek recording system.
- BB = Guralp CMG-40T 3-D broadband velocity sensor.
- BB3 = Guralp CMG3T 3-D broadband velocity sensor.
- BBZ = Broad Band sensor, PMD 2024, vertical component only.
- K2 = Kinemetrics Episensor accelerometers and K2 Recording System

The "TELEMETRY" field indicates the type of telemetry used to recover the data.

- D = dial-up,
- L = continuously telemetered via dedicated lease-line telephone lines,
- L-PPP = continuously telemetered via dedicated lease-line telephone lines using PPP protocol
- I = continuously telemetered via Internet,
- E = continuously telemetered via Internet from a remote EARTHWORM system

TABLE 2C

Strong-motion three-component stations operating at the end of the first quarter 2001. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME	SENSORS	TELEMETRY
ALCT	%	47 38 51.0	122 02 13.2	0.055	Alcott Elementary, Redmond	K2	I
ALST	%	46 6 31.2	123 01 47.4	0.000	Alston, Oregon BPA	A20	L,E,D
ALVY	%	43 59 53.2	123 00 57.0	0.155	Alvey Substation, Eugene, Oregon BPA	K2	L,E
BEVT	%	47 55 11.9	122 16 11.9		Boeing Everett Plant	K2	I
BRKS	%	47 45 19.7	122 17 18.4	0.100	Brookside Elementary, Lake Forest Park	K2,BBZ	I
CSEN	%	47 48 04.5	122 13 06.5	0.055	Crystal Springs Elementary, Bothell	K2	I
CSO	#	45 31 01.0	122 41 22.5	0.036	Canyon Substation, Oregon	FBA23	D
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, OR (UO CREST)	EPI,BB3	E,L-PPP
EARN	%	47 44 24.0	122 02 24.0	0.010	East Ridge Elementary, Woodinville	K2	I
ELW	%	47 29 38.8	121 52 21.6	0.267	Echo Lake, WA	A,BB	L,D
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie, WA	A,BB	L,D
FINN	%	47 43 08.9	122 13 55.0	0.010	Finn Hill Jr High, Juanita	K2	I
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mountain, WA (CREST)	EPI,BB3	L-PPP
HAO	#	45 30 33.1	122 39 24.0	0.018	Harrison Substation, Oregon	FBA23	D
HOLY	%	47 33 55.3	122 23 02.1	0.106	Holy Rosary	K2	I
KEEL	%	45 33 0.0	122 53 44.4	0.000	Keeler, Oregon BPA	A20	L,E,D
KIMB	%	47 34 30.9	122 18 05.9	0.100	Kimball Elementary, Seattle	K2	I
KIMR	%	47 30 11.7	122 46 01.9	0.123	Kitsap Moderate Risk Waste	K2	I
KINR	%	47 45 06.0	122 38 35.0	0.010	Kitsap North Road Shed	K2	I
KITP	%	47 40 30.0	122 37 47.0	0.100	Kitsap Treatment Plant	K2	I
LANE	%	44 03 06.5	123 13 54.8	0.120	Lane Substation, Eugene, Oregon	K2	L,E
LAWT	%	47 39 23.4	122 23 21.9	0.111	Lawton Elementary, Seattle	A20	I
LEOT	%	47 46 04.4	122 06 54.3	0.155	Leota Jr High, Woodinville	A	I
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire (CREST)	EPI,BB3	L-PPP,D
MBPA	%	47 53 56.6	121 53 20.2	0.186	Monroe BPA	A20	L,D
MPL	%	47 28 08.2	122 11 06.2	0.122	Maple Valley	A	L,D
NOWS	%	47 41 12.0	122 15 21.2	0.000	NOAA, Bldg 3	A20	I
PCEP	%	47 06 43.0	122 17 24.2	0.160	PC East Precinct	K2	I
PCFR	%	46 59 23.3	122 26 27.4	0.137	PC Training Center	K2	I
PCMD	%	46 53 20.9	122 18 00.9	0.239	PC Mountain Detachment	K2	I
PIN	%	43 48 40.0	120 52 19.0	1.865	Pine Mt., OR (U0 CREST)	EPI,BB3	E,L-PPP
PNLK	%	47 34 50.0	122 01 42.4	0.128	Pine Lake Middle School, Issaquah	K2	I
QAW	%	47 37 53.2	122 21 15.0	0.140	Queen Anne	A	L
RAW	%	47 20 14.0	121 55 57.6	0.208	Raver BPA	A	L,D
RBEN	%	47 26 05.4	122 11 10.2	0.000	Benson Elementary, Renton	K2	I
RBO	#	45 32 27.0	122 33 51.5	0.158	Rocky Butte, Oregon	FBA23	D
RHAZ	%	47 32 25.8	122 11 08.4	0.108	Hazelwood Elementary, Newcastle	A	I
ROSS	%	45 39 46.2	122 39 37.0	0.100	Ross BPA	A20	L,E,D
RWW	%	46 57 50.1	123 32 35.9	0.015	Ranney Well (CREST)	EPI,BB3	L-PPP
SBES	%	48 46 05.9	122 24 54.2	0.000	Silver Beach Elementary, Bellingham	K2	I
SEA	%	47 39 18.0	122 18 30.0	0.030	Seattle	A,BB	L,D
SP2	%	47 33 23.3	122 14 52.8	0.030	Seward Park, Seattle	A,BB	L
SQM	%	48 04 39.0	123 02 44.0	0.030	Sequim, WA (CREST)	EPI,BB	L-PPP
TBPA	%	47 15 28.1	122 22 05.9	0.002	Tacoma WA BPA	A	L,D
TKCO	%	47 32 12.7	122 18 01.5	0.005	King Co EOC	A20	I
UPS	%	47 15 51.4	122 28 56.3	0.113	University of Puget Sound	K2	I
WISC	%	47 36 32.0	122 10 27.8	0.056	Wilburton Instructional Services Center, Bellevue	K2	I

Table 2D shows stations recorded by the PNSN but not initiated in PNSN EARTHWORM nodes during the first quarter 2001. Columns as in Table 2A. "Canada" are stations received from the Pacific Geoscience Centre in British Columbia, Canada; PNNL is the Battelle Pacific Northwest National Labs; MT is Montana Bureau of Mines; OSU is Oregon State University; USNSN is the US National Seismic Network; CAL-NET is the USGS Northern California Network.

TABLE 2D

STA	F	LAT	LONG	EL	NAME
BEN		46 31 12.0	119 43 18.0	0.335	PNNL station
CHMT		46 54 51.0	113 15 07.0	-	Chamberlain Mtn. MT
COR		44 35 08.5	123 18 11.5	0.121	Corvallis, Oregon (IRIS-OSU)
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon (UO CREST)
GBB		46 36 31.8	119 37 40.2	0.185	PNNL Station
H2O		46 23 45.0	119 25 22.0	-	Water PNNL Station
HAWA		46 23 32.3	119 31 57.2	0.367	Hanford Nike USGS-USNSN
HLID		43 33 45.0	114 24 49.3	1.772	Hailey, ID USGS-USNSN
KEB		42 52 20.0	124 20 03.0	0.818	CAL-NET
KSX		41 49 51.0	123 52 33.0	-	CAL-NET
KTR		41 54 31.2	123 22 35.4	1.378	CAL-NET
LAM		41 36 35.2	122 37 32.1	1.769	CAL-NET
LCCM		45 50 16.8	111 52 40.8	1.669	Lewis and Clark Caverns, MT
MCMT		44 49 39.6	112 50 55.8	2.323	McKenzie Canyon, MT
NEW		48 15 50.0	117 07 13.0	0.760	Newport Observatory USNSN BB
OCWA		47 44 56.0	124 10 41.2	0.671	Octopus Mtn. (USGS-USNSN)
OZB		48 57 37.1	125 29 34.1	0.671	Canada
PFB		48 34 30.0	124 26 39.8	0.465	P. Renfrew, Canada
PIN	%	43 48 40.0	120 52 19.0	1.865	Pine Mt., Oregon (U0 CREST)
PNT		49 18 57.6	119 36 57.6	0.550	Canada, BB
RED		46 17 51.0	119 26 15.6	0.330	Red Mountain PNNL Station
SNB		48 46 33.6	123 10 16.3	0.408	Canada
SNI		46 27 80.0	119 39 50.0	-	PNNL station
VDB		49 01 34.0	122 06 10.1	0.404	Canada
VGZ		48 24 50.0	123 19 27.8	0.067	Canada
WVOR		42 26 02.0	118 38 13.0	1.344	Wildhorse Valley, Oregon (USGS-USNSN)

OUTREACH ACTIVITIES

The PNSN Seismology Lab staff provides an educational outreach program to better inform the public, educators, businesses, policy makers, and the emergency management community about seismicity and natural hazards. Our outreach includes lab tours, lectures, classes and workshops, press conferences, TV and radio news programs and talk shows, field trips, and participation in regional earthquake planning efforts. We provide basic information through information sheets, an audio library, and the Internet on the World-Wide-Web (WWW):

http://www.geophys.washington.edu/SEIS/PNSN

Special Events

- The magnitude 6.8 Nisqually earthquake generated many media activities for the PNSN. See the special section on Nisqually earthquake outreach activities, below.
- The PNSN assisted the Shoreline Historical Museum with an earthquake exhibit.
- Ruth Ludwin made presentations on Native American stories related to Cascadia Subduction Zone earthquakes at the Burke Museum and to the Olympic Peninsula Intertribal Cultural Advisory Committee.
- Steve Malone presented the PNSN perspective at a Tsunami meeting at the State EOC on Jan. 7, 2001.
- Steve Malone presented an invited plenary talk to the National Physics Society meeting in Seattle on March 12, 2001 called "Shake and Bake - The physics of earthquakes and volcanos in Seattle's backyard"
- On March 19-20, the UW hosted a 2-day workshop titled "Juan de Fuca Slab Earthquake Science and Hazards Appraisal". The workshop was convened by Ken Creager of the UW and Steve Kirby of the USGS and included discussion of the current state of knowledge of JDF slab structure and hazards, and upcoming, planned, and future active and passive seismic experiments. Although the workshop had been scheduled far in advance, the Nisqually Earthquake gave an added sense of purpose to the proceedings.

Press Interviews, Lab Tours, and Workshops

PNSN Staff provided a countless number of television, radio, or print press interviews this quarter following the Nisqually earthquake. The demand for K-12 educational outreach services continues to increase. This quarter, about 30 requests for tours and lectures were turned down due to a lack of staff and a three week moratorium on tours following the Nisqually earthquake. Despite these limitations this quarter, the PNSN staff provided 19 K-12 lab tours serving 475 students and escorts, 4 college classes with 65 students, one tour for State of Washington emergency managers, and one tour for the UW custodial services organization.

Normally we provide estimates of how many calls we respond to during the quarter from emergency management and government, from the media, from educators from the business community, and from the general public. However, this quarter we completely lost track of the numbers. A rough estimate would be that the number of calls was about 10 times the normal level (normally we get about 150 calls/month) in the month following the earthquake.

Telephone, Mail, and On-line outreach

The PNSN audio library system received about 1,400 calls this quarter, with calls up about 10-fold after the Nisqually earthquake. We provide several recordings. The most popular is a frequently updated message on current seismic activity. In addition we have a tape describing the seismic hazards in Washington and Oregon, and another on earthquake prediction. Callers often request our one-page information and resource sheet on seismic hazards in Washington and Oregon. Thousands of these have been mailed out or distributed, and we encourage others to reproduce and further distribute this sheet. Our information sheet discussing earthquake prediction is also frequently requested. Callers to the audio library can also choose to be transferred to the Seismology Lab, where additional information is available.

Nisqually Earthquake Outreach Activities

The Nisqually earthquake at the end of February was the cause of many, many phone calls to our lab. In the hours following the earthquake, lab staff and student helpers shifted into high gear. Our top priority is to communicate with emergency managers and NEIC personnel, followed by media and regional organizations with critical need-to-know. We were very fortunate to have a well-trained crew of student helpers, including undergraduate (Erich Lenz, Graylan Vincent, John-Patrick Luethe, and Nate Jacobson) and graduate students (Guy Medema, Josh Jones, Adam Haulter, and Tom Van Wagoner). Two former student employees, Gerick Bergsma and Rob Willis, showed up to help although they were not currently working for the Seismology lab. Both had prior experience handling phone calls and assisting after significant local quakes in 1997 and 1999. The students provided basic information about the earthquake to numerous media contacts and screened and prioritized calls. Having personnel to handle basic phone contacts allowed us to return almost all of the telephone calls before the end of the day.

Press coverage ranged from local to national, including Larry King Live, MSNBC, and many others. Besides TV coverage, the PNSN gave interviews to a variety of radio programs and newspapers nationwide. On-camera interviews were provided by PNSN Staff, UW faculty (from Engineering as well as Earth Sciences), and USGS scientists. Individuals with expertise came to the UW Seismology Lab and made themselves available to the press. A lot of interviews were conducted in the hallways, and the congestion in the Lab itself was less than we have experienced in smaller past events. This was no doubt due to the dramatic damage photo opportunities available elsewhere. Emergency Operations Centers were activated throughout the regions andy many other state, county, and local agencies were providing information.

USGS and academic seismologists from outside the Puget Sound area relayed basic information about the earthquake to the press and public. At a time of overwhelming pressure on the local group, it is very helpful to have outside people who can provide valuable expertise and insights to meet the very intense demand.

Shortly after the Nisqually earthquake, an unfounded rumor of an earthquake prediction began to make the rounds, soon swelling into a minor panic. Many additional press contacts resulted, as we attempted to defuse the furor. The false rumors may have resulted from a pseudo-scientific pundit who put two true statements together in a way that invited misinterpretation (1. "A magnitude 9+ earthquake could occur in the PNW." 2. "My next prediction window is from March ?? to March ??").

Press interaction continued at high rates through the end of the quarter, although the focus of attention shifted from the PNSN to damage and ground failure issues. In addition, we responded to numerous strong-motion data requests from engineers.

Web-based outreach of the Nisqually earthquake is discussed in the the Seismicity section of this report.

Internet outreach

The PNSN web-site offers many other web pages, including maps and lists of the most recent PNW earthquakes, general information on earthquakes and PNW earthquake hazards, information on past damaging PNW earthquakes, and catalogs of earthquake summary cards. Web-pages on seismicity of Cascade Volcanos, and Quarterly summaries of seismicity are also included. The PNSN recent earthquake list is available through the World-Wide-Web (WWW) at:

http://www.geophys.washington.edu/SEIS/PNSN

"Webicorder" pages allow Web visitors (and us) to view continuous data from PNSN seismographic stations at:

http://www.geophys.washington.edu/SEIS/PNSN/WEBICORDER/

ShakeMap generates maps showing instrumentally measured shaking effects. Table 3A indicates which events this quarter generated ShakeMaps.

Shake Maps: **http://spike.geophys.washington.edu/shake/index.html**

Table 3A also indicates the felt events this quarter that generated Community Internet Intensity Maps (CIIM). CIIM maps are made using internet reports. For a well-felt event hundreds (or thousands) of people fill out an on-line form describing their experiences during the earthquake. These "felt" reports are converted into numeric intensity values, and the CIIM map shows the average intensity by zip code.

CIIM Maps: **http://pasadena.wr.usgs.gov/shake/pnw/**

In addition to the PNSN web site, the UW Geophysics Program and the PNSN host several other earthquake-related web sites:

- **Volcano Systems Center**: **http://www.vsc.washington.edu** is a cooperative effort of the UW and the USGS that links volcano-related activities of the UW Geological Sciences, Geophysics, and Oceanography departments with related USGS activities.
- **Seismosurfing**: **http://www.geophys.washington.edu/seismosurfing.html** is a comprehensive listing of sites worldwide that offer substantive seismology data and information. This page is mirrored at two sites in Europe.
- The **Council of the National Seismic Systems** (CNSS): **http://www.cnss.org** features composite listings and maps of recent U.S. earthquakes, and documentation of the EARTHWORM system.
- "**Tsunami!**" : **http://www.geophys.washington.edu/tsunami** offers many pages, including an excellent discussion on the physics of tsunamis, and short movie clips. It was developed by Benjamin Cook under the direction of Dr. Catherine Petroff (UW Civil Engineering).
- **The UW Geophysics Program Global Positioning System (GPS)**: **http://www.geophys.washington.edu/GPS/gps.html** site provides information on geodetic studies of crustal deformation in Washington and Oregon.

EARTHQUAKE DATA - 2001-A

There were 1,174 events digitally recorded and processed at the University of Washington between January 1 and March 31, 2001. Locations in Washington, Oregon, or southernmost British Columbia were determined for 628 of these events; 509 were classified as earthquakes and 119 as known or suspected blasts. The remaining 546 processed events include teleseisms (153 events), regional events outside the PNSN (58), and unlocated events within the PNSN. Unlocated events within the PNSN include very small earthquakes and some known blasts. Frequent mining blasts occur near Centralia, Washington and we routinely locate them.

Table 3A is a listing of all earthquakes reported to have been felt during this quarter. Table 3B is a listing of earthquakes magnitude 2.5 or greater with reasonably constrained focal mechanisms from P-wave first motions. Table 3C is a listing of the Nisqually earthquake and its aftershocks. Table 5, located at the end of this report, is this quarter's catalog of earthquakes M 2.0 or greater, located within the network -

between 42-49.5 degrees north latitude and 117-125.3 degrees west longitude.

Fig. 2 shows earthquakes with magnitude greater than or equal to 0.0 ($M_c \geq 0$).
Fig. 3 shows blasts and probable blasts ($M_c \geq 0$).
Fig. 4 shows earthquakes located near Mt. Rainier ($M_c \geq 0$).
Fig. 5 shows earthquakes located at Mt. St. Helens ($M_c \geq 0$).
Fig. 6 shows reasonably well-constrained focal mechanisms for earthquakes with M 2.5 this quarter.

TABLE 3A - Felt Earthquakes during the 1st Quarter of 2001

DATE-(UTC)-TIME	LAT(N)	LON(W)	DEPTH	MAG	COMMENTS	CIIM	ShakeMap
yy/mm/dd hh:mm:ss	deg.	deg.	km				
01/02/14 03:54:54	48.76	123.12	20.9	2.3	26.0 km NNW of Friday Harbor, WA		
01/02/14 22:03:58	47.52	121.89	6.6	3.1	5.3 km S of Fall City, WA	x	x
01/02/24 07:40:50	47.54	122.07	22.6	2.2	13.2 km SE of Bellevue, WA		
01/02/28 07:16:13	47.75	120.04	0.6	3.2	10.0 km S of Chelan, WA	x	
01/02/28 18:54:32	47.16	122.73	51.9	6.8	17.6 km NE of Olympia, WA	x	x
01/03/01 09:10:20	47.21	122.72	54.3	3.4	22.3 km NE of Olympia, WA	x	
01/03/01 14:23:34	47.19	122.74	51.4	2.7	19.4 km NE of Olympia, WA		
01/03/10 06:26:05	47.49	122.81	19.3	1.7	15.9 km SW of Bremerton, WA		
01/03/11 17:08:54	47.60	121.93	21.6	2.9	4.4 km NNW of Fall City, WA		
01/03/16 02:41:11	47.57	122.09	18.2	2.2	10.2 km ESE of Bellevue, WA		
01/03/21 10:31:05	46.22	121.03	0.9	2.9	35.8 km E of Mt. Adams, WA		

TABLE 3B - Earthquakes M 2.5 or larger during the 1st Quarter of 2001

Focal mechanisms noted where computed. Some earthquakes have more than one possible mechanism.

DATE-(UTC)-TIME	LAT(N)	LON(W)	DEP	MAG	COMMENTS	STRIKE	DIP	RAKE
yy/mm/dd hh:mm:ss	deg.	deg.	km			deg.	deg.	deg.
01/01/24 18/47/39	48.26N	120.16W	0.6	2.8	44.6 km WSW of Okanogan, WA	35	30	100
01/02/14 22/03/58	47.52N	121.90W	6.6	3.1	5.4 km S of Fall City, WA	50	55	60
01/02/28 07/16/13	47.75N	120.03W	0.6	3.2	10.2 km S of Chelan, WA	275	90	90
						85	90	90
01/02/28 18/54/32	47.15N	122.73W	51.9	6.8	17.0 km NE of Olympia, WA	15	70	-120
01/03/01 09/10/20	47.20N	122.71W	54.3	3.4	21.6 km NE of Olympia, WA	20	70	-80
01/03/01 14/23/34	47.18N	122.73W	51.4	2.7	19.4 km NE of Olympia, WA	30	70	-90
01/03/11 17/08/54	47.60N	121.92W	21.6	2.9	4.4 km NNW of Fall City, WA	20	60	50
01/03/17 19/55/47	46.07N	122.10W	6.1	2.5	16.0 km SSE of Mt St Helens, WA	340	25	-100
						205	70	-70
01/03/21 10/31/05	46.21N	121.03W	0.9	2.9	35.4 km E of Mt Adams, WA	50	50	50

TABLE 3C - Nisqually Mainshock and Aftershocks

DATE-(UTC)-TIME	LAT(N)	LON(W)	DEPTH	MAG		COMMENTS
yy/mm/dd hh:mm:ss	deg.	deg.	km			
01/02/28 18:54:32	47.14	122.72	51.9	6.8	MAINSHOCK	17.0 km NE of Olympia, WA
01/02/28 19:02:03	47.18	122.72	52.3	1.0		19.7 km NE of Olympia, WA
01/03/01 09:10:20	47.19	122.71	54.3	3.4	FELT	21.6 km NE of Olympia, WA
01/03/01 14:23:34	47.18	122.72	51.4	2.7	FELT	19.4 km NE of Olympia, WA
01/03/11 11:57:36	47.20	122.62	47.8	1.2		14.9 km WSW of Tacoma, WA

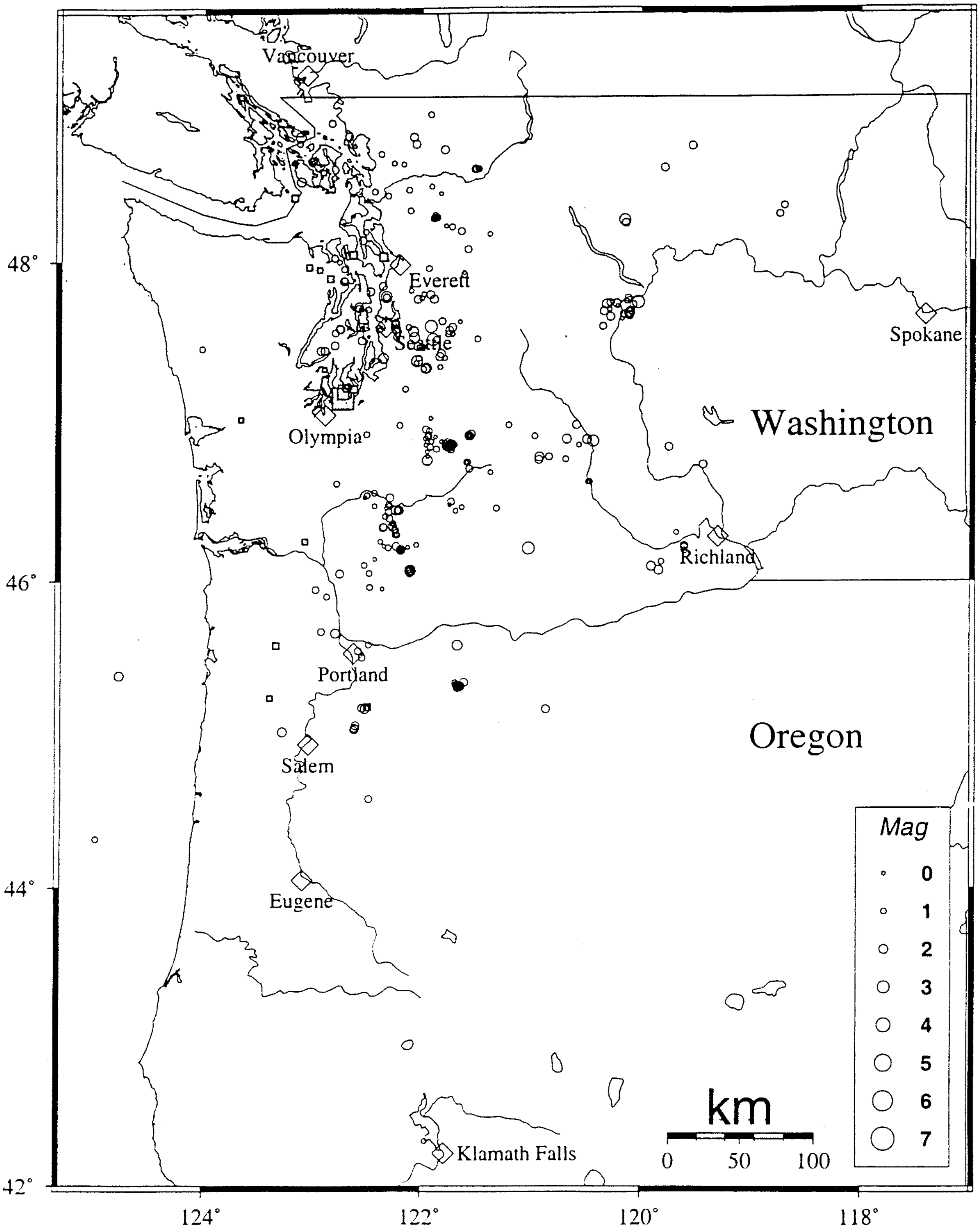

Figure 2. Located earthquakes, magnitude > 0, 1st quarter, 2001. Filled squares indicate earthquakes with depth greater than 30km. Unfilled diamonds represent cities.

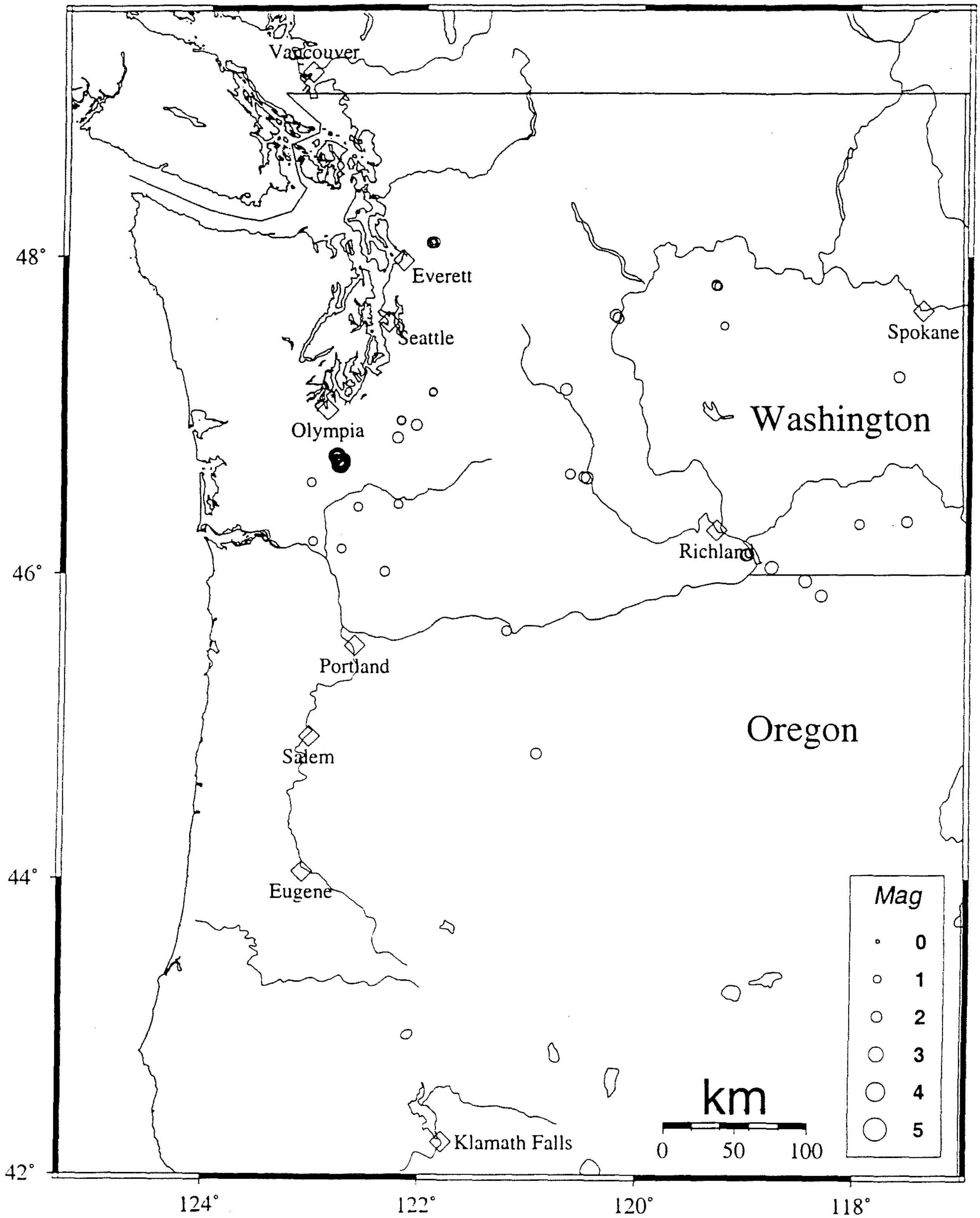

Figure 3. Blasts and probable blasts, 1st quarter, 2001. Unfilled diamonds represent cities.

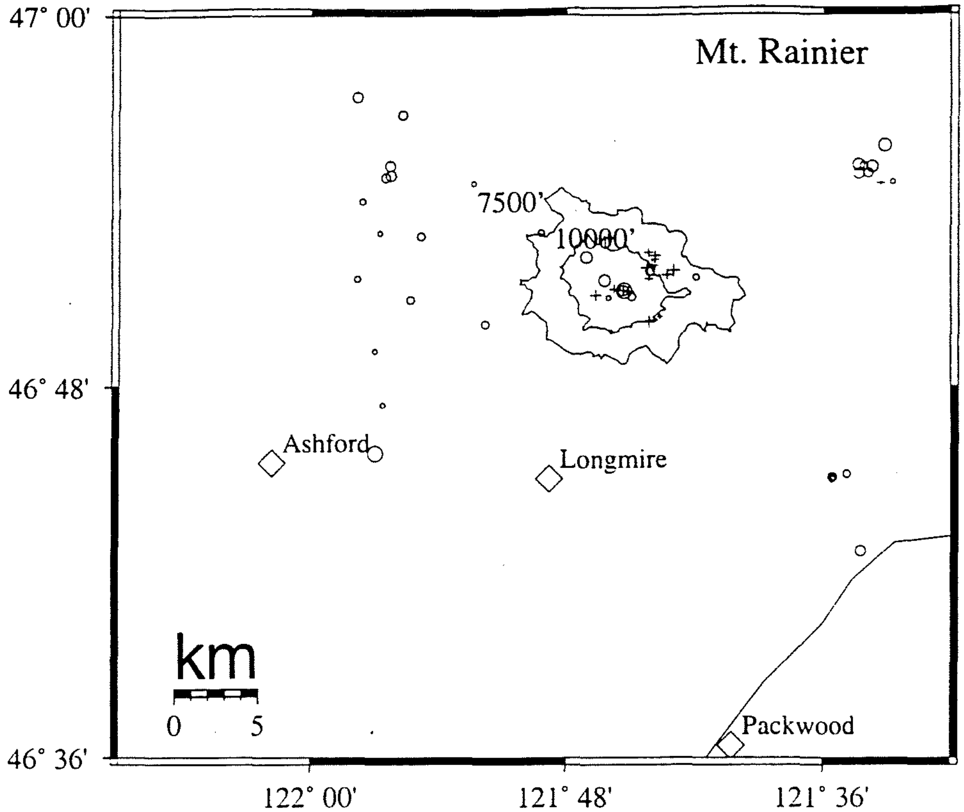

Figure 4. Earthquakes M > 0, 1st quarter, 2001. 'Plus' symbols indicate depth less than 1 km. Circles indicate depth greater than 1 km. Elevation contours shown in feet.

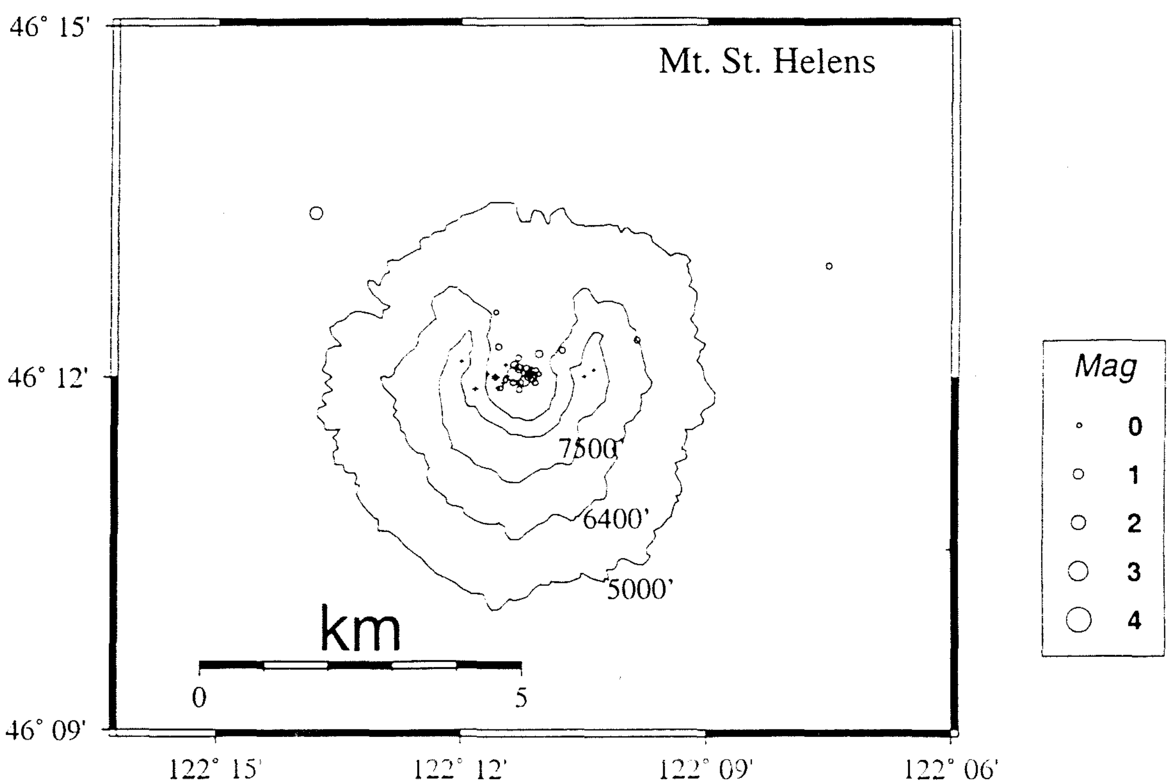

Figure 5. Earthquakes M > 0, 1st quarter, 2001. 'Plus' symbols indicate depth less than 1 km. Circles indicate depth greater than 1 km. Elevation contours shown in feet.

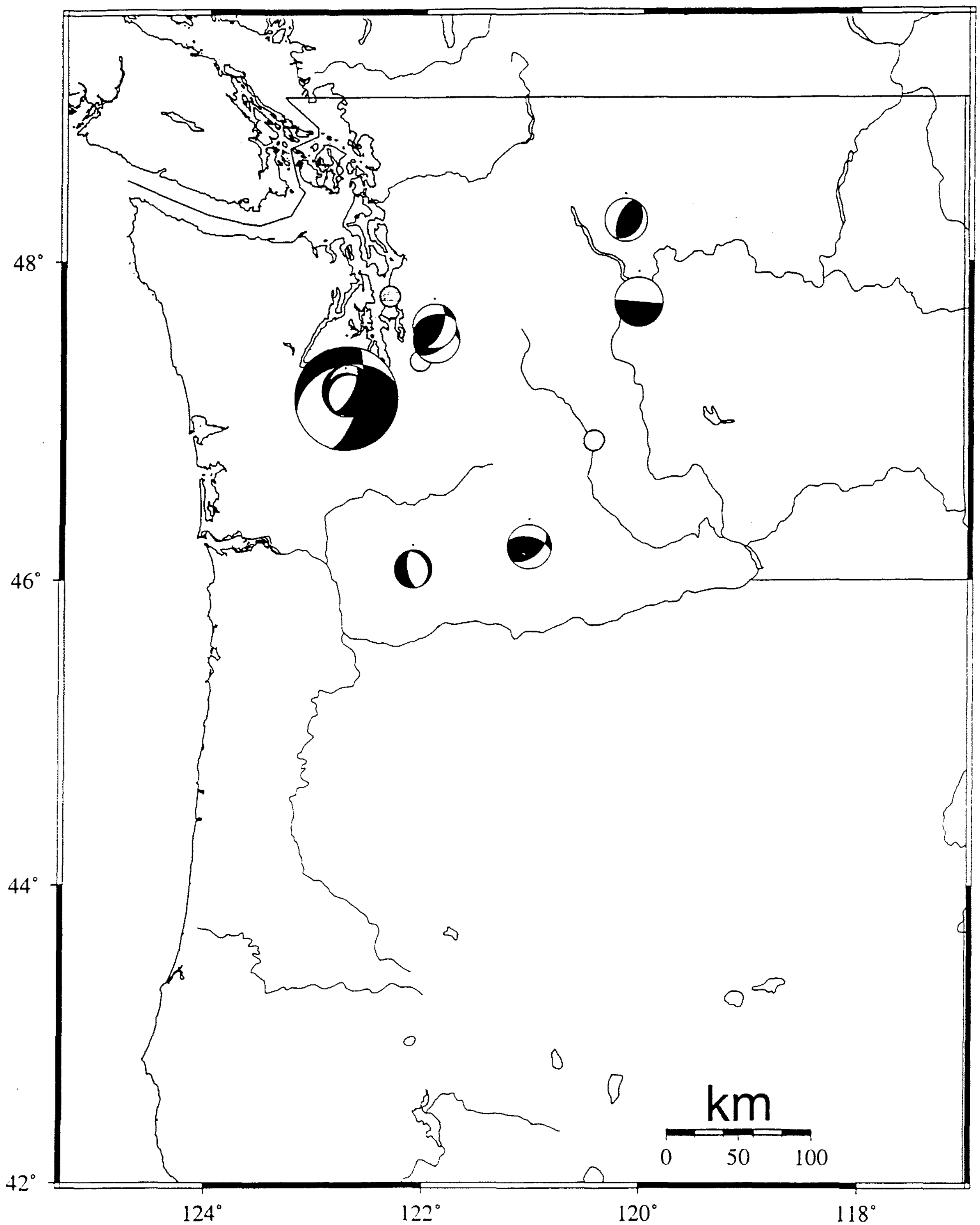

Figure 6. Events and fault plane solutions, 1st quarter 2001, Magnitude greater than or equal to 2.5. Focal symbol size reflects earthquake magnitude. Events without fault plane solutions are shown as filled dots. Table 3B lists event dates, locations, depths, magnitudes, and focal parameters.

OREGON SEISMICITY

During the first quarter of 2001, a total of 41 earthquakes were located in Oregon between 42.0° and 45.5° north latitude, and between 117° and 125° west longitude. The most interesting activity in Oregon this quarter was a swarm of events at Mt. Hood. The events began on January 10, 2001 and continued for most of the month of January. In total, between January 10-23, 2001, we recorded 24 earthquakes. The earthquakes were located approximately 5.0-8.0 km SSE of Mt. Hood at depths ranging from 3.0-7.0 km. The magnitudes of the earthquakes ranged from -0.8 to 2.0.

In the Klamath Falls area, only one earthquake occurred in the first quarter of 2001. Since 1994, most earthquakes in the Klamath Falls area have been considered aftershocks of a pair of damaging earthquakes in September of 1993. The 1993 earthquakes were followed by a vigorous aftershock sequence which decreased over time.

WESTERN WASHINGTON SEISMICITY

During the first quarter of 2001, 416 earthquakes were located between 45.5° and 49.5° north latitude and between 121° and 125.3° west longitude. Nine earthquakes were felt this quarter in western Washington. Details are in Table 3. The 52 km deep, magnitude (Mw) 6.8 Nisqually earthquake on February 28, 2001 was the largest earthquake to occur in western Washington since 1949. The earthquake and its aftershocks are described in a special section of this report.

Other felt earthquakes this quarter include a M 2.3 earthquake on February 14, located about 26 km NNW of Friday Harbor, WA, and reported felt in Friday Harbor. Also on February 14, a M 3.1 felt earthquake occurred about 5.0 km S of Fall City, WA and was felt in Snoqualmie, Redmond, North Bend, Kirkland, Issaquah, Fall City, Duvall, and Carnation. On February 24 an earthquake located about 13 km SE of Bellevue, WA with a magnitude of 2.2 was reported felt in Bellevue and Kenmore.

Following the Nisqually earthquake, we received many felt reports for small earthquakes, either a result of heightened sensitivity of residents or a result of the public checking our website for recent earthquakes and then reporting them as felt. The first felt earthquake after the Nisqually earthquake and its aftershocks was a magnitude 1.7 which occurred on March 10 about 16 km SW of Bremerton, WA. This event was reported felt by residents in Port Orchard. On March 11, a magnitude 2.9 earthquake occurred about 4.0 km NNW of Fall City, WA and was felt by residents in North Bend. The last felt earthquake in western Washington for this quarter occurred on March 16 about 10 km ESE of Bellevue, WA. The magnitude 2.2 earthquake was reported felt by residents in Redmond. Details are in Table 3.

Special Report: The Mw 6.8 Nisqually Earthquake of February 28, 2001

The magnitude (Mw) 6.8 Nisqually earthquake occurred on February 28 at 1854 UTC (10:54 AM PST). It was located at a depth of 52 km beneath the Nisqually River delta about 18 km NE of Olympia, WA. The earthquake occurred in the eastward-dipping Wadati-Benioff zone within the subducting Juan de Fuca plate. This location was within 20 km of the magnitude 7.1 earthquake in 1949 and may have ruptured the same fault. A similarly deep subduction zone earthquake occurred in 1965 about 40 km northeast of the Nisqually earthquake with a magnitude of 6.5.

For the PNSN, the Nisqually earthquake came at a good time. First of all, the time of day was convenient. The seismologists and PNSN staff were not far away, which made the response to the earthquake quick. Second, the timing was great because we had just completed the installation of 22 new real-time, strong motion seismographs in the summer of 2000. In January 2001, our main Earthworm data acquisition and processing system had been upgraded to a new machine. Also in January, the *ShakeMap* software was implemented and being run in test mode.

Fortunately for the PNSN, the power remained on during and after the earthquake. The seismology lab sustained no damage, even though other areas on the University of Washington campus did suffer earthquake damage, mostly non-structural.

The Earthworm automatic solution was sent out to pagers, e-mail, and RACE systems about five minutes after the earthquake. Unfortunately, the pagers that depend on telephone lines between the University of Washington and the paging service, including the RACE system, did not receive this preliminary solution. This is because the phone lines overloaded immediately after the earthquake. However, the pagers that use e-mail between the University of Washington and the paging service worked fine. The preliminary location was very good, within two km of the later reviewed epicenter and within three km of the final depth. The preliminary magnitude, 4.7, was not accurate because the algorithm we use to determine preliminary magnitudes is a coda duration technique that does not work well for large earthquakes.

Immediately after the initial solution was released, a magnitude estimate of 6.7 was determined by running a brand-new earthworm module called *localmag*. This program was still in the process of being tested and calibrated. Therefore, we were not confident in releasing that magnitude. Instead we released, along with the verified solution, a magnitude of 6.2 within 50 minutes after the earthquake. This 6.2 magnitude was reported to us by the West Coast- Alaska Tsunami Warning Center. Within three hours after the earthquake, the magnitude was revised to Mw=6.8 after consultation with the NEIC.

Updated information was provided all day following the earthquake. Many interviews with the local media were given and the staff and students handled the phone lines, responding to calls from emergency managers, the media, and the public. Information about the earthquake was also available on the PNSN Web server (see additional details in outreach section). However, many computer users trying to connect experienced slow response time. The Web server volumes did increase immediately after the earthquake, but they did not get completely saturated until an hour later. Maximum hit rates were about 40 per second with about 500 simultaneous open sessions. One reason network usage was so heavy was due to people leaving open our webicorder pages, which automatically update every two minutes. Therefore, in addition to new people requesting pages on our web site, all other users who were looking at the webicorder pages were requesting another transfer every two minutes. For the future, when an event such as this occurs, we will make the webicorder reload interval larger. Also, to satisfy this huge demand, a Web delivery strategy of multiple servers on multiple networks is needed. This will be coordinated with other seismic networks in the U.S.

After any significant event, we automatically produce a standard "Special Event" directory and main web page. In the case of the Nisqually Earthquake the strengths and weaknesses of our "Special Event" web offerings became very clear. The notable strength of our "Special Event" format is that all of the files linked from our main page for the event reside in a single directory, with no links from any of the "Special" pages to other pages on our site. This format was quite helpful in the hours following the earthquake when we made a tar file of all the pages, and e-mailed it to the USGS Pasadena Office, which provided a mirror of these pages for a short time while our server was bogged down. The main weakness of our "Special Event" page was that it did not reflect recent changes, including good links to CIIM and ShakeMap pages. ShakeMap pages are currently outside the "Special Event" directory, and those pages would not have been included for mirroring. In the days following the earthquake, we added many links to our "Nisqually Earthquake" page as we monitored requests for information from our web users, and learned of useful web resources provided by other organizations.

Earthworm operation worked very well. All data exports worked well, although the West Coast-Alaska Tsunami Warning Center did not get hypocenter information for the Nisqually earthquake because one export module had died the night before on our back-up machine and went unnoticed. The only other problem was that our connection to Dittmer (Vancouver, WA) was lost for a short period after the earthquake.

Strong Motion recording of the Nisqually Earthquake: Table 6 gives peak ground accelerations and velocities recorded during the Nisqually earthquake. At the time of the Nisqually earthquake, data from 31 strong motion stations (ANSS strong motion instruments plus instruments installed previously) were available in real-time. Recovery of data from additional PNSN and USGS National Strong Motion Program (NSMP) stations has produced records from 91 sites within 100 km epicentral distance. These strong motion recordings were used to produce an instrumental intensity *ShakeMap*. A preliminary version of *ShakeMap*, which included data from the 31 real-time strong motion instruments, was available on the Web within one day of the earthquake. Revised versions became available as more data were recovered in the days and weeks following the earthquake. Strong motion waveforms were made available as ASCII files accessible via a Web browser the day following the earthquake.

We imported the code that produces *ShakeMap* web pages from the TriNet group in southern California during the last quarter of 2000, and finished the local implementation in January, 2001. We generated *ShakeMap* entries for a number of previous events; earthquakes in 1999 and 2000 with at least 10 strong motion records. The system was still being run in test mode when the Nisqually earthquake occurred on February 28 and, because of this, it took many hours to generate a valid *ShakeMap* for this event. Considerable help was received from the *ShakeMap* team in Pasadena and from staff of the National Strong Motion Program in Menlo Park. In the course of checking the results, some errors in our database of station calibration information were found and corrected. *ShakeMap* still does not properly take into account the unique attenuation relation for deep earthquakes in the Pacific Northwest nor does it yet run automatically from an automatic trigger.

Aftershocks of the Nisqually Earthquake: The PNSN recorded four aftershocks in the two weeks following the Nisqually earthquake. The first aftershock, M 1.0, occurred within the coda of the main shock and was located about three km north of the mainshock. The two largest aftershocks, M 3.4, and 2.7, occurred in the early morning hours of the day after the mainshock, at 1:10 AM local time (M 3.4, located about six km north and slightly deeper than the main shock) and 6:23 AM local (M 2.7). Both events were felt, the larger one quite widely. The last aftershock, M 1.2, occurred twelve days after the main shock, It was located about 13 km to the east-northeast of and four km shallower than the main shock. Details are given in Table 3C.

Focal Mechanism of the Nisqually Earthquake: The first-motion focal mechanism of the Nisqually Earthquake is described in Table 3B and shown on Figure 6. Fault-plane solutions for two largest aftershocks are similar to the mainshock solution, and all indicate normal faulting consistent with downdip extension in the subducted slab, with T axes trending eastward to east-southeastward.

CASCADE VOLCANOS

Mount Rainier Area: Figure 4 shows earthquakes near Mount Rainier. The number of events in close proximity to the cone of Mt. Rainier varies over the course of the year, since the source of much of the shallow activity is presumably ice movement or avalanching at the surface, which is seasonal in nature. Events with very low frequency signals (1-3 Hz) believed to be icequakes are assigned type "L" in the catalog. Emergent, very long duration signals, probably due to rockfalls or avalanches, are assigned type "S" (see Key to Earthquake Catalog). There were 6 events flagged "L" or "S" that were located at Mount Rainier this quarter and an additional 144 "L" or "S" events were recorded, but were too small to locate reliably. "L" and "S" type events are listed in the catalog, but not shown in Fig. 4.

A total of 75 tectonic events (27 of these were smaller than magnitude 0.0, and thus are not shown in Fig. 4) were located within the region shown in Fig. 4. Of these, 22 were tectonic events located in the "Western Rainier Seismic Zone" (WRSZ), a north-south trending lineation of seismicity approximately 15 km west of the summit of Mt. Rainier (for counting purposes, the western zone is defined as 46.6-47 degrees north latitude and 121.83-122 west longitude). The largest tectonic earthquake located near Mt. Rainier this quarter was a magnitude 2.2 and was located about 0.5 km ESE of the summit at a depth of 1.5 km. This earthquake occurred on February 1, 2001.

This quarter, there were 29 (13 smaller than magnitude 0.0 and thus not shown in Fig. 4) higher-frequency tectonic-style earthquakes within 5 km of the summit. The remaining events were scattered around the cone of Rainier as seen in Fig. 4.

Mount St. Helens Area: Figure 5 shows volcano-tectonic earthquakes near Mount St. Helens. Low frequency (L) and avalanche or rockfall events (S) are not shown. This quarter, 112 earthquakes were located at Mount St. Helens in the area shown in Fig. 5. Of these earthquakes, 42 were magnitude 0.0 or larger and 8 were deeper than 4 km. The largest tectonic earthquake at Mount St. Helens this quarter was a magnitude 1.8 event located 0.3 km NE of Mount St. Helens.

One type "S" or "L" event was located at Mount St. Helens, and 11 "L" or "S" events too small to locate were recorded.

EASTERN WASHINGTON SEISMICITY

During the first quarter of 2001, 53 earthquakes were located in eastern Washington in the area described in Table 4. Two felt earthquakes occurred in the first quarter of 2001 in eastern Washington. The first, M 3.2, was located 10 km S of Chelan, WA on February 28 UTC (February 27 PST), and was felt by residents in Chelan and Manson.

Some dubious felt reports were received for a very shallow M 2.9 earthquake located about 36 km E of Mt. Adams on March 21. This earthquake was in a remote area of the Yakima Indian Reservation, and no felt reports were received from the nearby the event. However several felt reports, all from locations at considerable distance from the quake, were received via internet. Felt reports were received from Rock Island, Rainier, Enumclaw, Seattle, Bremerton, and Lynnwood although these locations are very far from the epicenter. Such improbable reports are likely due to nervousness and a heightened sensitivity to non-seismic vibrations following the Nisqually earthquake.

Times, locations, and depths of felt earthquakes in the PNSN region are given in Table 3. Table 4 is a summary table of various earthquake counts-per-quarter over several years.

TABLE 4 Quarterly (Q) comparison of earthquake counts over several years.

"Total" events are all events located within the PNSN network area; between 42.0-49.5 degrees north latitude and 117-125.3 degrees west longitude. The smallest detectable earthquake varies over the region. "Total" events are subdivided into "Quakes", "Blasts" and "L or S"(low frequency or surficial). The remaining numbers are counts of tectonic (no L or S)earthquakes in western and eastern Washington, and in Oregon. Western Washington earthquakes are those between 45.5 and 49.5 degrees north latitude and 121-125.3 degrees west longitude. Within western Washington, earthquakes counted as "Rainier" are between 46.6-47.0 degrees north latitude and 121.5-122.15 degrees west longitude (same area as Figure 4), and at Mt. St. Helens (MSH) counted events are between 46.15-46.25 degrees north latitude and 122.10-122.27 degrees west longitude (same area as Figure 5). "Eastern Washington" earthquake counts are for quakes between 45.5-49.5 degrees north latitude and 117-121 degrees west longitude. "Oregon" earthquakes are located between 42-45.5 degrees north latitude and 117-125 degrees west longitude.

Year	Q	Total	Quakes	Blasts	L or S	western WA	MSH	Rainier	eastern WA	OR
1996	A	**504**	433	70	1	**302**	82	55	**53**	**75**
	B	**967**	860	103	4	**748**	68	54	**39**	**72**
	C	**696**	535	152	9	**417**	83	66	**45**	**67**
	D	**476**	381	89	6	**306**	65	53	**45**	**29**
1997	A	**417**	353	64	0	**270**	49	47	**45**	**34**
	B	**525**	472	52	1	**385**	70	30	**65**	**21**
	C	**633**	562	65	6	**468**	181	42	**66**	**28**
	D	**680**	606	66	8	**497**	286	45	**56**	**45**
1998	A	**692**	636	53	3	**475**	293	33	**57**	**106**
	B	**1248**	1180	65	3	**1045**	776	44	**74**	**58**
	C	**1728**	1622	93	13	**1450**	1100	70	**84**	**86**
	D	**772**	721	43	8	**612**	349	62	**59**	**49**
1999	A	**475**	449	25	1	**247**	122	15	**50**	**148**
	B	**465**	404	60	1	**275**	133	30	**45**	**83**
	C	**593**	493	87	13	**379**	134	33	**55**	**58**
	D	**661**	607	50	4	**391**	147	48	**62**	**153**
2000	A	**507**	435	60	12	**284**	83	27	**61**	**88**
	B	**514**	440	68	6	**333**	67	48	**44**	**63**
	C	**939**	614	96	229	**472**	136	51	**82**	**61**
	D	**863**	692	117	54	**589**	224	85	**73**	**29**
2001	A	**628**	509	119	7	**416**	111	75	**53**	**41**

OTHER SOURCES OF EARTHQUAKE INFORMATION

We provide automatic computer-generated alert messages about significant Washington and Oregon earthquakes by e-mail, FAX or via the pager-based RACE system to institutions needing such information, and we regularly exchange phase data via e-mail with other regional seismograph network operators. The "Outreach Activities" section describes how to access PNSN data via e-mail, Internet, and World-Wide-Web. To request additional information by e-mail, contact seis_info@geophys.washington.edu.

Earthquake information in the quarterlies has been published in final form by the Washington State Department of Natural Resources as information circulars entitled "Earthquake Hypocenters in Washington and Northern Oregon" covering the period 1970-1989 (see circulars Nos. 53, 56, 64-66, 72, 79, 82-84, and 89). These circulars, plus circular No. 85, "Washington State Earthquake Hazards", are available from Washington Dept. of Natural Resources, Division of Geology and Earth Resources, Post Office Box 47007, Olympia, WA. 98504-7007, or by telephone at (360) 902-1450.

Several excellent maps of Pacific Northwest seismicity are available. A very colorful perspective-view map (18" x 27") entitled "Major Earthquakes of the Pacific Northwest" depicts selected epicenters of strong earthquakes (magnitudes > 5.1) that have occurred in the Pacific Northwest. A more detailed full-color map is called "Earthquakes in Washington and Oregon 1872-1993", by Susan Goter (USGS Open-File Report 94-226A). It is accompanied by a companion pamphlet "Washington and Oregon Earthquake History and Hazards", by Yelin, Tarr, Michael, and Weaver (USGS Open-File Report 94-226B). The pamphlet is also available separately. Maps can be ordered from: "Earthquake Maps", U.S. Geological Survey, Box 25046, Federal Center, MS 967, Denver, CO 80225, phone (303) 273-8477. The price of each map is $12. (including US shipping and handling).

USGS Cascades Volcano Observatory has a video, "Perilous Beauty: The Hidden Dangers of Mount Rainier", about the risk of lahars from Mount Rainier. Copies are available through: North west Interpretive Association (NWIA), 909 First Avenue Suite 630, Seattle WA 98104, Telephon e: (206) 220-4141, Fax: (206) 220-4143.

Other regional agencies provide earthquake information. These include the Geological Survey of Canada (Pacific Geoscience Centre, Sidney, B.C.; (250) 363-6500, FAX (250) 363-6565), which produces monthly summaries of Canadian earthquakes; the US Geological Survey which produces weekly reports called "Seismicity Reports for Northern California" (USGS, attn: Steve Walter, 345 Middlefield Rd, MS-977, Menlo Park, CA. 94025) and "Weekly Earthquake Report for Southern California" (USGS, attn: Dr. Kate Hutton or Dr. Lucy Jones, CalTech, Pasadena, CA.).

Key to Earthquake Catalog in Table 5

TIME Origin time is calculated for each earthquake on the basis of multi-station arrival times. Time is given in **Coordinated Universal Time** (UTC), in hours:minutes:seconds. To convert to Pacific Standard Time (PST) subtract eight hours, or to Pacific Daylight Time subtract seven hours.

LAT North latitude of the epicenter, in degrees and minutes.

LONG West longitude of the epicenter, in degrees and minutes.

DEPTH The depth, given in kilometers, is usually freely calculated from the arrival-time data. In some instances, the depth must be fixed arbitrarily to obtain a convergent solution. Such depths are noted by an asterisk (*) in the column immediately following the depth. A **$** or a # following the depth mean that the maximum number of iterations has been exceeded without meeting convergence tests and both the location and depth have been fixed.

MAG Coda-length magnitude M_c, an estimate of local magnitude M_L (Richter, C.F., 1958, Elementary Seismology: W.H. Freeman and Co., 768p), calculated using the coda-length/magnitude relationship determined for Washington (Crosson, R.S., 1972, Bull. Seism. Soc. Am., v. 62, p. 1133-1171). Where blank, data were insufficient for a reliable magnitude determination. Normally, the only earthquakes with undetermined magnitudes are very small ones. Magnitudes may be revised as we improve our analysis procedure.

NS/NP NS is the number of station observations, and **NP** the number of P and S phases used to calculate the earthquake location. A minimum of three stations and four phases are required. Generally, more observations improve the quality of the solution.

GAP Azimuthal gap. The largest angle (relative to the epicenter) containing no stations.

RMS The root-mean-square residual (observed arrival time minus predicted arrival time) at all stations used to locate the earthquake. It is only useful as a measure of the quality of the solution when 5 or more well-distributed stations are used in the solution. Good solutions are normally characterized by **RMS** values less than about 0.3 sec.

Q Two **Quality factors** indicate the general reliability of the solution (**A** is best quality, **D** is worst). Similar quality factors are used by the USGS for events located with the computer program HYPO71. The first letter is a measure of the hypocenter quality based on travel-time residuals. For example: **A** quality requires an **RMS** less than 0.15 sec while an **RMS** of 0.5 sec or more is **D** quality (estimates of the uncertainty in hypocenter location also affect this quality parameter). The second letter of the quality code depends on the spatial distribution of stations around the epicenter, i.e. number of stations, their azimuthal distribution, and the minimum distance (**DMIN**) from the epicenter to a station. Quality **A** requires a solution with 8 or more phases, **GAP** $\leq 90^\circ$ and **DMIN** $\leq$ (5 km or depth, whichever is greater). If the number of phases, **NP**, is 5 or fewer or **GAP** $> 180^\circ$ or **DMIN** $>$ 50 km the solution is assigned quality **D**.

MOD The crustal velocity model used in location calculations.

- **P3** - Puget Sound model
- **C3** - Cascade model
- **S3** - Mt. St. Helens model including Elk Lake
- **N3** - northeastern model
- **E3** - southeastern model
- **O0** - Oregon model
- **K3** - Southern Oregon, Klamath Falls area model
- **R0 and J1** - Regional and Offshore models

TYP Events flagged in Table 5 use the following code:

- **F** - earthquake reported to have been felt
- **P** - probable explosion
- **L** - low frequency earthquake (e.g. glacier movement, volcanic activity)
- **H** - handpicked from helicorder records
- **S** - Special event (e.g. rockslide, avalanche, volcanic steam emission, harmonic tremor, sonic boom), not a man-made explosion or tectonic earthquake
- **X** - known explosion

TABLE 5

Tectonic Earthquakes, Magnitude 2.0 or larger, First Quarter, 2001.

Within an area 42-49.5 degrees north latitude and 117-125.3 degrees west longitude.

Jan 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
12	11:57:26.75	45 40.18	122 47.70	20.20	2.0	37/40	53	0.10	AA	C3	
19	04:38:23.84	46 04.23	119 50.45	0.02*	2.0	20/22	166	0.20	BC	E3	
19	17:45:34.10	45 19.43	121 39.38	7.15*	2.0	16/17	78	0.27	BB	O0	
24	18:47:39.19	48 15.53	122 09.56	0.56S	2.8	21/29	96	0.54	DC	N3	
26	08:18:38.03	46 21.43	122 16.47	13.76	2.1	36/38	66	0.20	BA	S3	
29	00:26:31.91	47 24.47	122 21.30	15.55	2.3	44/47	31	0.12	AA	P3	

Feb 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	03:32:19.86	46 51.15	121 45.45	1.45	2.2	40/45	51	0.13	AA	C3	
1	05:30:48.70	45 23.37	124 46.38	17.36*	2.0	08/09	280	0.52	DD	O0	
6	09:01:11.38	46 53.65	120 26.55	8.15	2.5	15/16	62	0.22	BB	E3	
6	09:01:27.26	46 54.17	120 30.37	17.02	2.1	08/10	170	0.30	BC	E3	
12	10:46:46.74	48 29.17	123 07.22	25.72	2.1	18/20	127	0.25	BB	P3	
14	03:54:54.90	48 45.63	123 07.43	20.85	2.3	16/16	189	0.15	BD	P3	F
20	06:22:07.75	47 47.20	122 20.10	24.41	2.5	46/47	36	0.15	BA	P3	
24	07:40:50.75	47 32.47	122 04.15	22.58	2.2	44/46	68	0.22	BA	P3	F
24	11:14:22.22	46 46.33	121 57.58	3.44	2.2	33/38	60	0.17	BC	C3	
28	07:16:13.18	47 45.07	120 02.37	0.57	3.2	29/30	47	0.27	BB	N3	F
28	18:54:32.83	47 09.57	122 44.00	51.90	6.8	66/66	31	0.20	BA	P3	F

Mar 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	09:10:20.93	47 12.37	122 43.33	54.31	3.4	83/86	31	0.27	BA	P3	F
1	14:23:34.37	47 11.35	122 44.27	51.39	2.7	54/57	55	0.18	BA	P3	F
6	06:33:40.00	47 20.73	121 57.87	22.99	2.2	30/32	54	0.21	BA	P3	
9	03:36:30.24	45 35.37	121 40.30	8.57	2.3	29/32	77	0.23	BB	C3	
9	20:45:58.41	47 23.28	122 03.23	12.47	2.5	38/40	32	0.19	BA	P3	
11	17:08:54.12	47 36.20	121 55.52	21.61	2.9	54/54	85	0.17	BA	P3	F
11	22:19:67.14	47 37.57	122 14.83	3.25	2.0	19/22	94	0.15	AB	P3	
14	14:42:22.44	46 47.20	120 56.17	6.56	2.1	20/23	50	0.15	BB	C3	
16	02:41:11.07	47 34.32	122 05.18	18.15	2.2	32/35	47	0.13	AA	P3	F
16	16:46:55.90	46 06.10	119 54.60	0.02*	2.1	18/18	82	0.30	BC	E3	
17	19:55:47.44	46 04.27	122 06.62	6.09*	2.5	29/32	65	0.13	AB	S3	
21	10:31:05.93	46 13.05	121 01.85	0.86S	2.9	58/72	35	0.31	CC	C3	F

TABLE 6 - PGA and PGV for Feb. 28, 2001 Nisqually Earthquake
Ordered by distance from epicenter
See Tables 2B and 2C for station locations.

STA	COMP	Dist (km)	PGA (%g)	PGV cm/sec)
MURR	ELE	12	5.7621	5.4440
MURR	ELN	12	4.4534	2.8727
MURR	ELZ	12	10.8793	2.1103
UPS	ELE	22	5.5066	7.4585
UPS	ELN	22	6.0686	5.6492
UPS	ELZ	22	5.4854	2.4324
PCFR	ELE	28	11.0287	13.1767
PCFR	ELN	28	13.0824	7.0978
PCFR	ELZ	28	14.0885	4.1459
PCEP	ELE	33	20.3869	13.4826
PCEP	ELN	33	21.3314	10.4620
PCEP	ELZ	33	15.4756	6.0600
KIMR	ELE	39	16.2800	9.5761
KIMR	ELN	39	15.0155	8.7221
KIMR	ELZ	39	7.0458	3.8006
PCMD	ELE	43	15.7629	9.4342
PCMD	ELN	43	11.0448	7.0103
PCMD	ELZ	43	6.7582	3.5916
GNW	SLE	46	15.9131	3.9985
GNW	SLN	46	8.1006	4.2376
GNW	SLZ	46	6.1948	4.2376
RBEN	ELE	51	10.9706	8.2590
RBEN	ELN	51	10.9340	7.4443
RBEN	ELZ	51	4.5480	2.8960
HOLY	ELE	53	6.7837	5.5279
HOLY	ELN	53	7.9608	7.6551
HOLY	ELZ	53	5.1697	4.9389
TKCO	ELE	53	27.2808	21.8842
TKCO	ELN	53	17.0435	13.5065
TKCO	ELZ	53	7.7742	6.6995
MPL	ELE	54	9.7708	7.3443
MPL	ELN	54	8.1218	7.7945
MPL	ELZ	54	4.9519	3.5493
KIMB	ELE	57	13.5246	18.2652
KIMB	ELN	57	9.2460	10.9508
KIMB	ELZ	57	4.7102	7.0607
SP2	ELE	57	30.7736	20.1153
SP2	ELN	57	18.9968	13.2044
SP2	ELZ	57	11.7024	5.6010
KITP	ELE	59	4.8238	5.6193
KITP	ELN	59	4.9300	7.4803
KITP	ELZ	59	2.6688	5.2385
RHAZ	ELE	59	4.5409	4.1628
RHAZ	ELN	59	3.9331	4.4836
RHAZ	ELZ	59	3.6510	1.7393

TABLE 6: Nisqually EQ PGA and PGV, continued

STA	COMP	Dist (km)	PGA (%g)	PGV cm/sec)
TBPA	ELE	29	6.3899	10.8881
TBPA	ELN	29	6.4892	9.2587
TBPA	ELZ	29	4.6574	5.1942
QAW	ELE	60	10.4653	8.3897
QAW	ELN	60	11.4009	11.8705
QAW	ELZ	60	7.6529	6.3960
LAWT	ELE	62	10.4470	14.1014
LAWT	ELN	62	8.8907	12.1953
LAWT	ELZ	62	5.0959	3.5384
RAW	ELE	63	17.2692	16.9713
RAW	ELN	63	12.4685	10.6601
RAW	ELZ	63	5.5912	4.3713
SEA	ELZ	65	3.5447	3.0676
SEA	ELN	65	7.0610	7.3752
SEA	ELE	65	6.7194	7.4367
WISC	ELE	65	11.3350	10.1150
WISC	ELN	65	9.4362	6.6778
WISC	ELZ	65	3.4447	3.0764
RWW	SLE	66	7.5285	5.8512
RWW	SLN	66	6.2679	4.2860
RWW	SLZ	66	4.3369	4.2861
KINR	ELE	67	7.5468	4.9980
KINR	ELN	67	4.9383	6.5310
KINR	ELZ	67	3.1434	2.7611
NOWS	ELE	70	7.9761	9.8671
NOWS	ELN	70	8.7143	9.7131
NOWS	ELZ	70	2.8744	3.8580
PNLK	ELE	71	3.4272	4.8039
PNLK	ELN	71	5.2579	4.2815
PNLK	ELZ	71	3.6240	3.3475
FINN	ELE	73	4.2829	4.1484
FINN	ELN	73	5.0782	8.4859
FINN	ELZ	73	2.9933	2.2145
BRKS	ELE	75	7.7101	7.6893
BRKS	ELN	75	10.3843	10.9947
BRKS	ELZ	75	4.5837	2.4127
ALCT	ELE	75	3.4694	5.1120
ALCT	ELN	75	3.5982	5.2421
ALCT	ELZ	75	2.9485	4.1967
ELW	ELE	75	5.6345	4.1192
ELW	ELN	75	5.5387	4.0568
ELW	ELZ	75	3.4791	2.5077
ELW	HHE	75	5.5937	1.2520
ELW	HHN	75	5.1238	1.2643
ELW	HHZ	75	3.5170	1.2208
CSEN	ELE	82	3.0000	3.1717
CSEN	ELN	82	3.2249	5.1696
CSEN	ELZ	82	1.7990	1.9915

TABLE 6: Nisqually EQ PGA and PGV, continued

STA	COMP	Dist (km)	PGA (%g)	PGV cm/sec)
LEOT	ELE	82	6.3702	6.3091
LEOT	ELN	82	7.5394	4.5621
LEOT	ELZ	82	3.9979	2.5002
EARN	ELE	83	5.7923	4.6989
EARN	ELN	83	4.7226	4.2047
EARN	ELZ	83	2.0057	1.8106
LON	SLZ	83	1.5992	1.7097
LON	SLN	83	2.8322	1.6087
LON	SLE	83	3.7477	2.7262
TTW	SLE	99	11.1794	8.4884
TTW	SLN	99	9.1473	5.2555
TTW	SLZ	99	7.1435	3.4471
MBPA	ELE	104	12.0099	5.2956
MBPA	ELN	104	15.4664	4.8905
MBPA	ELZ	104	4.9960	1.4898
SQM	BHE	106	1.9576	1.1260
SQM	BHN	106	1.3091	1.1531
SQM	BHZ	106	1.0024	0.8925
ALST	ELE	119	6.0839	4.8109
ALST	ELN	119	7.5772	5.1293
ALST	ELZ	119	2.3699	1.7748
ERW	ELE	145	0.9461	0.8639
ERW	ELN	145	0.8498	0.6474
ERW	ELZ	145	0.8471	0.7151
ERW	HHE	145	0.9507	0.8889
ERW	HHN	145	0.7971	0.5869
ERW	HHZ	145	0.7997	0.6414
ROSS	ELE	166	1.8721	1.2357
ROSS	ELN	166	2.5431	1.2719
ROSS	ELZ	166	1.3269	0.6439
KEEL	ELE	179	1.4429	2.3138
KEEL	ELN	179	1.3636	1.8225
KEEL	ELZ	179	0.7195	0.9027
SBES	ELE	181	0.6301	0.6421
SBES	ELN	181	0.5017	0.5225
SBES	ELZ	181	0.4800	0.3448
LANE	ELZ	347	0.0595	0.1365
LANE	ELN	347	0.0856	0.2216
LANE	ELE	347	0.0856	0.2414
ALVY	ELZ	351	0.0557	0.1205
ALVY	ELN	351	0.1153	0.2953

QUARTERLY NETWORK REPORT 2001-B
on
Seismicity of Washington and Oregon

April 1 through June 30, 2001

Pacific Northwest Seismograph Network
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This report is prepared as a preliminary description of the seismic activity in Washington State and Oregon. Information contained in this report should be considered preliminary, and not cited for publication without checking directly with network staff. The views and conclusions contained in this document should not be interpreted as necessarily representing the official policies, either express or implied, of the U.S. Government.

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INTRODUCTION

This is the second quarterly report of 2001 from the University of Washington Dept. of Earth and Space Sciences *Pacific Northwest Seismograph Network* (PNSN), covering seismicity of Washington and western Oregon.

Comprehensive quarterlies have been produced by the PNSN since the beginning of 1984. Prior to that we published quarterly reports for western Washington in 1983 and for eastern Washington from 1975 to 1983. Annual technical reports covering seismicity in Washington since 1969 are available from the U.W. Dept. of Earth and Space Sciences. Beginning in 1999, the quarterly PNSN catalog listing changed; earthquakes smaller than magnitude 2.0 are no longer listed in the quarterly reports. The complete PNSN catalog is available on-line, both through our web-site and through the CNSS catalog. We will continue to provide special coverage (figures, counts, listings, etc.) of earthquake swarms, aftershock sequences, etc.

This quarterly report discusses network operations, seismicity of the region, unusual events or findings, and our educational and outreach activities. This report is preliminary, and subject to revision. The PNSN routinely records signals from selected stations in adjoining networks. This improves our ability to locate earthquakes at the edges of our network. However, our earthquake locations may be revised if new data become available, such as P and S readings from Canadian seismograph stations. Findings mentioned in these quarterly reports should not be cited for publication.

NETWORK OPERATIONS

Figure 1A shows a map view of stations operating during the quarter. Figure 1B is a more detailed view of stations in the Puget Sound area. Table 1A gives approximate periods of time when individual stations were inoperable. Data for Table 1A are compiled from weekly plots of network-wide teleseismic arrivals and automated and manual digital and analog signal checks, plus records of maintenance and repair visits.

This quarter was a busy one, as we prepared for an ambitious season of strong-motion and CREST station installations. Details of these installations are given below.

Strong Motion Instrumentation and Recording Update

The PNSN strong-motion team is in the process of installing twenty additional ANSS strong-motion instruments in the greater Puget Sound Region. By the end of the second quarter the siting process was largely complete, and three new strong-motion stations (HICC, PAYL, and RRHS) were installed and operational. In addition, station MARY, at Marymoor Park in Redmond, was installed at a trial location without GPS timing to test the reliability of the Internet telemetry.

In the second quarter of 2001, we upgraded to *ShakeMap* version 2.1, and began revising maps from previous events.

CREST Instrument Update

Station TTW at Tolt Reservoir in the Puget Sound area, formerly a 3-component broad-band, was reinstalled as a CREST station in January of last quarter with Internet telemetry through the Seattle Water Department's fiber-optic network. For about a year before that, the GPS clock at TTW had been drifting, leading to timing problems with picks on TTW. Some site improvements are still underway at TTW to lessen exposure to cultural noise.

Two CREST (Consolidated Reporting of EarthquakeS and Tsunamis) stations were installed this quarter; in Eugene Oregon (station EUO, telemetered through UO), and at Peninsula College (station OPC) in Port Angeles, WA.

One of the CREST stations slated for installation this summer was temporarily installed in Spokane (SPUD) in late June to record an unusual swarm of earthquake activity right in the Spokane urban area.

The Bonneville Power Administration (BPA) has agreed to site and provide telemetry for four CREST stations at BPA power substations near the coast (3 along the Oregon coast, and one in southwestern Washington).

The Washington State Patrol has agreed to provide a site and part of the telemetry path for a CREST station at Boistfort Peak in southwestern Washington. However, the telemetry between the terminus of the

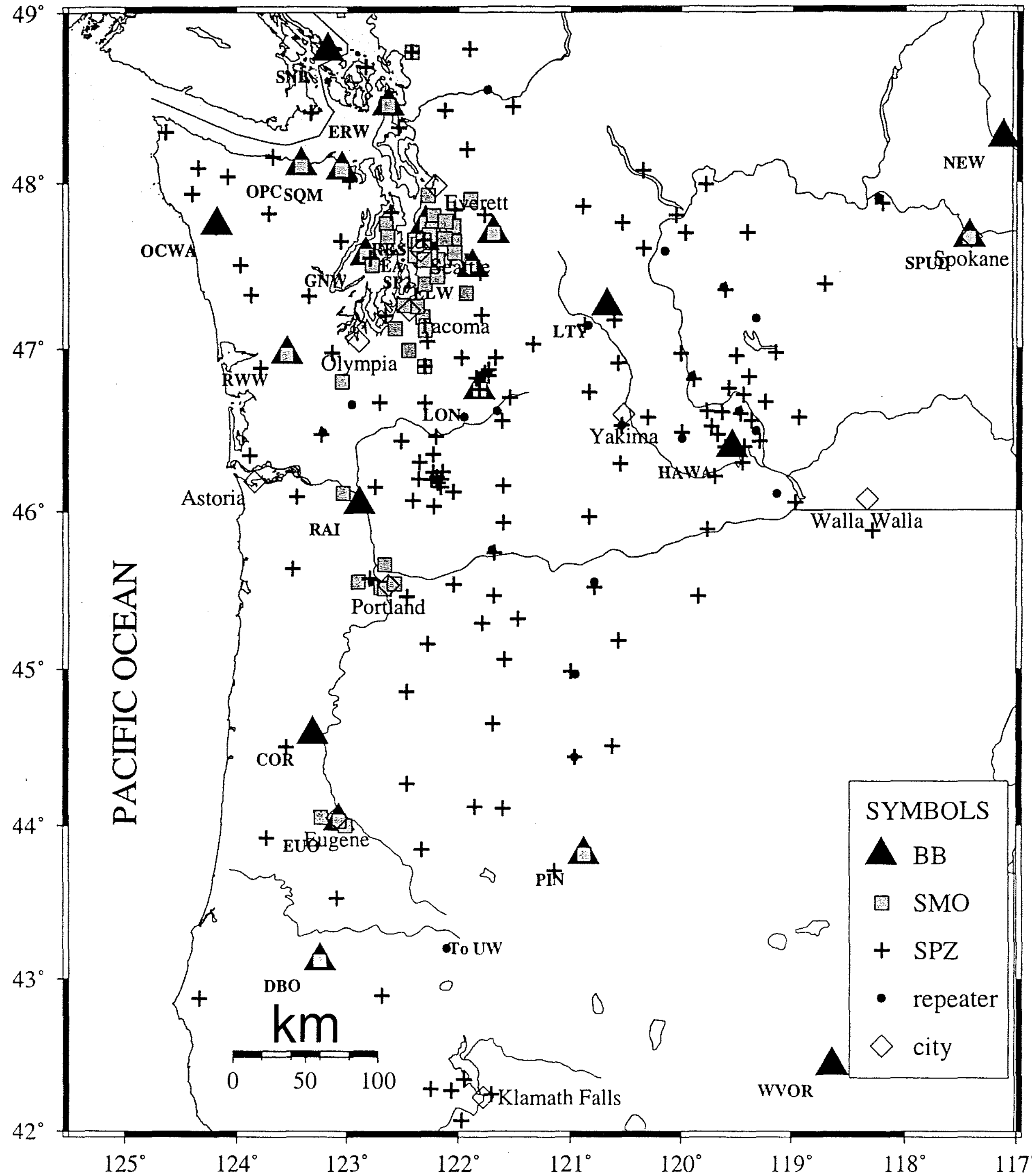

Figure 1A. Stations operating at the end of 2nd quarter, 2001. Stations shown are short period vertical (SP), 3-component broadband (BB), or strong motion (SMO).

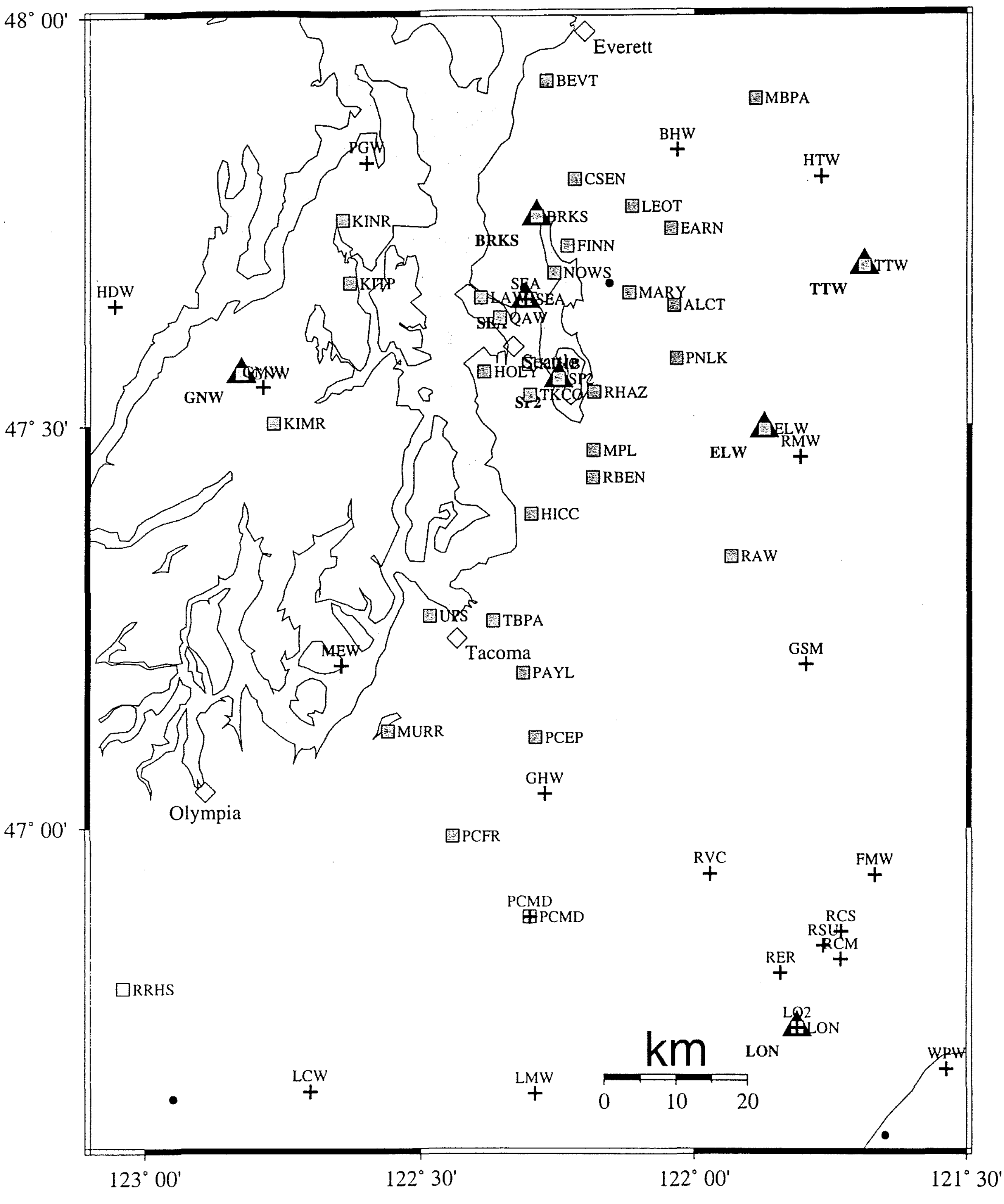

Figure 1B. Stations operating at the end of 2nd quarter, 2001. Detail of Figure 1A.

State Patrol/Dept of Transportation communication system and the University of Washington is still being worked out.

Temporary stations installed in Spokane

Following unusual seismicity in the Spokane urban area, Tom Yelin of the USGS, and UW graduate students Guy Medema and Josh Jones installed five short-period three-component PASSCAL instruments in a perimeter around Spokane. Temporary Spokane station locations are listed in Table 1B. All sites were located at private residences. No prior permissions had been given so sites were found by knocking on doors and asking. In general, residents were very willing to allow instruments to be placed on their property, including the use of their line power. The PASSCAL stations recorded continuously, but had no telemetry. One instrument was installed to the north of downtown Spokane on the evening of 6/30/01. Three others to the south, west and east were installed on 7/1/01. The last station was installed further to the north on 7/2/01. These five stations were set to 100 samples/sec and 16-bit. Stations 1,2 and 3 had gain = 128 x. Stations 4 and 5 had gain = 32 x.

Station SPUD (also temporary) is a CREST-type station, with 3 BB components and 3 strong-motion components. It is located at the Public Utilities Bldg., was installed on June 26, and has Internet telemetry.

Other news about stations, operations, and personnel

Jim Ramey, our head electronics engineer, retired at the end of April. Jim started working with seismic recording equipment at the UW in the mid 1970s. Jim kicked off his retirement with some substantial relaxation but, lucky for us, his expertise will continue to be available on a part-time basis. We conducted a national search for a replacement network engineer, and were fortunate to attract the interest of Erwin McPherson Jr., who previously worked at the the University of Utah in a capacity similar to Jim Ramey's. Erwin will be starting work in September.

Amy Lindemuth, who works on the installation and maintenance of the strong motion stations, was hired as a permanent employee (research scientist) back in January of last quarter. In other "Amy" news, our data analyst (also a research scientist), previously known as Amy Tieman is now Amy Wright following her marriage this quarter. Congratulations to both Amys!

A new three-component short-period station (HUO) became operational in early July at Husband, OR following the report (in May) of ground uplift about 5 km west of South Sister volcano in the Three Sisters region of the central Oregon Cascade Range. A "Three Sisters" link has been added to the PNSN "Cascade Volcano Information" page to provide links to research and daily updates on seismicity in the area. The Three Sisters region generally has very low seismicity. The closest short-period station to the area, TCO, was repaired at the beginning of July. The seismometer was replaced. Prior to the repair, the station had been marginal for some time, but the low rate of activity makes it difficult to pinpoint a failure date. TCO is a noisy site, located in trees next to a road, it is also a target (as in "target practice") for vandalism.

In other station news, a new station is planned in the Cascades near Glacier Peak. A preliminary trip to scout out possible sites was made last fall, and this quarter further scouting was done during an airplane flight. In Oregon station news, short-period station BRO was installed to replace FBO, which had become shaded by overgrowth. Station VRC, in southern Oregon, was removed due to vandalism. A new site will be sought to replace VRC.

Data Recording and EARTHWORM Update

This quarter, *scossa* remained our main EARTHWORM machine, with *milli* serving as our primary backup and *verme* as the secondary backup. *Milli* and *verme* still serve as the principal computers for data acquisition for many of the digital stations. We are currently running EARTHWORM-V5.1.

The SUNWORM digitizer for our primary system, *waggles*, went down form almost 24 hours on April 30-May 1. Data from analog systems was not digitized. However, no events were noted on the helicorder records during that time period. Since that time, there have been no additional problems with the waggles digitizter. The SUNWORM digitizer for *wiggles*, our backup system, began to have problems last year, and in the first quarter of this year we received an official EARTHWORM digitizer from the central EARTHWORM team. This quarter, we worked on the wiring configuration needed for the new digitizer.

TABLE 1A
Station Outages, Repairs, and Installations 2nd quarter 2001

Station	Outage Dates	Comments
BOW	12/01/00-End	Intermittent, mostly dead
BRO	5/16/01	INSTALLED (used to be FBO)
ELL	3/16/01-End	Intermittent, mostly dead
EUO	4/18/01	Eugene, Oregon: INSTALLED (CREST)
HUO	7/07/01	Husband, Oregon: INSTALLED (3-component short-period)
HICC	6/27/01	INSTALLED (SMO)
JUN	4/01/01-End	Noisy, intermittent
LMW	2/28/01-5/9/01	Dead - Improved spontaneously with better weather
MARY	6/10/01	INSTALLED (SMO)
NLO	12/1/00-End	Dead
OPC	6/14/01	INSTALLED (CREST)
PAYL	6/28/01	INSTALLED (SMO)
RCS	5/01/01-End	Dead
RRHS	6/20/01	INSTALLED (SMO)
RSU	9/30/00-End	Dead
SSO	9/00-End	Intermittent, mostly dead
SPUD	6/26/01	INSTALLED CREST-type station, Temporary installation in Spokane
TCO	5/1/00??-7/1/01	Repaired, seismometer replaced
TKO	1/4/99-End	REMOVED
TTW	1/1/00-1/26/01	Time Drifting due to GPS problems
TTW	1/26/01	REINSTALLED AS A CREST STATION
VRC	10/1/00-End	REMOVED VCO was shot with a gun, pulled out 11/2/00
VT2	4/01/01-End	Noisy, intermittent
WPW	5/15/01-End	Dead

TABLE 1B - Temporary stations installed in the Spokane Area

STA	LAT	LONG	EL	NAME
SPUD	47 39 54.3	117 25 35.2	-	Spokane County Pub Works, temporary
SPK1	47 44 02.2	117 25 53.2	-	Spokane Temp 6047
SPK2	47 42 11.2	117 19 16.0	-	Spokane Temp 6127
SPK3	47 38 36.2	117 22 55.2	-	Spokane Temp 6132
SPK4	47 41 28.8	117 30 36.0	-	Spokane Temp 6085
SPK5	47 46 46.3	117 27 49.8	-	Spokane Temp 6128

STATIONS USED FOR LOCATION OF EVENTS

Table 2A lists short-period, mostly vertical-component stations used in locating seismic events in Washington and Oregon. The first column in the table gives the 3-letter station designator, followed by a symbol designating the funding agency; stations marked by a percent sign (%) were supported by USGS joint operating agreement 01-HQ-AG-0011. A plus (+) indicates support under Pacific Northwest National Laboratory, Battelle contract 259116-A-B3. Stations designated "#" are USGS-maintained stations recorded at the PNSN. Stations designated by letters are operated by other networks, and telemetered to the PNSN. "M" stations are received from the Montana Bureau of Mines and Geology, "C" stations from the Canadian Pacific Geoscience Center, "U" stations from the US Geological Survey (ususally USNSN stations), "N" stations from the USGS Northern California Network, and "H" stations from the Hanford Reservation via the Pacific Northwest National Labs. Other designation indicate support from other sources. Additional columns give station north latitude and west longitude (in degrees, minutes and seconds), station elevation in km, and comments indicating landmarks for which stations were named.

Table 2B lists broad-band stations used in locating seismic events in Washington and Oregon, and Table 2C lists strong-motion stations.

TABLE 2A - Short-period Stations operated by the PNSN during the second quarter 2001

STA	F	LAT	LONG	EL	NAME
ASR	%	46 09 09.9	121 36 01.6	1.357	Mt. Adams - Stagman Ridge
AUG	%	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BBO	%	42 53 12.6	122 40 46.6	1.671	Butler Butte, Oregon
BEN	H	46 31 12.0	119 43 18.0	0.335	PNNL station
BHW	%	47 50 12.6	122 01 55.8	0.198	Bald Hill
BLN	%	48 00 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	%	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
BPO	%	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
BRO	%	44 16 02.5	122 27 07.1	0.135	Big Rock Lookout, Oregon
BRV	+	46 29 07.2	119 59 28.2	0.920	Black Rock Valley
BSMT	M	47 51 04.8	114 47 13.2	1.950	Bassoo Peak, MT
BUO	%	42 16 42.5	122 14 43.1	1.797	Burton Butte, Oregon

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
BVW	+	46 48 39.5	119 52 56.4	0.670	Beverly
CBS	+	47 48 17.4	120 02 30.0	1.067	Chelan Butte, South
CDF	%	46 07 01.4	122 02 42.1	0.756	Cedar Flats
CHMT	M	46 54 51.0	113 15 07.0	-	Chamberlain Mtn, MT
CMM	%	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.
CMW	%	48 25 25.3	122 07 08.4	1.190	Cultus Mtns.
CPW	%	46 58 25.8	123 08 10.8	0.792	Capitol Peak
CRF	+	46 49 30.0	119 23 13.2	0.189	Corfu
DPW	+	47 52 14.3	118 12 10.2	0.892	Davenport
DY2	+	47 59 06.6	119 46 16.8	0.890	Dyer Hill 2
EDM	%	46 11 50.4	122 09 00.0	1.609	East Dome, Mt. St. Helens
ELK	%	46 18 20.0	122 20 27.0	1.270	Elk Rock
ELL	+	46 54 34.8	120 33 58.8	0.789	Ellensburg
EPH	+	47 21 22.8	119 35 45.6	0.661	Ephrata
ET3	+	46 34 38.4	118 56 15.0	0.286	Eltopia (replaces ET2)
ETW	+	47 36 15.6	120 19 56.4	1.477	Entiat
FHE	+	46 57 06.9	119 29 49.0	0.455	Frenchman Hills East
FL2	%	46 11 47.0	122 21 01.0	1.378	Flat Top 2
FMW	%	46 56 29.6	121 40 11.3	1.859	Mt. Fremont
GBB	H	46 36 31.8	119 37 40.2	0.185	PNNL Station
GBL	+	46 35 54.0	119 27 35.4	0.330	Gable Mountain
GHW	%	47 02 30.0	122 16 21.0	0.268	Garrison Hill
GL2	+	45 57 35.0	120 49 22.5	1.000	New Goldendale
GLK	%	46 33 27.6	121 36 34.3	1.305	Glacier Lake
GMO	%	44 26 20.8	120 57 22.3	1.689	Grizzly Mountain, Oregon
GMW	%	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GSM	%	47 12 11.4	121 47 40.2	1.305	Grass Mt.
GUL	%	45 55 27.0	121 35 44.0	1.189	Guler Mt.
H2O	H	46 23 45.0	119 25 22.0	-	Water PNNL Station
HAM	%	42 04 08.3	121 58 16.0	1.999	Hamaker Mt., Oregon
HBO	%	43 50 39.5	122 19 11.9	1.615	Huckleberry Mt., Oregon
HDW	%	47 38 54.6	123 03 15.2	1.006	Hoodsport
HOG	%	42 14 32.7	121 42 20.5	1.887	Hogback Mtn., Oregon
HSO	%	43 31 33.0	123 05 24.0	1.020	Harness Mountain, Oregon
HSR	%	46 10 28.0	122 10 46.0	1.720	South Ridge, Mt. St. Helens
HTW	%	47 48 14.2	121 46 03.5	0.833	Haystack Lookout
HUO	%	44 07 10.9	121 50 53.5	2.037	Husband OR (UO)
JBO	+	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JCW	%	48 11 42.7	121 55 31.1	0.792	Jim Creek
JUN	%	46 08 50.0	122 09 04.4	1.049	June Lake
KEB	N	42 52 20.0	124 20 03.0	0.818	CAL-NET
KMO	%	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	%	46 27 46.7	122 11 41.3	0.610	Kosmos
KSX	N	41 49 51.0	123 52 33.0	-	CAL-NET
KTR	N	41 54 31.2	123 22 35.4	1.378	CAL-NET
LAB	%	42 16 03.3	122 03 48.7	1.774	Little Aspen Butte, Oregon
LAM	N	41 36 35.2	122 37 32.1	1.769	CAL-NET
LCCM	M	45 50 16.8	111 52 40.8	1.669	Lewis and Clark Caverns, MT
LCW	%	46 40 14.4	122 42 02.8	0.396	Lucas Creek
LMW	%	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
LNO	+	45 52 18.6	118 17 06.6	0.771	Lincton Mt., Oregon
LO2	%	46 45 00.0	121 48 36.0	0.853	Longmire
LOC	+	46 43 01.2	119 25 51.0	0.210	Locke Island
LVP	%	46 03 59.4	122 24 10.2	1.134	Lakeview Peak
MBW	%	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCMT	M	44 49 39.6	112 50 55.8	2.323	McKenzie Canyon, MT
MCW	%	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MDW	+	46 36 47.4	119 45 39.6	0.330	Midway
MEW	%	47 12 07.0	122 38 45.0	0.097	McNeil Island
MJ2	+	46 33 27.0	119 21 32.4	0.146	May Junction 2
MOX	+	46 34 38.4	120 17 53.4	0.501	Moxie City
MPO	%	44 30 17.4	123 33 00.6	1.249	Mary's Peak, Oregon
MTM	%	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
MURR	%	47 07 12.0	122 33 36.0	0.100	Camp Murry ANSS-SMO
NAC	+	46 43 59.4	120 49 25.2	0.728	Naches
NCO	%	43 42 14.4	121 08 18.0	1.908	Newberry Crater, Oregon
NEL	+	48 04 12.6	120 20 24.6	1.500	Nelson Butte
NLO	%	46 05 21.9	123 27 01.8	0.826	Nicolai Mt., Oregon
OBC	%	48 02 07.1	124 04 39.0	0.938	Olympics - Bonidu Creek
OBH	%	47 19 34.5	123 51 57.0	0.383	Olympics - Burnt Hill
OCP	%	48 17 53.5	124 37 30.0	0.487	Olympics - Cheeka Peak
OD2	+	47 23 15.6	118 42 34.8	0.553	Odessa site 2
OFR	%	47 56 00.0	124 23 41.0	0.152	Olympics - Forest Resource Cen
OHW	%	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ON2	%	46 52 50.8	123 46 51.8	0.257	Olympics - North River
OOW	%	47 44 03.6	124 11 10.2	0.561	Octopus West
OSD	%	47 48 59.2	123 42 13.7	2.008	Olympics - Snow Dome
OSR	%	47 30 20.3	123 57 42.0	0.815	Olympics Salmon Ridge

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
OT3	+	46 40 08.4	119 13 58.8	0.322	New Othello (replaces OT2 8/26
OTR	%	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PAT	+	45 52 55.2	119 45 08.4	0.262	Paterson
PCMD	%	46 53 20.9	122 18 00.9	0.239	PC Mountain Detachment SMUT-SM
PGO	%	45 27 42.6	122 27 11.5	0.253	Gresham, Oregon
PGW	%	47 49 18.8	122 35 57.7	0.122	Port Gamble
PRO	+	46 12 45.6	119 41 08.4	0.553	Prosser
RCM	%	46 50 08.9	121 43 54.4	3.085	Mt. Rainier, Camp Muir
RCS	%	46 52 15.6	121 43 52.0	2.877	Mt. Rainier, Camp Schurman
RED	H	46 17 51.0	119 26 15.6	0.330	Red Mountain PNNL Station
RER	%	46 49 09.2	121 50 27.3	1.756	Mt. Rainier, Emerald Ridge
RMW	%	47 27 35.0	121 48 19.2	1.024	Rattlesnake Mt. (West)
RNO	%	43 54 58.9	123 43 25.5	0.850	Roman Nose, Oregon
RPW	%	48 26 54.0	121 30 49.0	0.850	Rockport
RRHS	%	46 47 58.6	123 02 25.4	0.047	Rochester HS ANSS-SMO
RSU	%	46 51 12.0	121 45 47.0	4.440	Rainier summit
RSW	+	46 23 40.2	119 35 28.8	1.045	Rattlesnake Mt. (East)
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
RVN	%	47 01 38.6	121 20 11.9	1.885	Raven Roost (former NEHRP temp
RVW	%	46 08 53.2	122 44 32.1	0.460	Rose Valley
SAW	+	47 42 06.0	119 24 01.8	0.701	St. Andrews
SBES	%	48 46 05.9	122 24 54.2	0.119	Silver Beach ES SMO
SEA	%	47 39 15.8	122 18 29.3	0.030	UW, Seattle (Wood Anderson BB
SEP	#	46 12 00.7	122 11 28.1	2.116	September lobe, Mt. St. Helens
SFER	%	47 37 10.4	117 21 55.7	-	Spokane Schools, Ferris High S
SHW	%	46 11 37.1	122 14 06.5	1.425	Mt. St. Helens
SLF	%	47 45 32.0	120 31 40.0	1.750	Sugar Loaf
SMW	%	47 19 10.7	123 20 35.4	0.877	South Mtn.
SNI	H	46 27 80.0	119 39 50.0	-	PNNL station
SOS	%	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
SSO	%	44 51 21.6	122 27 37.8	1.242	Sweet Springs, Oregon
STD	%	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	%	48 09 03.1	123 40 11.1	0.308	Striped Peak
TBM	+	47 10 12.0	120 35 52.8	1.006	Table Mt.
TCO	%	44 06 27.6	121 36 02.1	1.975	Three Creek Meadows, Oregon.
TDH	%	45 17 23.4	121 47 25.2	1.541	Tom,Dick,Harry Mt., Oregon
TDL	%	46 21 03.0	122 12 57.0	1.400	Tradedollar Lake
TRW	+	46 17 32.0	120 32 31.0	0.723	Toppenish Ridge
TWW	+	47 08 17.4	120 52 06.0	1.027	Teanaway
UWFH	%	48 32 46.0	123 00 43.0	0.010	UW Friday Harbor SMUT-SMO
VBE	%	45 03 37.2	121 35 12.6	1.544	Beaver Butte, Oregon
VCR	%	44 58 58.2	120 59 17.4	1.015	Criterion Ridge, Oregon
VDB	C	49 01 34.0	122 06 10.1	0.404	Canada
VFP	%	45 19 05.0	121 27 54.3	1.716	Flag Point, Oregon
VG2	%	45 09 20.0	122 16 15.0	0.823	Goat Mt., Oregon
VGB	+	45 30 56.4	120 46 39.0	0.729	Gordon Butte, Oregon
VGZ	C	48 24 50.0	123 19 27.8	0.067	Canada
VIP	%	44 30 29.4	120 37 07.8	1.731	Ingram Pt., Oregon
VLL	%	45 27 48.0	121 40 45.0	1.195	Laurance Lk., Oregon
VLM	%	45 32 18.6	122 02 21.0	1.150	Little Larch, Oregon
VSP	%	42 20 30.0	121 57 00.0	1.539	Spence Mtn, Oregon
VT2	+	46 58 02.4	119 59 57.0	1.270	Vantage2
VTH	%	45 10 52.2	120 33 40.8	0.773	The Trough, Oregon
WA2	+	46 45 19.2	119 33 56.4	0.244	Wahluke Slope
WAT	+	47 41 55.2	119 57 14.4	0.821	Waterville
WIB	%	46 20 34.8	123 52 30.6	0.503	Willapa Bay
WIW	+	46 25 45.6	119 17 15.6	0.128	Wooded Island
WPO	%	45 34 24.0	122 47 22.4	0.334	West Portland, Oregon
WPW	%	46 41 55.7	121 32 10.1	1.280	White Pass
WRD	+	46 58 12.0	119 08 41.4	0.375	Warden
WRW	%	47 51 26.0	120 52 52.0	1.189	Wenatchee Ridge
YA2	+	46 31 36.0	120 31 48.0	0.652	Yakima
YEL	#	46 12 35.0	122 11 16.0	1.750	Yellow Rock, Mt. St. Helens
YPT	+	46 02 55.8	118 57 44.0	0.325	Yellepit

OUTREACH ACTIVITIES

The PNSN Seismology Lab staff provides an educational outreach program to better inform the public, educators, businesses, policy makers, and the emergency management community about seismicity and natural hazards. Our outreach includes lab tours, lectures, classes and workshops, press conferences, TV and radio news programs and talk shows, field trips, and participation in regional earthquake planning efforts. We provide basic information through information sheets, an audio library, and the Internet on the World-Wide-Web (WWW):

http://www.ess.washington.edu/SEIS/PNSN

TABLE 2B

Broad-band three-component stations operating at the end of the second quarter 2001. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME
BRKS	%	47 45 19.1	122 17 17.9	0.020	Brookside Sch. (vertical BB only) ANSS-SMO
COR	U	44 35 08.5	123 18 11.5	0.121	Corvallis, Oregon (IRIS station, Operated by OSU)
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon (CREST - operated by UO)
ELW	%	47 29 38.8	121 52 21.6	0.267	Echo Lake, WA (operated by UW)
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie, WA (operated by UW)
EUO	%	44 01 45.7	123 04 08.2	0.160	Eugene,OR U0 CREST BB SMO
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mountain, WA (CREST - operated by UW)
HAWA	U	46 23 32.3	119 31 57.2	0.367	Hanford Nike (USGS-USNSN)
HLID	U	43 33 45.0	114 24 49.3	1.772	Hailey, ID (USGS-USNSN)
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire (CREST - operated by UW)
LTY	%	47 15 21.2	120 39 53.3	0.970	Liberty, WA (operated by UW)
NEW	U	48 15 50.0	117 07 13.0	0.760	Newport Observatory (USGS-USNSN)
OCWA	U	47 44 56.0	124 10 41.2	0.671	Octopus Mtn. (USGS-USNSN)
OPC	%	48 06 01.0	123 24 41.8	0.090	Olympic Penn College CREST BB
PIN	%	43 48 40.0	120 52 19.0	1.865	Pine Mt. Oregon (CREST - operated by UO)
PNT	C	49 18 57.6	119 36 57.6	0.550	Canada, BB
RAI		46 02 25.1	122 53 06.4	1.520	Trojan Plant, Oregon (OSU)
RWW	%	46 57 50.1	123 32 35.9	0.015	Ranney Well (CREST - operated by UW)
SEA	%	47 39 15.8	122 18 29.3	0.030	UW, Seattle (Wood Anderson BB)
SNB	C	48 46 33.6	123 10 16.3	0.408	Canada
SP2	%	47 33 23.3	122 14 52.8	0.030	Seward Park, Seattle (operated by UW)
SPUD	%	47 39 54.3	117 25 35.2	-	Spokane County Pub Works, temporary
SQM	%	48 04 39.0	123 02 44.0	0.030	Sequim (operated by UW, telemetered by Battelle)
TTW	%	47 41 40.7	121 41 20.0	0.542	Tolt Reservoir, WA (CREST - operated by UW)
WVOR	U	42 26 02.0	118 38 13.0	1.344	Wildhorse Valley, Oregon (USGS-USNSN)

Special Outreach Events

- The Nisqually Earthquake Clearinghouse continued to collect and organize data under the direction of Bill Steele and Tony Qamar. Data sets will be accessible soon through the University of Washington Spatial Data Archive at: http://maximus.ce.washington.edu/~nisqually/index.html.
- The PNSN hosted a meeting this quarter of the Contingency planners and Recovery Managers (CPARM) at the Burke Museum featuring presentations researchers participating in The Nisqually Earthquake Clearinghouse.
- The PNSN continued its long association with CREW participating in the quarterly membership meeting and workshop. Bill Steele also participates in Executive Board Meetings as Secretary of the organization.
- The PNSN hosted meetings of the ANSS Technical Integration Committee (see report at http://www.anss.org/ticplan/) and the ANNS Pacific Northwest Region Siting Advisory Committee Meeting (see http://spike.geophys.washington.edu/SEIS/ANSS/minutes_april01.html)
- The PNSN was well represented at the April meeting of the Seismological Society of America, with individual or shared authorship of numerous posters and presentations.
- Steve Malone presented seminar series on the Nisqually Earthquake in Catania (3 seminars) and Rome (2 seminars), Italy.
- Steve Malone and Bill Steele participated in the Incorporated Research Institutes for Seismology (IRIS) Annual Meeting in Jackson Hole Wyoming.
- Steve Malone and Bill Steele visited Washington D.C. to brief the Washington State Congressional Delegation on effects of the Nisqually Earthquake.
- Bill Steele attended the annual Western Washington Emergency Network conference held in conjunction with Washington Emergency Management in Bellevue, Washington, and spoke on the development of the Nisqually Earthquake Clearinghouse.
- Bill Steele made a presentation about the impacts of the Nisqually Earthquake to the Association of Geoscience Educators Conference at Bellevue Community College and made the keynote speech at the Seattle Middle Schools Science Fair at the Museum of Flight.
- Ruth Ludwin presented information on Native American stories related to Cascadia Subduction Zone earthquakes at a brown-bag seminar at the UW, to Nisqually Tribal Resource Managers and at the Juan de Fuca Festival in Port Angeles.
- Ruth Ludwin also gave a general talk on Pacific Northwest Earthquake hazards at the Juan de Fuca Festival in Port Angeles over Memorial Day weekend.

Table 2C lists strong-motion, three-component stations operating in Washington and Oregon that provide data in real or near-real time to the PNSN. Several of these stations also have broad-band instruments, as noted. The "SENSOR" field designates what type of seismic sensor is used;

- A = Terra-Tech SSA-320 SLN triaxial accelerometer/Terra-Tech IDS24
- A20 = Terra-Tech SSA-320 triaxial accelerometer/Terra-Tech IDS20 recording system,
- FBA23 = Kinemetrics FBA23 accelerometers and Reftek recording system,
- EPI = Kinemetrics Episensor accelerometers and Reftek recording system.
- BB = Guralp CMG-40T 3-D broadband velocity sensor.
- BB3 = Guralp CMG3T 3-D broadband velocity sensor.
- BBZ = Broad Band sensor, PMD 2024, vertical component only.
- K2 = Kinemetrics Episensor accelerometers and K2 Recording System

The "TELEMETRY" field indicates the type of telemetry used to recover the data.

- D = dial-up,
- L = continuously telemetered via dedicated lease-line telephone lines,
- L-PPP = continuously telemetered via dedicated lease-line telephone lines using PPP protocol
- I = continuously telemetered via Internet,
- E = continuously telemetered via Internet from a remote EARTHWORM system

TABLE 2C

Strong-motion three-component stations operating at the end of the second quarter 2001. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME	SENSORS	TELEMETRY
ALCT	%	47 38 51.0	122 02 13.2	0.055	Alcott Elementary, Redmond	K2	I
ALST	%	46 6 31.2	123 01 47.4	0.000	Alston, Oregon BPA	A20	L,E,D
ALVY	%	43 59 53.2	123 00 57.0	0.155	Alvey Substation, Eugene, Oregon BPA	K2	L,E
BEVT	%	47 55 11.9	122 16 11.9		Boeing Everett Plant	K2	I
BRKS	%	47 45 19.7	122 17 18.4	0.100	Brookside Elementary, Lake Forest Park	K2,BBZ	I
CSEN	%	47 48 04.5	122 13 06.5	0.055	Crystal Springs Elementary, Bothell	K2	I
CSO	#	45 31 01.0	122 41 22.5	0.036	Canyon Substation, Oregon	FBA23	D
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, OR (UO CREST)	EPI,BB3	E,L-PPP
EARN	%	47 44 24.0	122 02 24.0	0.010	East Ridge Elementary, Woodinville	K2	I
ELW	%	47 29 38.8	121 52 21.6	0.267	Echo Lake, WA	A,BB	L,D
EUO	%	44 01 45.7	123 04 08.2	0.160	Eugene,OR (U0 CREST)	EPI,BB3	E
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie, WA	A,BB	L,D
FINN	%	47 43 08.9	122 13 55.0	0.010	Finn Hill Jr High, Juanita	K2	I
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mountain, WA (CREST)	EPI,BB3	L-PPP
HAO	#	45 30 33.1	122 39 24.0	0.018	Harrison Substation, Oregon	FBA23	D
HICC	%	47 23 24.4	122 17 52.4	0.115	Highline CC, Des Moines	K2	I
HOLY	%	47 33 55.3	122 23 02.1	0.106	Holy Rosary	K2	I
KEEL	%	45 33 0.0	122 53 44.4	0.000	Keeler, Oregon BPA	A20	L,E,D
KIMB	%	47 34 30.9	122 18 05.9	0.100	Kimball Elementary, Seattle	K2	I
KIMR	%	47 30 11.7	122 46 01.9	0.123	Kitsap Moderate Risk Waste	K2	I
KINR	%	47 45 06.0	122 38 35.0	0.010	Kitsap North Road Shed	K2	I
KITP	%	47 40 30.0	122 37 47.0	0.100	Kitsap Treatment Plant	K2	I
LANE	%	44 03 06.5	123 13 54.8	0.120	Lane Substation, Eugene, Oregon	K2	L,E
LAWT	%	47 39 23.4	122 23 21.9	0.111	Lawton Elementary, Seattle	A20	I
LEOT	%	47 46 04.4	122 06 54.3	0.155	Leota Jr High, Woodinville	A	I
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire (CREST)	EPI,BB3	L-PPP,D
MARY	%	47 39 45.7	122 07 11.6	0.011	Marymoor Park, Redmond	K2	I
MBPA	%	47 53 56.6	121 53 20.2	0.186	Monroe BPA	A20	L,D
MPL	%	47 28 08.2	122 11 06.2	0.122	Maple Valley	A	L,D
MURR	%	47 07 12.0	122 33 36.0	0.100	Camp Murry	K2	none
NOWS	%	47 41 12.0	122 15 21.2	0.000	NOAA, Bldg 3	A20	I
OPC	%	48 06 01.0	123 24 41.8	0.090	Penninsula College (CREST)	EPI,BB3	I
PAYL	%	47 11 34.0	122 18 46.0	0.010	Aylen HS, Puyallup	K2	I
PCEP	%	47 06 43.0	122 17 24.2	0.160	PC East Precinct	K2	I
PCFR	%	46 59 23.3	122 26 27.4	0.137	PC Training Center	K2	I
PCMD	%	46 53 20.9	122 18 00.9	0.239	PC Mountain Detachment	K2	I
PIN	%	43 48 40.0	120 52 19.0	1.865	Pine Mt., OR (U0 CREST)	EPI,BB3	E,L-PPP
PNLK	%	47 34 50.0	122 01 42.4	0.128	Pine Lake Middle School, Issaquah	K2	I
QAW	%	47 37 53.2	122 21 15.0	0.140	Queen Anne	A	L
RAW	%	47 20 14.0	121 55 57.6	0.208	Raver BPA	A	L,D
RBEN	%	47 26 05.4	122 11 10.2	0.000	Benson Elementary, Renton	K2	I
RBO	#	45 32 27.0	122 33 51.5	0.158	Rocky Butte, Oregon	FBA23	D
RHAZ	%	47 32 25.8	122 11 08.4	0.108	Hazelwood Elementary, Newcastle	A	I
ROSS	%	45 39 46.2	122 39 37.0	0.100	Ross BPA	A20	L,E,D
RRHS	%	46 47 58.6	123 02 25.4	0.047	Rochester HS, Rochester	K2	none
RWW	%	46 57 50.1	123 32 35.9	0.015	Ranney Well (CREST)	EPI,BB3	L-PPP
SBES	%	48 46 05.9	122 24 54.2	0.000	Silver Beach Elementary, Bellingham	K2	I
SEA	%	47 39 18.0	122 18 30.0	0.030	Seattle	A,BB	L,D
SP2	%	47 33 23.3	122 14 52.8	0.030	Seward Park, Seattle	A,BB	L
SPUD	%	47 39 54.3	117 25 35.2	-	Spokane County Pub Works, tmp	EPI,BB or BB3	I
SQM	%	48 04 39.0	123 02 44.0	0.030	Sequim, WA (CREST)	EPI,BB	L-PPP
TBPA	%	47 15 28.1	122 22 05.9	0.002	Tacoma WA BPA	A	L,D
TKCO	%	47 32 12.7	122 18 01.5	0.005	King Co EOC	A20	I
TTW	%	47 41 40.7	121 41 20.0	0.542	Tolt Res, WA (CREST)	EPI,BB3	I
UPS	%	47 15 51.4	122 28 56.3	0.113	University of Puget Sound	K2	I
WISC	%	47 36 32.0	122 10 27.8	0.056	Wilburton Instructional Services Center, Bellevue	K2	I

Press Interviews, Lab Tours, and Workshops

This quarter, the PNSN staff provided 11 K-12 lab tours serving, and 3 college classes serving over 265 students and their escorts.

Telephone, Mail, and On-line outreach

The PNSN audio library system received about 900 calls this quarter. Calls increased by a factor of 3 in June, when a magnitude 5.0 Benioff zone earthquake occurred near Satsop and an unusual sequence of shallow earthquakes began near Spokane. Our audio library provides several recordings. The most popular is a frequently updated message on current seismic activity. In addition we have a tape describing the seismic hazards in Washington and Oregon, and another on earthquake prediction. Callers often request our one-page information and resource sheet on seismic hazards in Washington and Oregon. Thousands of these have been mailed out or distributed, and we encourage others to reproduce and further distribute this sheet. Our information sheet discussing earthquake prediction is also frequently requested. Callers to the audio library can also choose to be transferred to the Seismology Lab, where additional information is available. This quarter we responded in person to: ~30 calls from management and government, ~40 calls from the media, ~25 calls from educators ~25 calls from the business community, and about 120 calls from the general public.

Internet outreach

The PNSN web-site offers many web pages, including maps and lists of the most recent PNW earthquakes, general information on earthquakes and PNW earthquake hazards, information on past damaging PNW earthquakes, and catalogs of earthquake summary cards. Web-pages on seismicity of Cascade Volcanos, and Quarterly summaries of seismicity are also included. The PNSN recent earthquake list is available through the World-Wide-Web (WWW) at:

http://www.ess.washington.edu/SEIS/PNSN

"Webicorder" pages allow Web visitors (and us) to view continuous data from PNSN seismographic stations at:

http://www.ess.washington.edu/SEIS/PNSN/WEBICORDER/

ShakeMap generates maps showing instrumentally measured shaking effects. Table 3A indicates which events this quarter generated ShakeMaps.

Shake Maps: **http://spike.ess.washington.edu/shake/index.html**

Table 3A also indicates the felt events this quarter that generated Community Internet Intensity Maps (CIIM). CIIM maps are made using Internet reports. For a well-felt event hundreds (or thousands) of people fill out an on-line form describing their experiences during the earthquake. These "felt" reports are converted into numeric intensity values, and the CIIM map shows the average intensity by zip code.

CIIM Maps: **http://pasadena.wr.usgs.gov/shake/pnw/**

In addition to the PNSN web site, the UW Dept. of Earth and Space Sciences and the PNSN host several other earthquake-related web sites:

- **Volcano Systems Center**: **http://www.vsc.washington.edu** is a cooperative effort of the UW and the USGS that links volcano-related activities of the UW Dept. of Earth and Space Sciences and Oceanography departments with related USGS activities.
- **Seismosurfing**: **http://www.ess.washington.edu/seismosurfing.html** is a comprehensive listing of sites worldwide that offer substantive seismology data and information. This page is mirrored at two sites in Europe.
- The **Council of the National Seismic Systems** (CNSS): **http://www.cnss.org** features composite listings and maps of recent U.S. earthquakes, and documentation of the EARTHWORM system.
- **"Tsunami!"** : **http://www.ess.washington.edu/tsunami** offers many pages, including an excellent discussion on the physics of tsunamis, and short movie clips. It was developed by Benjamin Cook under the direction of Dr. Catherine Petroff (UW Civil Engineering).
- **The UW Dept. of Earth and Space Sciences Global Positioning System (GPS)**:
  http://www.ess.washington.edu/GPS/gps.html
  site provides information on geodetic studies of crustal deformation in Washington and Oregon.

EARTHQUAKE DATA - 2001-A

There were 1,604 events digitally recorded and processed at the University of Washington between April 1 and June 30, 2001. Locations in Washington, Oregon, or southernmost British Columbia were determined for 729 of these events; 584 were classified as earthquakes and 145 as known or suspected blasts. The remaining 875 processed events include teleseisms (218 events), regional events outside the PNSN (102), and unlocated events within the PNSN. Unlocated events within the PNSN include very small earthquakes and some known blasts. Frequent mining blasts occur near Centralia, Washington and we routinely locate some of them.

Table 3A is a listing of all earthquakes reported to have been felt during this quarter. Table 3B is a listing of earthquakes magnitude 2.5 or greater with reasonably constrained focal mechanisms from P-wave first motions. Table 4, located at the end of this report, is this quarter's catalog of earthquakes M 2.0 or greater, located within the network - between 42-49.5 degrees north latitude and 117-125.3 degrees west longitude.

Fig. 2 shows earthquakes with magnitude greater than or equal to 0.0 ($M_c \geq 0$).
Fig. 3 shows blasts and probable blasts ($M_c \geq 0$).
Fig. 4 shows earthquakes located near Mt. Rainier ($M_c \geq 0$).
Fig. 5 shows earthquakes located at Mt. St. Helens ($M_c \geq 0$).
Fig. 6 shows reasonably well-constrained focal mechanisms for earthquakes with M 2.5 this quarter.

TABLE 3A - Felt Earthquakes during the 2nd Quarter of 2001

DATE-(UTC)-TIME	LAT(N)	LON(W)	DEPTH	MAG	COMMENTS	CIIM	ShakeMap
01/02/14 03:54:54	48.76	123.12	20.9	2.3	26.0 km NNW of Friday Harbor, WA		
01/04/07 16:02:35	48.72	124.76	41.8	3.9	90.6 km NNW of Forks, WA	x	
01/06/10 13:19:11	47.16	123.50	40.7	5.0	18.3 km N of Satsop, WA	x	x
01/06/25 14:15:22	47.68	117.39	10.5	3.9	1.3 km NNE of Spokane, WA	x	
01/06/25 15:01:27	47.70	117.41	11.1	3.4	3.4 km N of Spokane, WA		
01/06/25 16:49:16	47.73	117.47	0.0	2.3	9.0 km NNW of Spokane, WA		
01/06/25 22:58:13	47.72	117.46	0.0	2.3	7.0 km NW of Spokane, WA		
01/06/26 01:21:21	47.75	117.48	0.0	2.1	11.4 km NNW of Spokane, WA		
01/06/26 05:52:26	47.75	117.48	8.0	2.4	10.9 km NW of Spokane, WA		
01/06/27 09:07:45	47.72	117.45	0.4	2.4	6.8 km NW of Spokane, WA		
01/06/27 14:45:37	47.70	117.41	7.3	2.9	4.2 km N of Spokane, WA	x	
01/06/28 07:51:42	47.69	117.43	0.5	2.1	3.6 km NW of Spokane, WA		
01/06/28 11:47:48	47.66	117.41	0.2	0.7	1.0 km WSW of Spokane, WA		
01/06/29 01:13:27	47.67	117.41	0.3	2.3	1.0 km NNW of Spokane, WA		
01/06/30 01:23:31	46.85	121.97	7.7	3.3	16.2 km W of Mt Rainier, WA	x	

TABLE 3B - Earthquakes M 2.5 or larger during the 2nd Quarter of 2001
Focal mechanisms noted where computed. Some earthquakes have more than one possible mechanism.

DATE-(UTC)-TIME	LAT(N)	LON(W)	DEP	MAG	COMMENTS	STRIKE	DIP	RAKE
yy/mm/dd hh:mm:ss	deg.	deg.	km			deg.	deg.	deg.
01/04/07 16/02/35	48.72N	124.77W	41.8	3.9	90.6 km NNW of Forks, WA	-	-	-
01/04/24 13/21/29	46.63N	120.59W	13.5	2.6	7.0 km WNW of Yakima, Wa	0	20	171
01/04/25 20/50/07	48.77N	119.03W	0.7	2.6	60.8 km NE of Okanogan, WA	-	-	-
01/05/06 15/11/06	45.25N	123.53W	54.2	2.7	33.6 km SE of Tillamook, OR	120	5	10
01/05/10 20/51/34	42.20N	124.45W	31.4	2.6	53.2 km NNW of Crescent City, CA	-	-	-
01/05/11 06/25/54	47.23N	119.35W	11.1	3.3	12.4 km NNW of Moses Lake, WA	95	40	60
01/05/14 12/54/12	47.63N	119.69W	12.6	2.6	30.6 km W of Coulee City, WA	35	35	0
01/06/07 12/15/22	48.49N	124.37W	40.0	2.9	60.6 km N of Forks, WA	330	85	-160
01/06/07 12/45/42	46.96N	119.52W	20.1	2.6	25.5 km SW of Moses Lake, WA	115	30	110
						290	65	110
01/06/10 13/19/11	47.17N	123.50W	40.7	5.0	18.3 km N of Satsop, WA	130	40	-100
01/06/18 06/49/54	45.19N	120.11W	0.0	2.6	7.9 km SE of Condon, OR	-	-	-
01/06/25 14/15/22	47.68N	117.40W	10.5	3.9	1.3 km NNE of Spokane, WA	35	55	-60
01/06/25 15/01/27	47.70N	117.41W	11.1	3.4	3.4 km N of Spokane, WA	170	40	-159
01/06/25 15/05/66	47.71N	117.45W	0.4	2.8	5.3 km NW of Spokane, WA	-	-	-
01/06/27 14/45/37	47.71N	117.41W	7.3	2.9	4.2 km N of Spokane, WA	-	-	-
01/06/30 01/23/31	46.86N	121.97W	7.7	3.3	16.2 km W of Mt Rainier, WA	125	50	80

OREGON SEISMICITY

During the second quarter of 2001, a total of 38 earthquakes were located in Oregon between 42.0° and 45.5° north latitude, and between 117° and 125° west longitude. None of the earthquakes in Oregon this quarter were reported felt. The most interesting feature of seismic activity in Oregon this quarter was a

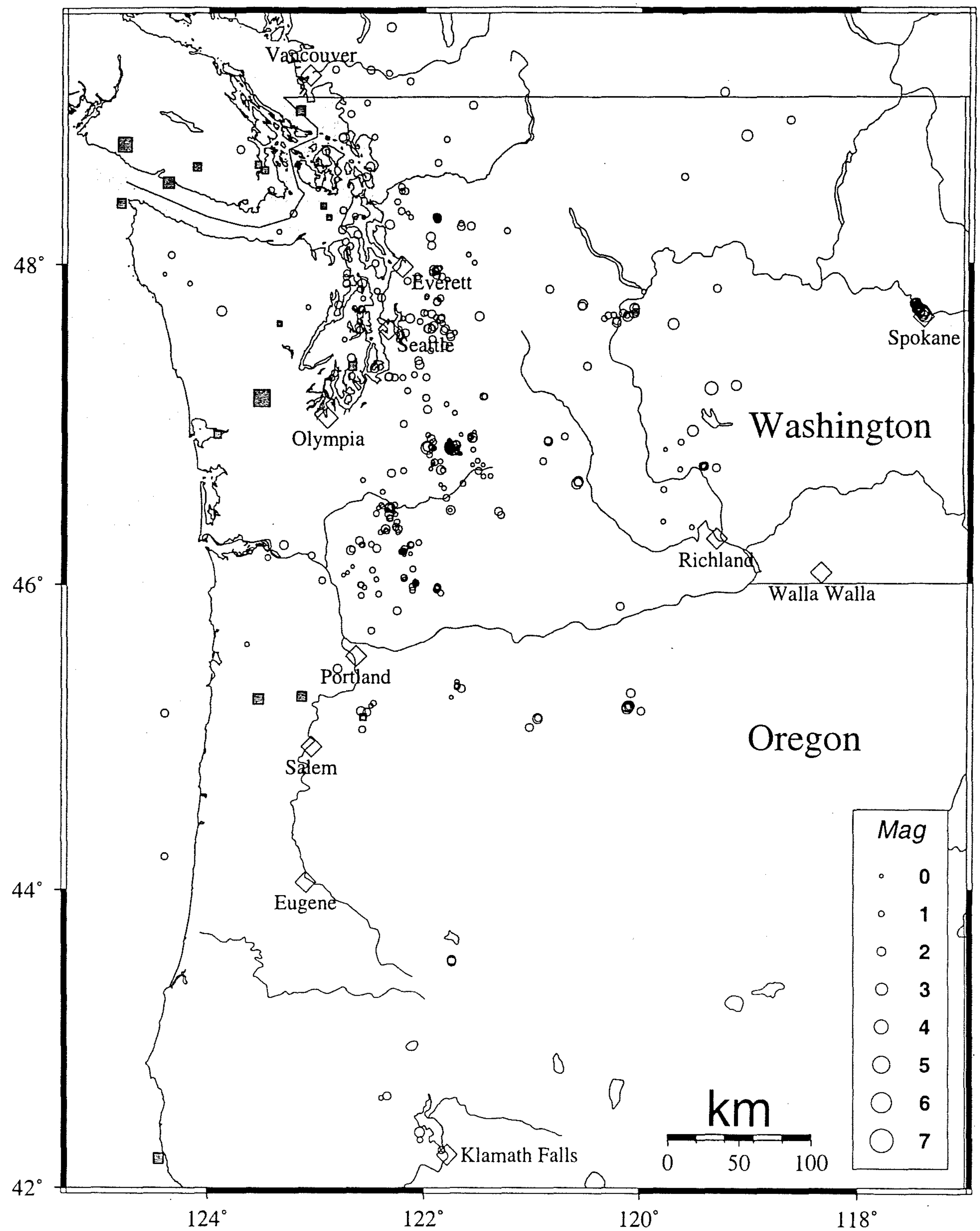

Figure 2. Located earthquakes, magnitude > 0, 2nd quarter, 2001. Filled squares indicate earthquakes with depth greater than 30km. Unfilled diamonds represent cities.

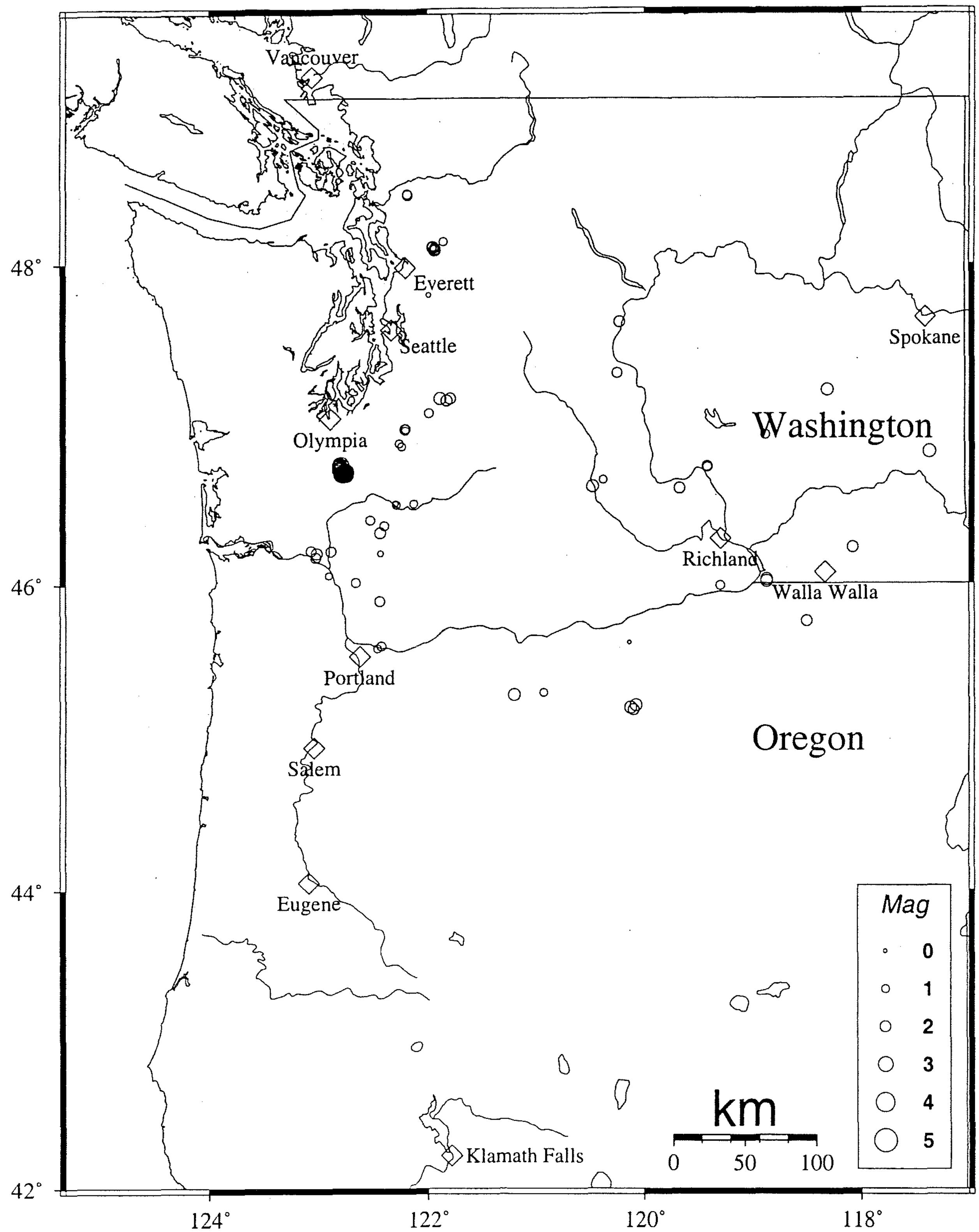

Figure 3. Blasts and probable blasts, 2nd quarter, 2001. Unfilled diamonds represent cities.

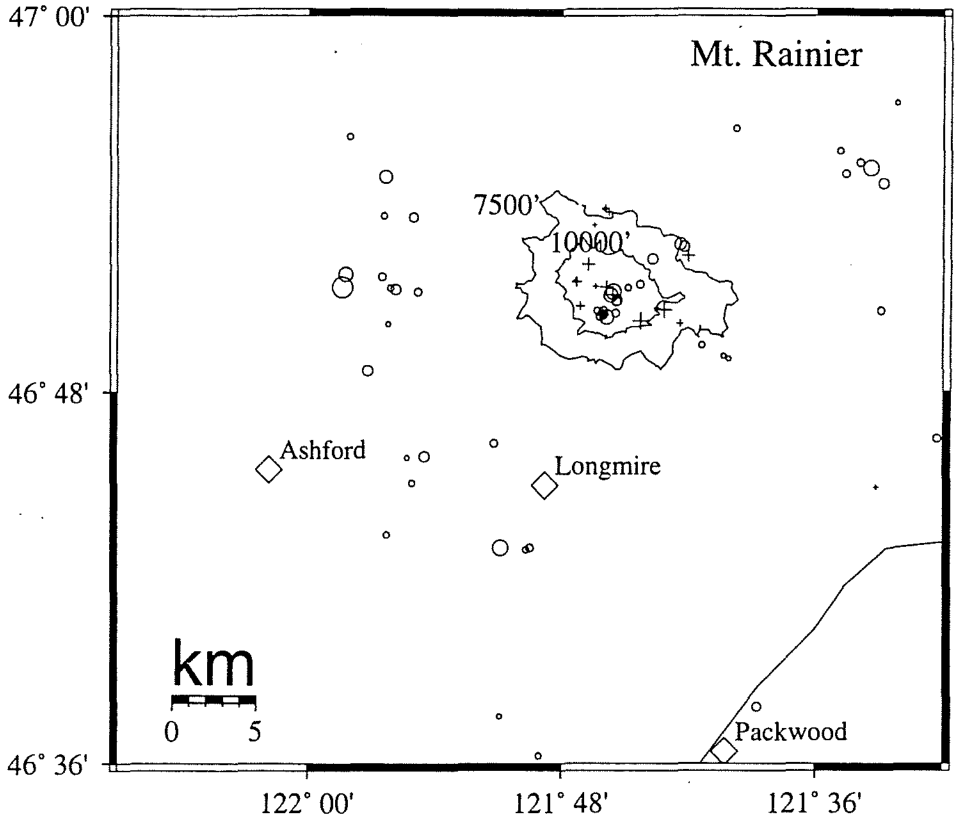

Figure 4. Earthquakes M > 0, 2nd quarter, 2001. 'Plus' symbols indicate depth less than 1 km. Circles indicate depth greater than 1 km. Elevation contours shown in feet.

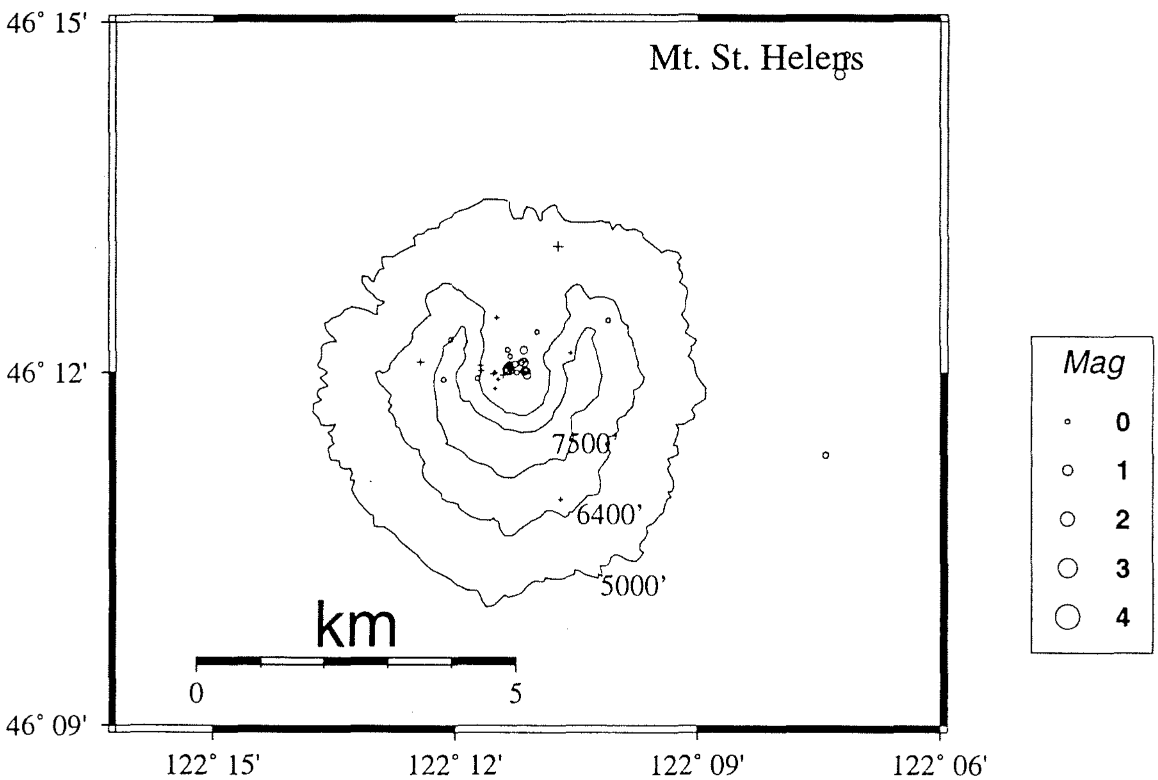

Figure 5. Earthquakes M > 0, 2nd quarter, 2001. 'Plus' symbols indicate depth less than 1 km. Circles indicate depth greater than 1 km. Elevation contours shown in feet.

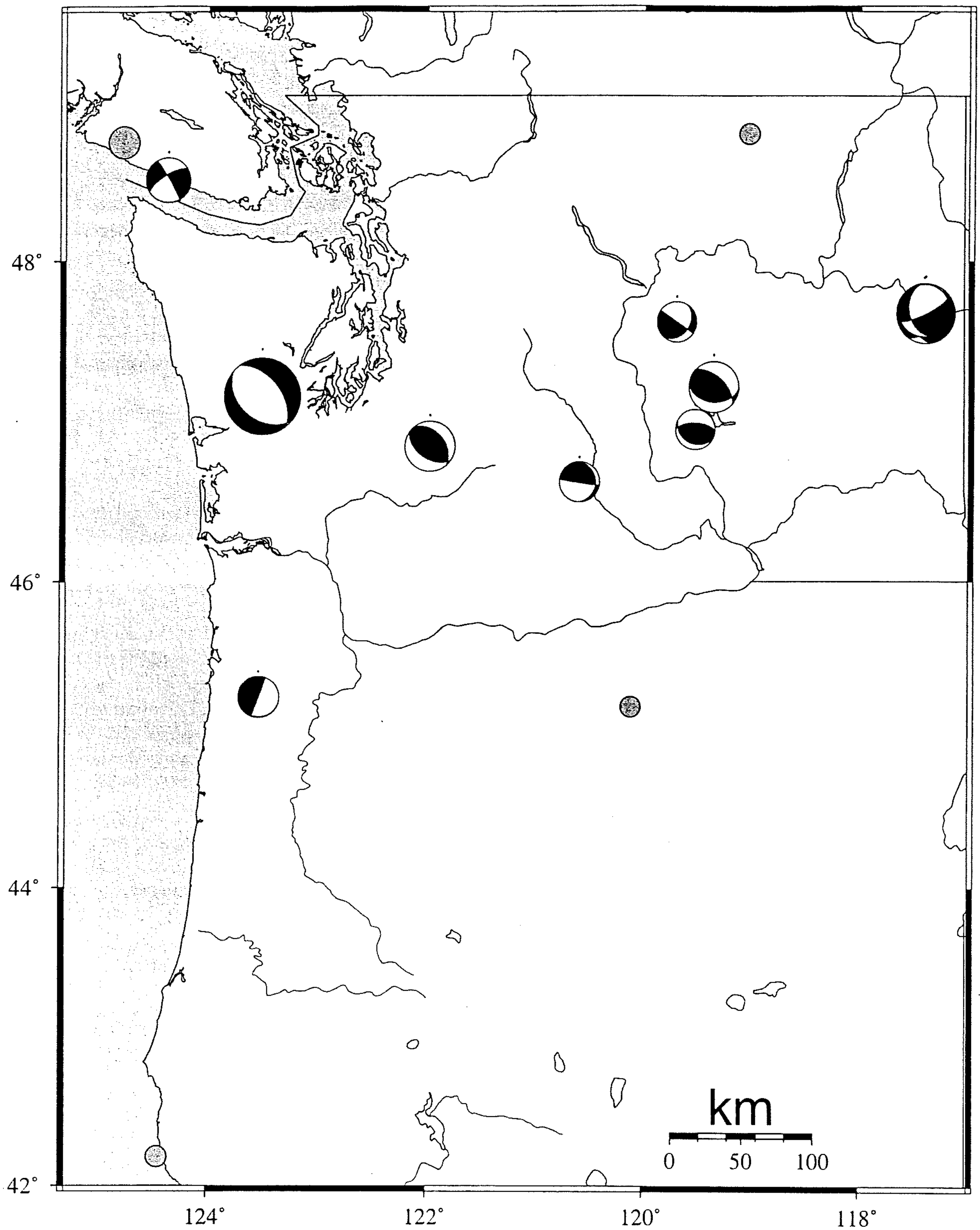

Figure 6. Events and fault plane solutions, 2nd quarter 2001, Magnitude greater than or equal to 2.5. Focal symbol size reflects earthquake magnitude. Events without fault plane solutions are shown as filled dots.

M 2.7 earthquake on May 6 located at a depth of 54 km about 34 km southeast of Tillamook. Events of this depth are unusual in Oregon.

In the Klamath Falls area, six earthquakes occurred in the second quarter of 2001. Since 1994, most earthquakes in the Klamath Falls area have been considered aftershocks of a pair of damaging earthquakes in September of 1993. The 1993 earthquakes were followed by a vigorous aftershock sequence which decreased over time.

WESTERN WASHINGTON SEISMICITY

During the second quarter of 2001, 477 earthquakes were located between 45.5° and 49.5° north latitude and between 121° and 125.3° west longitude. Three earthquakes were felt this quarter in western Washington. Details are in Table 3.

The largest felt earthquake in western Washington was a magnitude 5.0 earthquake on June 10 at 13:19 UTC. This earthquake was located near Satsop, Washington at a depth of about 41 km. A larger earthquake (Mw=5.8) occurred nearby (about 11 km SSE) and at a similar depth in July of 1999. Like the Feb. 2001 Nisqually earthquake, these are Benioff zone earthquakes within the subducting oceanic plate. The June 10 earthquake was well recorded by strong motion instruments in the Puget Sound.
A ShakeMap is available at:

http://spike.ess.washington.edu/shake/0106101319/intensity.html

and a CIIM "felt" map at:

http://pasadena.wr.usgs.gov/shake/pnw/STORE/X6101319/ciim_display.html

The CIIM web site received nearly 1500 "felt" reports from more than 200 different zip codes around Puget Sound. No damage was reported. The amplitude of shaking (PGA) in the June 10 quake was considerably less (about an order of magnitude) than in the Nisqually earthquake of Feb., 2001.

CASCADE VOLCANOS

Mount Rainier Area: Figure 4 shows earthquakes near Mount Rainier. The number of events in close proximity to the cone of Mt. Rainier varies over the course of the year, since the source of much of the shallow activity is presumably ice movement or avalanching at the surface, which is seasonal in nature. Events with very low frequency signals (1-3 Hz) believed to be icequakes are assigned type "L" in the catalog. Emergent, very long duration signals, probably due to rockfalls or avalanches, are assigned type "S" (see Key to Earthquake Catalog). There were 7 events flagged "L" or "S" that were located at Mount Rainier this quarter and an additional 191 "L" or "S" events were recorded, but were too small to locate reliably. Type L and S events are not shown in Fig. 4.

A total of 95 tectonic events (30 of these were smaller than magnitude 0.0, and thus are not shown in Fig. 4) were located within the region shown in Fig. 4. Of these, 30 were tectonic events located in the "Western Rainier Seismic Zone" (WRSZ), a north-south trending lineation of seismicity approximately 15 km west of the summit of Mt. Rainier (for counting purposes, the western zone is defined as 46.6-47 degrees north latitude and 121.83-122 west longitude). The largest tectonic earthquake located near Mt. Rainier this quarter was the felt magnitude 3.3 earthquake on June 30, located about 16.2 km west of the summit at a depth of about 8 km (see Tables 3A and 3B for details).

This quarter, there were 36 (20 smaller than magnitude 0.0 and thus not shown in Fig. 4) higher-frequency tectonic-style earthquakes within 5 km of the summit. The remaining events were scattered around the cone of Rainier as seen in Fig. 4.

Mount St. Helens Area: Figure 5 shows volcano-tectonic earthquakes near Mount St. Helens. Low frequency (L) and avalanche or rockfall events (S) are not shown. This quarter, 116 earthquakes were located at Mount St. Helens in the area shown in Fig. 5. Of these earthquakes, 39 were magnitude 0.0 or larger and 16 were deeper than 4 km. The largest tectonic earthquakes at Mount St. Helens this quarter were magnitude 1.3 events on April 17 and May 27 (UTC) located 0.3 and 2.4 km NE and NNE, resprctively, of Mount St. Helens.

No type "S" or "L" events were located at Mount St. Helens, but 140 "L" or "S" events too small to locate were recorded.

EASTERN WASHINGTON SEISMICITY

During the second quarter of 2001, 69 earthquakes were located in eastern Washington in the area between 45.5-49.5 degrees north latitude and 117-121 degrees west longitude.

This quarter a very unusual sequence of earthquakes began in the Spokane urban area. We located 22 earthquakes (11 reported felt) within about 11 km of Gonzaga University. (Earthquake locations for Spokane are given in relation to a point at 117.405W longitude, 47.672N latitude, near the intersection of Mission Ave and Hamilton Ave and just a few blocks north of Gonzaga University.) Details are given in Table 3C.

It is a bit difficult to pinpoint exactly when the sequence commenced, as Spokane is at the edge of the PNSN, and the nearest stations, NEW and DPW are more than 60 km away from the activity. The largest earthquake in the sequence to date was on June 25. It was located beneath downtown Spokane near Gonzaga University. Magnitude estimates were 3.9 (Mc) and 3.8 (Ml using localmag). The sequence included a possible foreshock, magnitude 2.0, on May 24. It is not clear whether the May 24 event was felt, but numerous people have informed us that shocks were felt on June 24, and possibly earlier. The June 25 mainshock caused some minor damage as bricks to tumbled from a few chimneys, and a few dishes, fell from shelves, etc.

Because of the poor station coverage in the area, on June 25 the PNSN deployed equipment already on hand (for a CREST station) and installed a 6-component broad-band strong-motion station at the Spokane Public Utilities Dept (the station is named SPUD) with Internet telemetry to the UW. Reports of unrecorded felt earthquakes continued despite the new station, and the PNSN continued to record earthquakes of magnitude 2.0 and larger through June 30. Five additional PASSCAL stations were requested and these were installed between June 30 and July 2 (see details in Network Operations section). Additional felt and recorded earthquakes are continuing into early July. The neighborhoods where people report feeling continuing un-recorded shaking are confined to the part of Spokane immediately north of downtown. Reports of explosion-like sounds accompanying the shocks are common.

Very little is known about the seismic hazard to Spokane, as there is no history of damaging earthquakes in the area. Mike Zientek of the USGS Spokane Office has informed us that geologists have long suspected that the course of the Spokane River was structurally controlled. It flows east to west toward Spokane, where it abrubtly changes to a northwest direction. Hangman Creek (sometimes called Latah Creek) flows into the Spokane River near the bend along the same NW striking lineament. This lineament is clearly expressed in the topography, paricularly along Hangman Creek, which is quite straight compared to the complex dendritic pattern more commonly displayed by other drainage in this area.

However, direct evidence for faulting is skimpy:

• At Hangman Valley Golf course flood deposits are uptilted to 35 degrees.

• Well data from either side of Hangman Creek shows elevation or thickness differences in the Grande Ronde CRB flow. However, the flow was deposited onto a Miocene landscape and it is difficult to determine whether differences result from flows interacting with the ancient landscape or from faulting.

• Likewise exposures of basalt along the near "Bowl and Pitcher" in Riverside State Park differ from what is seen at "Five Mile Prarie" across the river. Again it is difficult to pinpoint the cause of this.

Looking back at the history of EQs in the area, minor damage has been caused by events outside the immediate Spokane area (e.g. Hebgen Lake quake of 1959), and there is also a history of quakes felt only locally in Spokane.

Events felt only in and around Spokane occurred in 1915, 1920, 1922, 1941, 1942, 1948, 1952, 1961 and 1962. In some instances the shaking was accompanied by explosion-like noises, and in some cases several events close together in time were reported. No extended sequence like the current activity is known.

The Spokesman Review (copies of articles kindly provided by Mike Prager of the Spokesman Review) published stories about the 1915, 1922, 1948, and 1952 events that provide summaries of what neighborhoods the events were felt in. Each earthquake was felt most strongly at one point or another along the same NW striking lineation that appears to control the paths of Hangman Creek and the Spokane River.

TABLE 3C - Earthquakes located near Spokane during the 2nd Quarter of 2001

DATE-(UTC)-TIME	LAT(N)	LON(W)	DEPTH	MAG	FELT	COMMENTS	CIIM
01/05/24 20:34:14	47.71	117.45	0.2	2.0		6.1 km NW of Spokane, WA	
01/06/25 14:15:22	47.68	117.39	10.5	3.9	FELT	1.3 km NNE of Spokane, WA	x
01/06/25 15:01:27	47.70	117.41	11.1	3.4	FELT	3.4 km N of Spokane, WA	
01/06/25 15:05:27	47.75	117.49	1.6	1.3		11.4 km NW of Spokane, WA	
01/06/25 15:06:06	47.71	117.44	0.4	2.8		5.3 km NW of Spokane, WA	
01/06/25 15:17:52	47.73	117.46	3.5	1.9		8.2 km NNW of Spokane, WA	
01/06/25 15:40:39	47.71	117.47	2.6	1.8		7.4 km NW of Spokane, WA	
01/06/25 16:49:16	47.73	117.47	0.0	2.3	FELT	9.0 km NNW of Spokane, WA	
01/06/25 20:48:37	47.73	117.45	0.0	2.2		8.0 km NNW of Spokane, WA	
01/06/25 22:58:13	47.72	117.46	0.0	2.3	FELT	7.0 km NW of Spokane, WA	
01/06/26 01:21:21	47.75	117.48	0.0	2.1	FELT	11.4 km NNW of Spokane, WA	
01/06/26 02:04:45	47.74	117.46	3.8	1.5		9.3 km NNW of Spokane, WA	
01/06/26 05:52:26	47.75	117.48	8.0	2.4	FELT	10.9 km NW of Spokane, WA	
01/06/26 09:21:15	47.75	117.47	0.0	1.8		11.1 km NNW of Spokane, WA	
01/06/26 10:11:11	47.76	117.46	3.5	1.5		11.1 km NNW of Spokane, WA	
01/06/27 09:07:45	47.72	117.45	0.4	2.4	FELT	6.8 km NW of Spokane, WA	
01/06/27 14:45:37	47.70	117.41	7.3	2.9	FELT	4.2 km N of Spokane, WA	x
01/06/27 18:35:57	47.69	117.43	0.5	1.5		3.9 km NW of Spokane, WA	
01/06/28 07:51:42	47.69	117.43	0.5	2.1	FELT	3.6 km NW of Spokane, WA	
01/06/28 11:47:48	47.66	117.41	0.2	0.7	FELT	1.0 km WSW of Spokane, WA	
01/06/29 01:13:27	47.67	117.41	0.3	2.3	FELT	1.0 km NNW of Spokane, WA	
01/06/29 11:09:13	47.81	117.57	0.0	0.0		20.3 km NW of Spokane, WA	

Times, locations, and depths of all felt earthquakes in the PNSN region this quarter are given in Table 3A.

OTHER SOURCES OF EARTHQUAKE INFORMATION

We provide automatic computer-generated alert messages about significant Washington and Oregon earthquakes by e-mail, FAX or via the pager-based RACE system to institutions needing such information, and we regularly exchange phase data via e-mail with other regional seismograph network operators. The "Outreach Activities" section describes how to access PNSN data via e-mail, Internet, and World-Wide-Web. To request additional information by e-mail, contact seis_info@ess.washington.edu.

Earthquake information in the quarterlies has been published in final form by the Washington State Department of Natural Resources as information circulars entitled "Earthquake Hypocenters in Washington and Northern Oregon" covering the period 1970-1989 (see circulars Nos. 53, 56, 64-66, 72, 79, 82-84, and 89). These circulars, plus circular No. 85, "Washington State Earthquake Hazards", are available from Washington Dept. of Natural Resources, Division of Geology and Earth Resources, Post Office Box 47007, Olympia, WA. 98504-7007, or by telephone at (360) 902-1450.

Several excellent maps of Pacific Northwest seismicity are available. A very colorful perspective-view map (18" x 27") entitled "Major Earthquakes of the Pacific Northwest" depicts selected epicenters of strong earthquakes (magnitudes > 5.1) that have occurred in the Pacific Northwest. A more detailed full-color map is called "Earthquakes in Washington and Oregon 1872-1993", by Susan Goter (USGS Open-File Report 94-226A). It is accompanied by a companion pamphlet "Washington and Oregon Earthquake History and Hazards", by Yelin, Tarr, Michael, and Weaver (USGS Open-File Report 94-226B). The pamphlet is also available separately. Maps can be ordered from: "Earthquake Maps", U.S. Geological Survey, Box 25046, Federal Center, MS 967, Denver, CO 80225, phone (303) 273-8477. The price of each map is $12. (including US shipping and handling).

USGS Cascades Volcano Observatory has a video, "Perilous Beauty: The Hidden Dangers of Mount Rainier", about the risk of lahars from Mount Rainier. Copies are available through: North west Interpretive Association (NWIA), 909 First Avenue Suite 630, Seattle WA 98104, Telephon e: (206) 220-4141, Fax: (206) 220-4143.

Other regional agencies provide earthquake information. These include the Geological Survey of Canada (Pacific Geoscience Centre, Sidney, B.C.; (250) 363-6500, FAX (250) 363-6565), which produces monthly summaries of Canadian earthquakes; the US Geological Survey which produces weekly reports called "Seismicity Reports for Northern California" (USGS, attn: Steve Walter, 345 Middlefield Rd, MS-977, Menlo Park, CA, 94025) and "Weekly Earthquake Report for Southern California" (USGS, attn: Dr. Kate Hutton or Dr. Lucy Jones, CalTech, Pasadena, CA.).

Key to Earthquake Catalog in Table 4

TIME Origin time is calculated for each earthquake on the basis of multi-station arrival times. Time is given in **Coordinated Universal Time** (UTC), in hours:minutes:seconds. To convert to Pacific Standard Time (PST) subtract eight hours, or to Pacific Daylight Time subtract seven hours.

LAT North latitude of the epicenter, in degrees and minutes.

LONG West longitude of the epicenter, in degrees and minutes.

DEPTH The depth, given in kilometers, is usually freely calculated from the arrival-time data. In some instances, the depth must be fixed arbitrarily to obtain a convergent solution. Such depths are noted by an asterisk (*) in the column immediately following the depth. A $ or a # following the depth mean that the maximum number of iterations has been exceeded without meeting convergence tests and both the location and depth have been fixed.

MAG Coda-length magnitude M_c, an estimate of local magnitude M_L (Richter, C.F., 1958, Elementary Seismology: W.H. Freeman and Co., 768p), calculated using the coda-length/magnitude relationship determined for Washington (Crosson, R.S., 1972, Bull. Seism. Soc. Am., v. 62, p. 1133-1171). Where blank, data were insufficient for a reliable magnitude determination. Normally, the only earthquakes with undetermined magnitudes are very small ones. Magnitudes may be revised as we improve our analysis procedure.

NS/NP **NS** is the number of station observations, and **NP** the number of P and S phases used to calculate the earthquake location. A minimum of three stations and four phases are required. Generally, more observations improve the quality of the solution.

GAP Azimuthal gap. The largest angle (relative to the epicenter) containing no stations.

RMS The root-mean-square residual (observed arrival time minus predicted arrival time) at all stations used to locate the earthquake. It is only useful as a measure of the quality of the solution when 5 or more well-distributed stations are used in the solution. Good solutions are normally characterized by **RMS** values less than about 0.3 sec.

Q Two **Quality factors** indicate the general reliability of the solution (**A** is best quality, **D** is worst). Similar quality factors are used by the USGS for events located with the computer program HYPO71. The first letter is a measure of the hypocenter quality based on travel-time residuals. For example: **A** quality requires an **RMS** less than 0.15 sec while an **RMS** of 0.5 sec or more is **D** quality (estimates of the uncertainty in hypocenter location also affect this quality parameter). The second letter of the quality code depends on the spatial distribution of stations around the epicenter, i.e. number of stations, their azimuthal distribution, and the minimum distance (**DMIN**) from the epicenter to a station. Quality **A** requires a solution with 8 or more phases, **GAP** $\leq 90^\circ$ and **DMIN** $\leq$ (5 km or depth, whichever is greater). If the number of phases, **NP**, is 5 or fewer or **GAP** > 180° or **DMIN** > 50 km the solution is assigned quality **D.**

MOD The crustal velocity model used in location calculations.

- **P3** - Puget Sound model
- **C3** - Cascade model
- **S3** - Mt. St. Helens model including Elk Lake
- **N3** - northeastern model
- **E3** - southeastern model
- **O0** - Oregon model
- **K3** - Southern Oregon, Klamath Falls area model
- **R0 and J1** - Regional and Offshore models

TYP Events flagged in Table 4 use the following code:

- **F** - earthquake reported to have been felt
- **P** - probable explosion
- **L** - low frequency earthquake (e.g. glacier movement, volcanic activity)
- **H** - handpicked from helicorder records
- **S** - Special event (e.g. rockslide, avalanche, volcanic steam emission, harmonic tremor, sonic boom), not a man-made explosion or tectonic earthquake
- **X** - known explosion

TABLE 4

Tectonic Earthquakes, Magnitude 2.0 or larger, Second Quarter, 2001.

Within an area 42-49.5 degrees north latitude and 117-125.3 degrees west longitude.

Apr 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
2	05:43:58.42	47 43.49	120 03.15	2.76*	2.3	18/20	47	0.29	BB	N3	
6	09:33:30.95	46 26.49	122 19.01	11.07	2.0	32/39	48	0.15	BA	S3	
7	00:46:28.33	48 55.10	123 08.87	40.13*	2.1	5/05	320	0.11	BD	P3	
7	16:02:35.13	48 43.20	124 46.13	41.80	3.9	17/18	284	0.34	CD	P3	F
8	01:04:37.65	45 11.25	120 06.87	1.36*	2.4	10/11	164	0.25	BC	O0	
8	12:49:01.18	47 14.78	119 07.01	1.09	2.4	24/25	106	0.18	BC	N3	
10	04:40:19.11	42 22.38	122 01.78	9.09*	2.3	9/10	126	0.32	CB	K3	
13	12:34:06.49	47 40.51	120 07.00	5.59	2.3	27/30	50	0.27	BC	N3	
14	07:21:57.67	47 36.05	121 57.07	10.96	2.2	43/43	41	0.19	BA	P3	
16	14:50:01.88	46 51.09	121 45.57	0.94#	2.4	35/38	59	0.20	BA	C3	
16	18:44:50.79	46 51.19	121 45.56	1.17*	2.2	30/33	78	0.16	BA	C3	
20	01:18:24.13	48 22.26	124 47.81	36.12	2.2	10/14	260	0.26	BD	P3	
23	08:33:53.72	46 53.84	120 51.32	5.41	2.0	24/25	66	0.34	CC	C3	
24	03:36:15.98	46 55.13	121 33.40	3.09	2.2	42/45	57	0.35	CB	C3	
24	13:21:29.90	46 37.77	120 35.38	13.48$	2.6	44/46	32	0.39	CA	E3	
24	13:37:48.34	46 28.90	122 18.58	19.04	2.3	42/42	35	0.18	BA	S3	
24	17:39:46.89	46 38.64	120 34.49	9.77$	2.2	26/26	69	0.32	CB	E3	
25	20:50:07.46	48 46.37	119 01.70	0.70$	2.6	15/18	147	0.58	DD	N3	
26	05:48:45.50	46 12.59	122 40.32	18.28	2.0	22/24	132	0.13	AB	C3	

May 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
4	05:28:10.32	45 07.42	120 56.80	19.15	2.2	10/10	92	0.12	AB	O0	
4	05:34:26.62	49 01.86	119 14.26	0.02*	2.1	6/07	286	0.18	BD	N3	
6	15:11:06.86	45 15.04	123 31.75	54.22	2.7	38/38	166	0.22	BC	O0	
8	15:03:19.19	46 20.61	122 20.93	17.80*	2.0	26/28	75	0.12	AA	S3	
10	20:51:34.21	42 11.85	124 26.87	31.35$	2.6	7/07	236	0.29	DD	K3	
11	06:25:54.83	47 13.75	119 20.90	11.06	3.3	35/35	81	0.26	BC	N3	
14	12:54:12.73	47 37.80	119 41.60	12.65$	2.6	21/26	78	0.15	AB	N3	
15	04:31:04.47	48 14.36	122 19.36	17.25	2.0	24/32	64	0.23	BB	P3	
19	16:18:39.83	47 39.83	122 08.02	6.73	2.1	34/34	45	0.13	AB	P3	
24	20:34:14.99	47 42.97	117 27.13	0.24#	2.0	7/10	206	0.26	BD	N3	
31	01:18:39.05	45 11.82	120 05.72	2.85	2.0	21/27	205	0.32	CD	O0	

June 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
2	12:31:04.42	47 42.79	123 52.40	0.02*	2.4	30/33	79	0.24	BC	P3	
2	17:08:00.70	45 15.95	123 07.76	30.92	2.3	35/37	124	0.22	BB	O0	
4	06:07:44.62	43 31.21	121 44.11	10.10$	2.1	14/14	160	0.19	CD	O0	
6	14:52:19.84	47 44.85	120 32.24	12.63	2.3	20/20	65	0.54	DA	C3	
7	12:15:22.57	48 29.56	124 21.92	39.98	2.9	16/16	208	0.15	BD	P3	
7	12:45:42.64	46 57.74	119 31.06	20.08	2.6	27/29	51	0.13	AA	E3	
10	13:19:11.29	47 10.04	123 30.15	40.71$	5.0	99/**	89	0.29	BA	P3	F
15	08:53:29.33	45 12.10	120 06.45	0.02*	2.5	15/16	171	0.24	BC	O0	
17	15:41:32.46	47 36.44	122 35.69	22.93	2.2	45/46	49	0.13	AA	P3	
18	06:49:54.26	45 11.38	120 06.61	0.03*	2.6	17/17	172	0.36	CC	O0	
21	06:46:09.62	46 42.98	121 50.87	7.36	2.1	46/47	39	0.16	BA	C3	
21	19:45:38.72	48 45.53	122 44.70	2.07	2.3	23/28	144	0.27	BC	P3	
25	14:15:22.97	47 40.91	117 23.82	10.52	3.9	19/19	205	0.29	BD	N3	F
25	15:01:27.71	47 42.10	117 24.68	11.14	3.4	18/18	203	0.51	DD	N3	F
25	15:06:06.85	47 42.62	117 26.80	0.43$	2.8	13/14	200	0.54	DD	N3	
25	16:49:16.71	47 44.33	117 28.29	0.03*	2.3	9/09	205	0.29	BD	N3	F
25	20:48:37.07	47 44.05	117 27.39	0.03*	2.2	12/14	141	0.50	CD	N3	
25	22:58:13.57	47 43.36	117 27.62	0.03#	2.3	14/14	142	0.56	DD	N3	F
26	01:21:21.37	47 45.43	117 29.25	0.02*	2.1	5/07	213	0.24	BD	N3	F
26	05:52:26.63	47 45.13	117 29.25	8.02	2.4	14/15	194	0.64	DD	N3	F
27	09:07:45.96	47 43.23	117 27.56	0.36$	2.4	18/21	135	0.45	DD	N3	F
27	14:45:37.91	47 42.55	117 24.83	7.27	2.9	18/20	203	0.74	DD	N3	F

June 2001 cont'd

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
28	07:51:42.14	47 41.71	117 26.32	0.52#	2.1	6/06	143	0.59	DC	N3	F
29	01:13:27.70	47 40.78	117 24.70	0.29$	2.3	4/06	195	0.51	DD	N3	F
30	01:23:31.81	46 51.34	121 58.36	7.66	3.3	65/66	25	0.26	BB	C3	F

QUARTERLY NETWORK REPORT 2001-C
on
Seismicity of Washington and Oregon

July 1 through September 30, 2001

Pacific Northwest Seismograph Network
Dept. of Earth and Space Sciences
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This report is prepared as a preliminary description of the seismic activity in Washington State and Oregon. Information contained in this report should be considered preliminary, and not cited for publication without checking directly with network staff. The views and conclusions contained in this document should not be interpreted as necessarily representing the official policies, either express or implied, of the U.S. Government.

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INTRODUCTION

This is the third quarterly report of 2001 from the University of Washington Dept. of Earth and Space Sciences *Pacific Northwest Seismograph Network* (PNSN), covering seismicity of Washington and western Oregon.

Comprehensive quarterlies have been produced by the PNSN since the beginning of 1984. Prior to that we published quarterly reports for western Washington in 1983 and for eastern Washington from 1975 to 1983. Annual technical reports covering seismicity in Washington since 1969 are available from the U.W. Dept. of Earth and Space Sciences. Beginning in 1999, the quarterly PNSN catalog listing changed; earthquakes smaller than magnitude 2.0 are no longer listed in the quarterly reports. The complete PNSN catalog is available on-line, both through our web-site and through the CNSS catalog. We will continue to provide special coverage (figures, counts, listings, etc.) of earthquake swarms, aftershock sequences, etc.

This quarterly report discusses network operations, seismicity of the region, unusual events or findings, and our educational and outreach activities. This report is preliminary, and subject to revision. The PNSN routinely records signals from selected stations in adjoining networks. This improves our ability to locate earthquakes at the edges of our network. However, our earthquake locations may be revised if new data become available. Findings mentioned in these quarterly reports should not be cited for publication.

NETWORK OPERATIONS

Figure 1A shows a map view of stations operating during the quarter. Figure 1B is a more detailed view of stations in the Puget Sound area. Table 1B gives approximate periods of time when individual stations were inoperable. Data for Table 1B are compiled from weekly plots of network-wide teleseismic arrivals and automated and manual digital and analog signal checks, plus records of maintenance and repair visits. This quarter was a busy one, as we engaged in an ambitious season of strong-motion and CREST station installations. Details of these installations are given below.

Strong Motion Instrumentation and Recording Update

The PNSN strong-motion team has completed installation of twenty new ANSS strong-motion instruments in the greater Puget Sound Region during FY 2001, including 17 stations in the third quarter and 3 in the second quarter. Five of these stations are "free-field", the others are "reference". The new installations brings our strong motion total to 41 ANSS stations and 13 older stations. The station density is now comparable to that in southern California in 1998 when ShakeMap was started.

CREST Instrument Update

CREST (Consolidated Reporting of EarthquakeS and Tsumamis) instrumentation temporarily installed in Spokane (SPUD) was removed on Sept. 25, and is slated for installation at Forks, Washington at the beginning of the fourth quarter.

The Bonneville Power Administration (BPA) has agreed to site and provide telemetry for four CREST stations at BPA power substations near the coast (3 along the Oregon coast, and one in southwestern Washington). BPA completed site preparation work at these four sites by the end of September.

The Washington State Patrol has agreed to provide a site and part of the telemetry path for a CREST station at Boistfort Peak in southwestern Washington. However, the telemetry between the terminus of the State Patrol/Dept of Transportation communication system and the University of Washington is still being worked out.

Temporary Spokane Stations

At the beginning of July, following unusual seismicity in the Spokane urban area, Tom Yelin of the USGS, and UW graduate students Guy Medema and Josh Jones installed five short-period three-component PASSCAL instruments in a perimeter around Spokane. Temporary Spokane station locations are listed in Table 1C. Sites were located at private residences. No prior permissions had been given so sites were found by knocking on doors and asking. In general, residents were very willing to allow instruments to be placed on their property, including the use of their line power. The PASSCAL stations had GPS timing and recorded continuously, but had no telemetry. Data were downloaded manually, and extensive reformatting was required in order to make the data compatible with UW data and analysis programs. All five stations were set to 100 samples/sec and 16-bit resolution. The seismometers had a natural frequency of 2 Hz, and

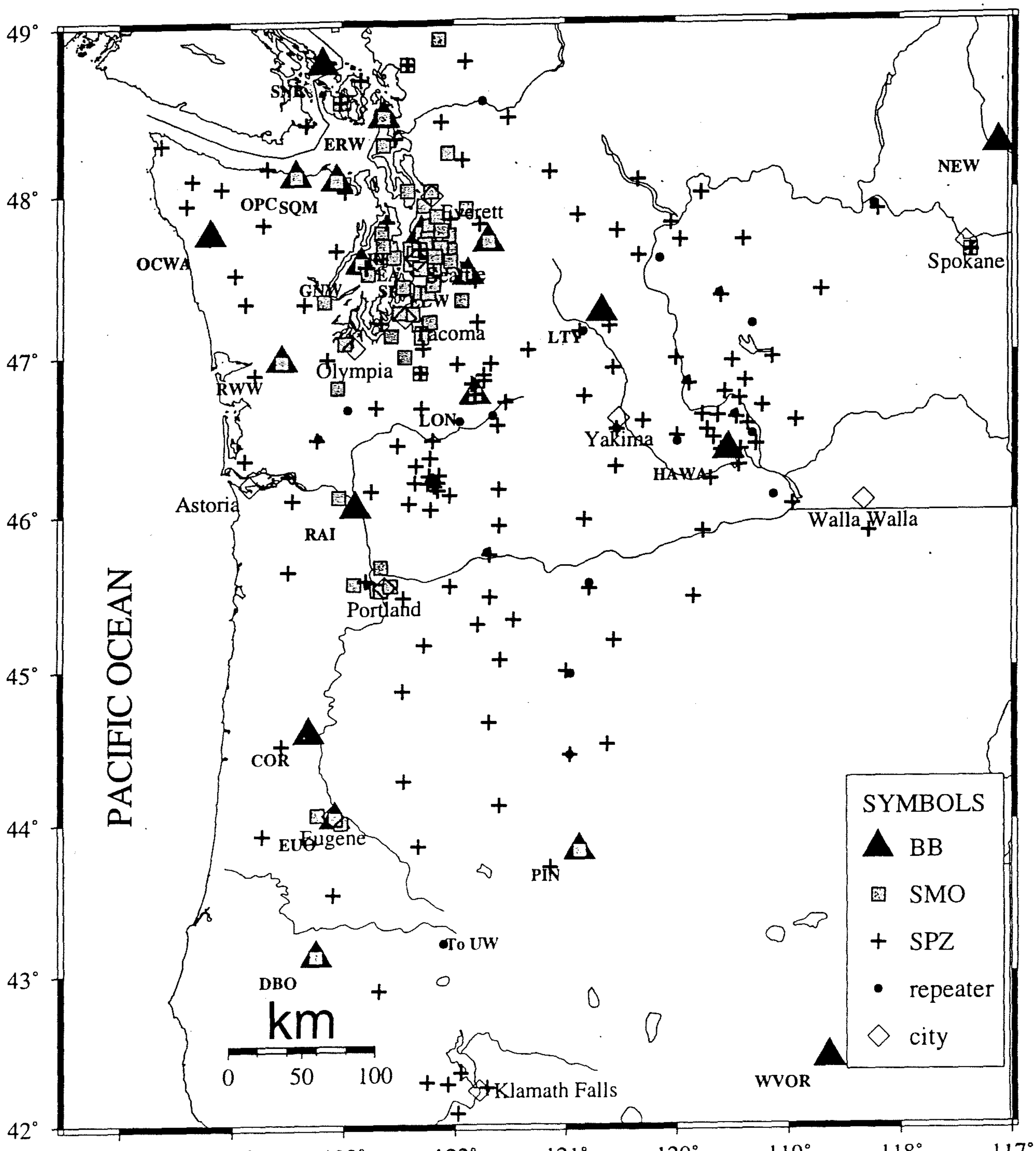

Figure 1A. Stations operating at the end of 3rd quarter, 2001. Stations shown are short period vertical (SPZ), 3-component broadband (BB), or strong motion (SMO).

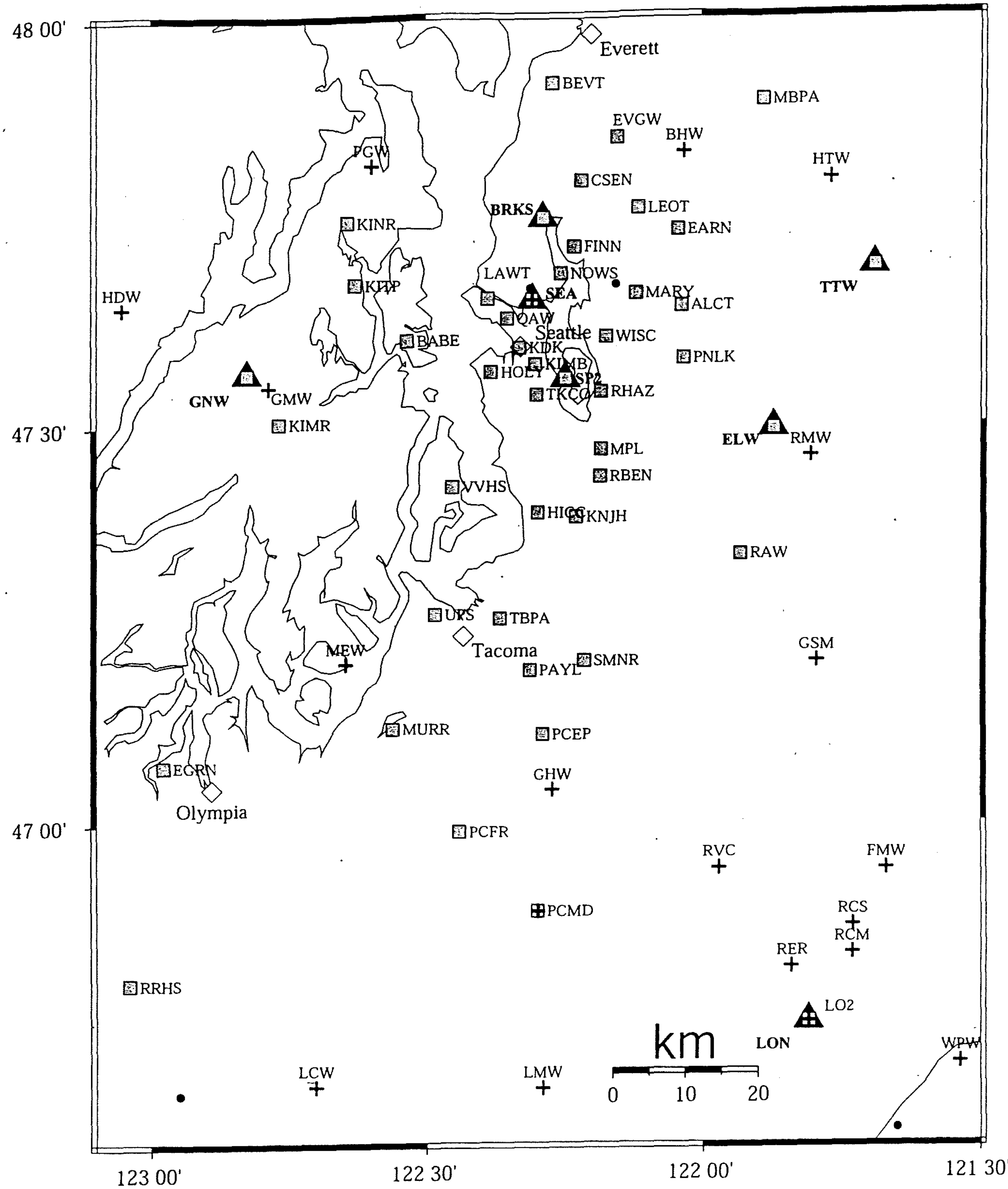

Figure 1B. Stations operating at the end of 3rd quarter, 2001. Detail of Figure 1A.

were 3-D Mark Products L-22 instruments. Stations 1, 2 and 3 had gain=128x, and stations 4 and 5 had gain=32 x. These stations were removed on July 24 and 25. See Table 1C for locations and operation dates.

Station SPUD (also temporary), a CREST-type station with 3 BB components and 3 strong-motion components, operated at the Public Utilities Bldg. from June 26-Sept. 25. SPUD had Internet telemetry, but lacked external reference GPS timing and relied on its internal clock to time-stamp data. Permanent station SFER was installed at Spokane's Ferris High School in August. See Table 1C for location and operation dates.

Other news about stations, operations, and personnel

Last spring we conducted a national search for a network engineer, who began work in early September. Unfortunately our new hire reconsidered after a close look at the cost of living in Seattle, and quit before the end of the month. Jim Ramey, our previous head electronics engineer, retired at the end of April and is currently working on a part-time basis. The current plan is to cover the engineer position with a rearrangement of, and additional training for, other network technical staff.

A new three-component short-period station (HUO) became operational in early July at Husband, OR following the report (in May) of ground uplift about 5 km west of South Sister volcano in the Three Sisters region of the central Oregon Cascade Range. A "Three Sisters" link has been added to the PNSN "Cascade Volcano Information" page to provide links to research and daily updates on seismicity in the area. The Three Sisters region generally has very low seismicity. The closest short-period station to the area, TCO, was repaired at the beginning of July. The seismometer was replaced. The station had been marginal for some time, but the low rate of activity makes it difficult to pinpoint a failure date. TCO is a noisy site, located in trees next to a road. It is also a target (as in "target practice") for vandalism. In other Oregon station news, short period station BUO was installed in July to replace station VRC, which had been removed due to vandalism.

In Washington station news, a new station (GPW) was installed in the Cascades on Glacier Peak. A helicopter lift of the heavy/awkward parts of the station was authorized by a special permit of the U.S. Forest service Four PNSN staff hiked in to the site to complete the installation during a three day trip in early September. Another difficult-to-access station, RCS on Mount Rainier, also required a visit from a hiking party and a near-total replacement of components.

Data Recording and EARTHWORM Update

This quarter, *scossa* remained our main EARTHWORM computer, with *milli* serving as our primary backup and *verme* as the secondary backup. *Milli* and *verme* still serve as the principal computers for data acquisition for many of the digital stations. We are currently running EARTHWORM-V5.1.

The SUNWORM digitizer for *wiggles*, our backup system, began to have problems last year and earlier this year we received an official Intel-based EARTHWORM digitizer running under Windows NT. This quarter, we worked on the wiring configuration needed for the new digitizer.

TABLE 1A
ANSS Strong Motion Station Installations 3rd quarter 2001

Installed Station	Install Date	Comments
ATES	9/6/01	Installed (ANSS Strong Motion Station)
BABE	7/31/01	Installed (ANSS Strong Motion Station)
EGRN	7/10/01	Installed (ANSS Strong Motion Station)
EVCC	8/28/01	Installed (ANSS Strong Motion Station)
EVGW	7/12/01	Installed (ANSS Strong Motion Station)
KDK	9/27/01	Installed (ANSS Strong Motion Station)
KICC	8/30/01	Installed (ANSS Strong Motion Station)
KNJH	7/9/01	Installed (ANSS Strong Motion Station)
MBKE	7/19/01	Installed (ANSS Strong Motion Station)
OHC	7/26/01	Installed (ANSS Strong Motion Station)
SFER	8/9/01	Installed (ANSS Strong Motion Station)
SMNR	7/17/10	Installed (ANSS Strong Motion Station)
SVOH	9/14/01	Installed (ANSS Strong Motion Station)
SWID	7/23/01	Installed (ANSS Strong Motion Station)
UWFH	8/2/01	Installed (ANSS Strong Motion Station)
VVHS	9/20/01	Installed (ANSS Strong Motion Station)

TABLE 1B
Station Outages, Repairs, and Installations 3rd quarter 2001

Station	Outage Dates	Comments
BOW	12/01/00-End	Dead because air cells have run down
BUO	7/25/01	Installed (Short-period vertical; equipment from VRC)
ELL	3/16/01-7/17/01	Began working
FL2	7/01-8/1/01	Seismometer cable repaired (chewed by animal)
GPW	9/10/01	Installed
HICC	8/10/01	Replaced K2 (ANSS Strong Motion Station)
JUN	4/1/01-8/1/01	Seismometer replaced
LVP	8/01-9/29/01	Seismometer replaced
MARY	7/27/01	Lantronix replaced because of communication loss
NLO	12/1/00-End	Dead
OCP	7/01-End	Dead
OTR	7/12/01	Rebuilt station (new VCO, seismometer, and batt)
RCM	8/20/01-End	Seismically dead
RCS	5/1/01-9/7/01	Replaced VCO & Seismometer
RSU	9/30/00-End	Dead
SFER	8/9/01	Permanent Spokane station INSTALLED
SPUD	9/26/01	Temporary Spokane station REMOVED
SSO	9/00-End	Intermittent, mostly dead
TCO	5/1/00??-7/1/01	Seismometer changed
WPW	5/15/01-End	Dead

TABLE 1C - Locations and Operating Dates of Temporary and Permanent Stations in the Spokane Area

STA	LAT	LONG	EL	NAME	DATES
SPUD	47 39 54.3	117 25 35.2	-	Spokane County Pub Works, Temp	6/26/01-9/25/01
SPK1	47 44 02.2	117 25 53.2	-	Spokane Temp 6047	7/1/01-7/13/01
SPK2	47 42 11.2	117 19 16.0	-	Spokane Temp 6127	7/1/01-7/24/01
SPK3	47 38 36.2	117 22 55.2	-	Spokane Temp 6132	7/1/01-7/24/01
SPK4	47 41 28.8	117 30 36.0	-	Spokane Temp 6085	7/2/01-7/25/01
SPK5	47 46 46.3	117 27 49.8	-	Spokane Temp 6128	7/2/01- 7/19/01
SFER	47 37 10.4	117 21 55.7	-	Ferris High School Permanent	8/9/01-

STATIONS USED FOR LOCATION OF EVENTS

Table 2A lists short-period, mostly vertical-component stations used in locating seismic events in Washington and Oregon. The first column in the table gives the 3-letter station designator, followed by a symbol designating the funding agency; stations marked by a percent sign (%) were supported by USGS joint operating agreement 01-HQ-AG-0011. A plus (+) indicates support under Pacific Northwest National Laboratory, Battelle contract 259116-A-B3. Stations designated "#" are USGS-maintained stations recorded at the PNSN. Stations designated by letters are operated by other networks, and telemetered to the PNSN. "M" stations are received from the Montana Bureau of Mines and Geology, "C" stations from the Canadian Pacific Geoscience Center, "U" stations from the US Geological Survey (ususally USNSN stations), "N" stations from the USGS Northern California Network, and "H" stations from the Hanford Reservation via the Pacific Northwest National Labs. Other designation indicate support from other sources. Additional columns give station north latitude and west longitude (in degrees, minutes and seconds), station elevation in km, and comments indicating landmarks for which stations were named.

Table 2B lists broad-band stations used in locating seismic events in Washington and Oregon, and Table 2C lists strong-motion stations.

TABLE 2A - Short-period Stations operated by the PNSN during the third quarter 2001

STA	F	LAT	LONG	EL	NAME
ASR	%	46 09 09.9	121 36 01.6	1.357	Mt. Adams - Stagman Ridge
AUG	%	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BBO	%	42 53 12.6	122 40 46.6	1.671	Butler Butte, Oregon
BEN	H	46 31 12.0	119 43 18.0	0.335	PNNL station
BHW	%	47 50 12.6	122 01 55.8	0.198	Bald Hill
BLN	%	48 00 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	%	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
BPO	%	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
BRO	%	44 16 02.5	122 27 07.1	0.135	Big Rock Lookout, Oregon
BRV	+	46 29 07.2	119 59 28.2	0.920	Black Rock Valley
BSMT	M	47 51 04.8	114 47 13.2	1.950	Bassoo Peak, MT
BUO	%	42 16 42.5	122 14 43.1	1.797	Burton Butte, Oregon
BVW	+	46 48 39.5	119 52 56.4	0.670	Beverly
CBS	+	47 48 17.4	120 02 30.0	1.067	Chelan Butte, South
CDF	%	46 07 01.4	122 02 42.1	0.756	Cedar Flats
CHMT	M	46 54 51.0	113 15 07.0	-	Chamberlain Mtn, MT
CMM	%	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
CMW	%	48 25 25.3	122 07 08.4	1.190	Cultus Mtns.
CPW	%	46 58 25.8	123 08 10.8	0.792	Capitol Peak
CRF	+	46 49 30.0	119 23 13.2	0.189	Corfu
DPW	+	47 52 14.3	118 12 10.2	0.892	Davenport
DY2	+	47 59 06.6	119 46 16.8	0.890	Dyer Hill 2
EDM	%	46 11 50.4	122 09 00.0	1.609	East Dome, Mt. St. Helens
ELK	%	46 18 20.0	122 20 27.0	1.270	Elk Rock
ELL	+	46 54 34.8	120 33 58.8	0.789	Ellensburg
EPH	+	47 21 22.8	119 35 45.6	0.661	Ephrata
ET3	+	46 34 38.4	118 56 15.0	0.286	Eltopia (replaces ET2)
ETW	+	47 36 15.6	120 19 56.4	1.477	Entiat
FHE	+	46 57 06.9	119 29 49.0	0.455	Frenchman Hills East
FL2	%	46 11 47.0	122 21 01.0	1.378	Flat Top 2
FMW	%	46 56 29.6	121 40 11.3	1.859	Mt. Fremont
GBB	H	46 36 31.8	119 37 40.2	0.185	PNNL Station
GBL	+	46 35 54.0	119 27 35.4	0.330	Gable Mountain
GHW	%	47 02 30.0	122 16 21.0	0.268	Garrison Hill
GL2	+	45 57 35.0	120 49 22.5	1.000	New Goldendale
GLK	%	46 33 27.6	121 36 34.3	1.305	Glacier Lake
GMO	%	44 26 20.8	120 57 22.3	1.689	Grizzly Mountain, Oregon
GMW	%	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GSM	%	47 12 11.4	121 47 40.2	1.305	Grass Mt.
GUL	%	45 55 27.0	121 35 44.0	1.189	Guler Mt.
H2O	H	46 23 45.0	119 25 22.0	-	Water PNNL Station
HAM	%	42 04 08.3	121 58 16.0	1.999	Hamaker Mt., Oregon
HBO	%	43 50 39.5	122 19 11.9	1.615	Huckleberry Mt., Oregon
HDW	%	47 38 54.6	123 03 15.2	1.006	Hoodsport
HOG	%	42 14 32.7	121 42 20.5	1.887	Hogback Mtn., Oregon
HSO	%	43 31 33.0	123 05 24.0	1.020	Harness Mountain, Oregon
HSR	%	46 10 28.0	122 10 46.0	1.720	South Ridge, Mt. St. Helens
HTW	%	47 48 14.2	121 46 03.5	0.833	Haystack Lookout
HUO	%	44 07 10.9	121 50 53.5	2.037	Husband OR (UO)
JBO	+	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JCW	%	48 11 42.7	121 55 31.1	0.792	Jim Creek
JUN	%	46 08 50.0	122 09 04.4	1.049	June Lake
KEB	N	42 52 20.0	124 20 03.0	0.818	CAL-NET
KMO	%	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	%	46 27 46.7	122 11 41.3	0.610	Kosmos
KSX	N	41 49 51.0	123 52 33.0	-	CAL-NET
KTR	N	41 54 31.2	123 22 35.4	1.378	CAL-NET
LAB	%	42 16 03.3	122 03 48.7	1.774	Little Aspen Butte, Oregon
LAM	N	41 36 35.2	122 37 32.1	1.769	CAL-NET
LCCM	M	45 50 16.8	111 52 40.8	1.669	Lewis and Clark Caverns, MT
LCW	%	46 40 14.4	122 42 02.8	0.396	Lucas Creek
LMW	%	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
LNO	+	45 52 18.6	118 17 06.6	0.771	Lincton Mt., Oregon
LO2	%	46 45 00.0	121 48 36.0	0.853	Longmire
LOC	+	46 43 01.2	119 25 51.0	0.210	Locke Island
LVP	%	46 03 59.4	122 24 10.2	1.134	Lakeview Peak
MBW	%	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCMT	M	44 49 39.6	112 50 55.8	2.323	McKenzie Canyon, MT
MCW	%	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MDW	+	46 36 47.4	119 45 39.6	0.330	Midway
MEW	%	47 12 07.0	122 38 45.0	0.097	McNeil Island
MJ2	+	46 33 27.0	119 21 32.4	0.146	May Junction 2
MOX	+	46 34 38.4	120 17 53.4	0.501	Moxie City
MPO	%	44 30 17.4	123 33 00.6	1.249	Mary's Peak, Oregon
MTM	%	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
MURR	%	47 07 12.0	122 33 36.0	0.100	Camp Murry ANSS-SMO
NAC	+	46 43 59.4	120 49 25.2	0.728	Naches
NCO	%	43 42 14.4	121 08 18.0	1.908	Newberry Crater, Oregon
NEL	+	48 04 12.6	120 20 24.6	1.500	Nelson Butte
NLO	%	46 05 21.9	123 27 01.8	0.826	Nicolai Mt., Oregon
OBC	%	48 02 07.1	124 04 39.0	0.938	Olympics - Bonidu Creek
OBH	%	47 19 34.5	123 51 57.0	0.383	Olympics - Burnt Hill
OCP	%	48 17 53.5	124 37 30.0	0.487	Olympics - Cheeka Peak
OD2	+	47 23 15.6	118 42 34.8	0.553	Odessa site 2
OFR	%	47 56 00.0	124 23 41.0	0.152	Olympics - Forest Resource Cen
OHW	%	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ON2	%	46 52 50.8	123 46 51.8	0.257	Olympics - North River
OOW	%	47 44 03.6	124 11 10.2	0.561	Octopus West
OSD	%	47 48 59.2	123 42 13.7	2.008	Olympics - Snow Dome
OSR	%	47 30 20.3	123 57 42.0	0.815	Olympics Salmon Ridge
OT3	+	46 40 08.4	119 13 58.8	0.322	New Othello (replaces OT2 8/26
OTR	%	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PAT	+	45 52 55.2	119 45 08.4	0.262	Paterson
PCMD	%	46 53 20.9	122 18 00.9	0.239	PC Mountain Detachment SMUT-SM
PGO	%	45 27 42.6	122 27 11.5	0.253	Gresham, Oregon
PGW	%	47 49 18.8	122 35 57.7	0.122	Port Gamble
PRO	+	46 12 45.6	119 41 08.4	0.553	Prosser
RCM	%	46 50 08.9	121 43 54.4	3.085	Mt. Rainier, Camp Muir
RCS	%	46 52 15.6	121 43 52.0	2.877	Mt. Rainier, Camp Schurman

TABLE 2A continued

STA	F	LAT	LONG	EL	NAME
RED	H	46 17 51.0	119 26 15.6	0.330	Red Mountain PNNL Station
RER	%	46 49 09.2	121 50 27.3	1.756	Mt. Rainier, Emerald Ridge
RMW	%	47 27 35.0	121 48 19.2	1.024	Rattlesnake Mt. (West)
RNO	%	43 54 58.9	123 43 25.5	0.850	Roman Nose, Oregon
RPW	%	48 26 54.0	121 30 49.0	0.850	Rockport
RRHS	%	46 47 58.6	123 02 25.4	0.047	Rochester HS ANSS-SMO
RSU	%	46 51 12.0	121 45 47.0	4.440	Rainier summit
RSW	+	46 23 40.2	119 35 28.8	1.045	Rattlesnake Mt. (East)
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
RVN	%	47 01 38.6	121 20 11.9	1.885	Raven Roost (former NEHRP temp
RVW	%	46 08 53.2	122 44 32.1	0.460	Rose Valley
SAW	+	47 42 06.0	119 24 01.8	0.701	St. Andrews
SBES	%	48 46 05.9	122 24 54.2	0.119	Silver Beach ES SMO
SEA	%	47 39 15.8	122 18 29.3	0.030	UW, Seattle (Wood Anderson BB
SEP	#	46 12 00.7	122 11 28.1	2.116	September lobe, Mt. St. Helens
SFER	%	47 37 10.4	117 21 55.7	-	Spokane Schools, Ferris High School
SHW	%	46 11 37.1	122 14 06.5	1.425	Mt. St. Helens
SLF	%	47 45 32.0	120 31 40.0	1.750	Sugar Loaf
SMW	%	47 19 10.7	123 20 35.4	0.877	South Mtn.
SNI	H	46 27 80.0	119 39 50.0	-	PNNL station
SOS	%	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
SSO	%	44 51 21.6	122 27 37.8	1.242	Sweet Springs, Oregon
STD	%	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	%	48 09 03.1	123 40 11.1	0.308	Striped Peak
TBM	+	47 10 12.0	120 35 52.8	1.006	Table Mt.
TCO	%	44 06 27.6	121 36 02.1	1.975	Three Creek Meadows, Oregon.
TDH	%	45 17 23.4	121 47 25.2	1.541	Tom,Dick,Harry Mt., Oregon
TDL	%	46 21 03.0	122 12 57.0	1.400	Tradedollar Lake
TRW	+	46 17 32.0	120 32 31.0	0.723	Toppenish Ridge
TWW	+	47 08 17.4	120 52 06.0	1.027	Teanaway
UWFH	%	48 32 46.0	123 00 43.0	0.010	UW Friday Harbor SMUT-SMO
VBE	%	45 03 37.2	121 35 12.6	1.544	Beaver Butte, Oregon
VCR	%	44 58 58.2	120 59 17.4	1.015	Criterion Ridge, Oregon
VDB	C	49 01 34.0	122 06 10.1	0.404	Canada
VFP	%	45 19 05.0	121 27 54.3	1.716	Flag Point, Oregon
VG2	%	45 09 20.0	122 16 15.0	0.823	Goat Mt., Oregon
VGB	+	45 30 56.4	120 46 39.0	0.729	Gordon Butte, Oregon
VGZ	C	48 24 50.0	123 19 27.8	0.067	Canada
VIP	%	44 30 29.4	120 37 07.8	1.731	Ingram Pt., Oregon
VLL	%	45 27 48.0	121 40 45.0	1.195	Laurance Lk., Oregon
VLM	%	45 32 18.6	122 02 21.0	1.150	Little Larch, Oregon
VSP	%	42 20 30.0	121 57 00.0	1.539	Spence Mtn, Oregon
VT2	+	46 58 02.4	119 59 57.0	1.270	Vantage2
VTH	%	45 10 52.2	120 33 40.8	0.773	The Trough, Oregon
WA2	+	46 45 19.2	119 33 56.4	0.244	Wahluke Slope
WAT	+	47 41 55.2	119 57 14.4	0.821	Waterville
WIB	%	46 20 34.8	123 52 30.6	0.503	Willapa Bay
WIW	+	46 25 45.6	119 17 15.6	0.128	Wooded Island
WPO	%	45 34 24.0	122 47 22.4	0.334	West Portland, Oregon
WPW	%	46 41 55.7	121 32 10.1	1.280	White Pass
WRD	+	46 58 12.0	119 08 41.4	0.375	Warden
WRW	%	47 51 26.0	120 52 52.0	1.189	Wenatchee Ridge
YA2	+	46 31 36.0	120 31 48.0	0.652	Yakima
YEL	#	46 12 35.0	122 11 16.0	1.750	Yellow Rock, Mt. St. Helens
YPT	+	46 02 55.8	118 57 44.0	0.325	Yellepit

TABLE 2B

Broad-band three-component stations operating at the end of the third quarter 2001. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME
BRKS	%	47 45 19.1	122 17 17.9	0.020	Brookside Sch. (vertical BB only) ANSS-SMO
COR	U	44 35 08.5	123 18 11.5	0.121	Corvallis, Oregon (IRIS station, Operated by OSU)
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon (CREST - operated by UO)
ELW	%	47 29 38.8	121 52 21.6	0.267	Echo Lake, WA (operated by UW)
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie, WA (operated by UW)
EUO	%	44 01 45.7	123 04 08.2	0.160	Eugene,OR UO CREST BB SMO
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mountain, WA (CREST - operated by UW)
HAWA	U	46 23 32.3	119 31 57.2	0.367	Hanford Nike (USGS-USNSN)
HLID	U	43 33 45.0	114 24 49.3	1.772	Hailey, ID (USGS-USNSN)
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire (CREST - operated by UW)
LTY	%	47 15 21.2	120 39 53.3	0.970	Liberty, WA (operated by UW)
NEW	U	48 15 50.0	117 07 13.0	0.760	Newport Observatory (USGS-USNSN)
OCWA	U	47 44 56.0	124 10 41.2	0.671	Octopus Mtn. (USGS-USNSN)
OPC	%	48 06 01.0	123 24 41.8	0.090	Olympic Penn College CREST BB
PIN	%	43 48 40.0	120 52 19.0	1.865	Pine Mt. Oregon (CREST - operated by UO)
PNT	C	49 18 57.6	119 36 57.6	0.550	Canada, BB
RAI		46 02 25.1	122 53 06.4	1.520	Trojan Plant, Oregon (OSU)
RWW	%	46 57 50.1	123 32 35.9	0.015	Ranney Well (CREST - operated by UW)
SEA	%	47 39 15.8	122 18 29.3	0.030	UW, Seattle (Wood Anderson BB)
SNB	C	48 46 33.6	123 10 16.3	0.408	Canada
SP2	%	47 33 23.3	122 14 52.8	0.030	Seward Park, Seattle (operated by UW)
SPUD	%	47 39 54.3	117 25 35.2	-	Spokane County Pub Works, temporary
SQM	%	48 04 39.0	123 02 44.0	0.030	Sequim (operated by UW, telemetered by Battelle)
TTW	%	47 41 40.7	121 41 20.0	0.542	Tolt Reservoir, WA (CREST - operated by UW)
WVOR	U	42 26 02.0	118 38 13.0	1.344	Wildhorse Valley, Oregon (USGS-USNSN)

Table 2C lists strong-motion, three-component stations operating in Washington and Oregon that provide data in real or near-real time to the PNSN. Several of these stations also have broad-band instruments, as noted. The "SENSOR" field designates what type of seismic sensor is used;

- A = Terra-Tech SSA-320 SLN triaxial accelerometer/Terra-Tech IDS24
- A20 = Terra-Tech SSA-320 triaxial accelerometer/Terra-Tech IDS20 recording system,
- FBA23 = Kinemetrics FBA23 accelerometers and Reftek recording system,
- EPI = Kinemetrics Episensor accelerometers and Reftek recording system.
- BB = Guralp CMG-40T 3-D broadband velocity sensor.
- BB3 = Guralp CMG3T 3-D broadband velocity sensor.
- BBZ = Broad Band sensor, PMD 2024, vertical component only.
- K2 = Kinemetrics Episensor accelerometers and K2 Recording System

The "TELEMETRY" field indicates the type of telemetry used to recover the data.

- D = dial-up,
- L = continuously telemetered via dedicated lease-line telephone lines,
- L-PPP = continuously telemetered via dedicated lease-line telephone lines using PPP protocol
- I = continuously telemetered via Internet,
- E = continuously telemetered via Internet from a remote EARTHWORM system

TABLE 2C

Strong-motion three-component stations operating at the end of the third quarter 2001. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME	SENSORS	TELEMETRY
ALCT	%	47 38 48.8	122 2 15.7	0.055	Alcott Elementary	K2	I
ALST	%	46 6 32.3	123 1 58.5	0.198	Alston	A20	E,M
ALVY	%	43 59 53.2	123 0 57.0	0.155	Alvey	K2	E,M
ATES	%	48 14 10.9	122 3 33.0	0.010	Trafton Elementary	K2	I
BABE	%	47 36 21.0	122 32 7.0	0.010	Blakely Elementary	K2	I
BEVT	%	47 55 12.0	122 16 12.0	0.170	Boeing Plant Everett	K2	I
BRKS	%	47 45 19.1	122 17 17.9	0.020	Brookside Elementary	K2,BBZ	I
CSEN	%	47 48 4.5	122 13 6.5	0.055	Crystal Springs Elementary	K2	I
CSO	#	45 31 1.0	122 41 22.5	0.036	Canyon	FBA23	D
DBO	%	43 7 9.0	123 14 34.0	0.984	Dodson Butte (CREST)	EPI,BB3	E,L-PPP
EARN	%	47 44 27.2	122 2 37.7	0.159	East Ridge Elementary	K2	I
EGRN	%	47 4 24.0	122 58 41.0	0.010	Evergreen State College	K2	None
ELW	%	47 29 39.4	121 52 17.2	0.267	Echo Lake	A,BB	D,M,L
ERW	%	48 27 14.4	122 37 30.2	0.389	Mount Erie	A,BB	D,L,M
EUO	%	44 1 45.7	123 4 8.2	0.160	Eugene (CREST)	EPI,BB3	E,L-PPP
EVCC	%	48 0 27.0	122 12 15.3	0.000	Everett Community College	K2	None
EVGW	%	47 51 15.8	122 9 12.2	0.010	Gateway Middle School	K2	I
FINN	%	47 43 10.2	122 13 55.9	0.121	Finn Hill Junior High	K2	I
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mountain (CREST)	EPI,BB3	L-PPP
HAO	#	45 30 33.1	122 39 24.0	0.018	Harrison	FBA23	D
HICC	%	47 23 24.4	122 17 52.4	0.115	Highline Community College	K2	I
HOLY	%	47 33 55.4	122 23 1.0	0.106	Holy Rosary School	K2	I
KDK	%	47 35 42.7	122 19 56.0	0.004	King Dome	K2	None
KEEL	%	45 33 0.8	122 53 42.4	0.067	Keeler	A20	D,E,M
KICC	%	47 34 37.9	122 37 52.4	0.010	Kitsap County Central Communications	K2	None
KIMB	%	47 34 29.3	122 18 10.1	0.069	Kimball Elementary	K2	I
KIMR	%	47 30 11.0	122 46 2.0	0.123	Moderate Risk Waste Collection Facility	K2	I
KINR	%	47 45 6.0	122 38 35.0	0.010	North Road Shed	K2	I
KITP	%	47 40 30.0	122 37 47.0	0.076	Wastewater Treatment Plant	K2	I
KNJH	%	47 23 5.0	122 13 42.0	0.010	Kent Junior High	K2	None
LANE	%	44 3 6.5	123 13 54.8	0.120	Lane	K2	E,M
LAWT	%	47 39 23.4	122 23 21.9	0.050	Lawton Elementary	A20	I
LEOT	%	47 46 4.4	122 6 56.2	0.115	Leota Junior High	K2	I
LON	%	46 45 0.0	121 48 36.0	0.853	Longmire Springs (CREST)	EPI,BB3	L-PPP
LTY	%	47 15 21.2	120 39 53.4	0.970	Liberty Heights Mine (CREST)	BB3	I
MARY	%	47 39 45.7	122 7 11.6	0.011	Marymoor Park	K2	I
MBKE	%	48 55 2.0	122 8 29.0	1.010	Kendall Elementary	K2	I
MBPA	%	47 53 54.7	121 53 20.2	0.186	Monroe	A20	D,M,L
MPL	%	47 28 7.0	122 11 4.5	0.122	Maple Valley	A	D,M,L
MURR	%	47 7 12.0	122 33 36.0	0.100	Camp Murray	K2	None
NOWS	%	47 41 12.0	122 15 21.2	0.002	NOAA Sand Point	A20	I
OHC	%	47 20 2.0	123 9 29.0	0.010	Hood Canal Junior High	K2	I
OPC	%	48 6 1.0	123 24 41.8	0.090	Peninsula College (CREST)	EPI,BB	I
PAYL	%	47 11 34.0	122 18 46.0	0.010	Aylen Junior High	K2	I
PCEP	%	47 6 41.8	122 17 24.0	0.160	Puyallup East Sheriff Precinct	K2	I
PCFR	%	46 59 23.3	122 26 27.4	0.137	Roy Training Center	K2	I
PCMD	%	46 53 20.9	122 18 0.9	0.239	Mountain Detachment	K2	I
PIN	%	43 48 40.0	120 52 19.0	1.865	Pine Mtn. (CREST)	EPI,BB3	E,L-PPP
PNLK	%	47 34 54.5	122 2 1.0	0.128	Pine Lake Middle School	K2	I
QAW	%	47 37 54.3	122 21 15.5	0.140	Queen Anne	A20	L
RAW	%	47 20 14.0	121 55 53.2	0.208	Raver	A20	M,L
RBEN	%	47 26 6.7	122 11 10.0	0.152	Benson Hill Elementary	K2	I
RBO	#	45 32 27.0	122 33 51.5	0.158	Rocky Butte	FBA23	D
RHAZ	%	47 32 24.7	122 11 1.3	0.108	Hazelwood Elementary	A20	I
ROSS	%	45 39 43.0	122 39 25.0	0.061	Ross	A20	E
RRHS	%	46 47 58.6	123 2 25.4	0.047	Rochester High School	K2	None
RWW	%	46 57 53.7	123 32 31.7	0.015	Ranney Well (CREST)	EPI,BB3	L-PPP
SBES	%	48 46 5.9	122 24 54.2	0.119	Silver Beach Elementary School	K2	I
SEA	%	47 39 15.8	122 18 29.3	0.030	University of Washington	A,BB	L
SFER	%	47 37 10.4	117 21 55.7	0.000	Ferris High School	K2	I
SMNR	%	47 12 16.6	122 12 53.4	0.010	Sumner High School	K2	I
SP2	%	47 33 23.3	122 14 52.8	0.030	Seward Park	A,BB	L
SPUD	%	47 39 53.3	117 25 35.2	0.573	Spokane Public Works (CREST)	EPI,BB	E
SQM	%	48 4 39.0	123 2 44.0	0.030	Sequim Battelle Properties (CREST)	EPI,BB	I,R
SVOH	%	48 17 21.8	122 37 54.8	0.010	Skagit Valley College Oak Harbor	K2	I
SWID	%	48 0 31.0	122 24 42.0	0.010	South Whidbey Primary School	K2	I
TBPA	%	47 15 29.0	122 22 1.0	0.002	Tacoma	A20	M,L,D
TKCO	%	47 32 12.7	122 18 1.5	0.005	King County Airport	A20	I
TTW	%	47 41 40.7	121 41 20.0	0.542	Tolt Reservoir (CREST)	EPI,BB3	I
UPS	%	47 15 50.2	122 29 1.1	0.113	University of Puget Sound	K2	I
UWFH	%	48 32 46.0	123 0 43.0	0.010	Friday Harbor Laboratories	K2	I
VVHS	%	47 25 25.1	122 27 13.1	0.095	Vashon High School	K2	None
WISC	%	47 36 32.0	122 10 27.8	0.056	Wilburton Instructional Services Center	K2	I

OUTREACH ACTIVITIES

The PNSN Seismology Lab staff provides an educational outreach program to better inform the public, educators, businesses, policy makers, and the emergency management community about seismicity and natural hazards. Our outreach includes lab tours, lectures, classes and workshops, press conferences, TV and radio news programs and talk shows, field trips, and participation in regional earthquake planning efforts. We provide basic information through information sheets, an audio library, and the Internet on the World-Wide-Web (WWW):

http://www.ess.washington.edu/SEIS/PNSN

Special Outreach Events

- The Nisqually Earthquake Clearinghouse continued to collect and organize data under the direction of Bill Steele and Tony Qamar. Some data sets currently available through the University of Washington Spatial Data Archive at: http://maximus.ce.washington.edu/~nisqually/index.html. More data will be added as they become available.
- Tony Qamar, Washington State Seismologist, has been appointed to the newly reconstituted Seismic Safety Committee of the Washington State Emergency Management Council to review progress on objectives set out in the 1991 Seismic Safety Advisory Committee study titled "A Policy Plan for Improving Seismic Safety in Washington State". A report will be made in early 2002 to the Governor and the legislature with new policy and funding priority recommendations. Dr. Qamar has been appointed chairman of the Information and Technology Subcommittee, one of four working groups. Dr. Craig Weaver (USGS - Seattle field Office) will head the subcommittee concerned with transportation, pipeline, and power "lifeline" safety recommendations.
- Amy Lindemuth has been developing additional PNSN web-site resources for K-12 educators. A committee of 4 local teachers (2 high school, 2 middle school) has been recruited to review our offerings and provide feedback. Schools throughout the Puget Sound area are participating in the ANSS urban strong motion seismometer network by hosting instruments and providing telemetry.
- Ruth Ludwin and Bill Steele continued to work with exhibits coordinators from the Burke Museum developing content for a touring exhibit that will be shown at locations throughout the region in 2002.
- July 11th- Steve Malone presented a review talk on magma recharge at quiescent volcanos to the International School of Earth Sciences, Erice, Italy
- July 26th- The PNSN hosted the CREW Executive Board annual meeting in the Peterson Room of the Allen Library.
- August 7th through 9th- The International Tsunami Society Meeting was held at the University of Washington. Bill Steele served on the NOAA/PMEL-led organizing committee, and PNSN staff assisted USGS Geologist Brian Atwater with a field trip to the Washington coast to see paleo-tsunami deposits. PNSN staff also participated in meetings with local emergency responders and in a community lecture and poster program in Ocean Shores, WA following the field trip.
- Steve Malone presented invited talks at Mount Rainier National Park (Aug. 8th - on earthquakes and volcanic hazards), and at Mount St. Helens National Monument (Aug 11th - on seismic evidence for magma recharge at Mount St. Helens).
- August 28th- Bill Steele, Craig Weaver and Steve Malone gave an overview of PNSN and USGS hazards research and seismic monitoring activities in the Pacific Northwest to a group of Congressional and Interior Dept. staff. The meeting was followed by a field trip to Waterman Point in Kitsap County, where USGS scientists gave a tour of trenches cutting aross a fault scarp.
- August 30th- Jeff Johnson, a recent Ph.D., gave a talk on PNW earthquake and volcano hazards to the West Seattle Lions Club.
- Sept. 4-6 Steve Malone attended the National Implementation Committee meeting of the ANSS as the PNW regional coordinator and as a member of the Technical Integration Committee.
- Sept. 14 Steve Malone presented an invited talk on "Our developing understanding of earthquakes and their effects on the PNW" to the Technology Alliance at the Rainier Club in Seattle.
- Sept 14th- Bill Steele provided a keynote address for the Harkins Surgical Society annual dinner.
- Sept. 25 and 26th- Ruth Ludwin accompanied George Crawford of WA State EMD, Tim Walsh of Washington State Dept. of Natural Resources and Craig Weaver of the USGS on a visit to Spokane, where they met with community members and county officials to discuss Spokane-area seismic hazards, earthquake monitoring, and preparedness.

Press Interviews, Lab Tours, and Workshops

This quarter PNSN staff provided five tours of the Seismology Lab or classes to K-12 students, including groups from innercity schools, private schools, and home schools. Two groups of Middle School science teachers and six groups of college students toured the Seismology Lab including two from community colleges, three UW Classes, and a group of geology students from another Puget Sound university. Additional tours were provided for US Congressional science committee staffers and UW employees. Altogether, tours and/or classes were provided for 190 individuals.

Telephone, Mail, and On-line outreach

The PNSN audio library system received about 700 calls this quarter. Our audio library provides several recordings. The most popular is a frequently updated message on current seismic activity. In addition we have a tape describing the seismic hazards in Washington and Oregon, and another on earthquake prediction. Callers often request our one-page information and resource sheet on seismic hazards in Washington and Oregon. Thousands of these have been mailed out or distributed, and we encourage others to reproduce and further distribute this sheet. Our information sheet discussing earthquake prediction is also frequently requested. Callers to the audio library can also choose to be transferred to the Seismology Lab, where additional information is available. This quarter we responded in person to: ~30 calls from emergency managers and government, ~50 calls from the media, ~35 calls from educators ~30 calls from the business community, and about 120 calls from the general public.

Internet outreach

The PNSN web-site offers many web pages, including maps and lists of the most recent PNW earthquakes, general information on earthquakes and PNW earthquake hazards, information on past damaging PNW earthquakes, and catalogs of earthquake summary cards. Web-pages on seismicity of Cascade Volcanos, and Quarterly summaries of seismicity are also included. The PNSN recent earthquake list is available through the World-Wide-Web (WWW) at:

http://www.ess.washington.edu/SEIS/PNSN

"Webicorder" pages allow Web visitors (and us) to view continuous data from PNSN seismographic stations at:

http://www.ess.washington.edu/SEIS/PNSN/WEBICORDER/

ShakeMap generates maps showing instrumentally measured shaking effects. Table 3A indicates which events this quarter generated ShakeMaps.

Shake Maps: **http://www.ess.washington.edu/shake/index.html**

Table 3A also indicates the felt events this quarter that generated Community Internet Intensity Maps (CIIM). CIIM maps are made using Internet reports. For a well-felt event hundreds (or thousands) of people fill out an on-line form describing their experiences during the earthquake. These "felt" reports are converted into numeric intensity values, and the CIIM map shows the average intensity by zip code.

CIIM Maps: **http://pasadena.wr.usgs.gov/shake/pnw/**

In addition to the PNSN web site, the UW Dept. of Earth and Space Sciences and the PNSN host several other earthquake-related web sites:

- **Volcano Systems Center**: **http://www.vsc.washington.edu** is a cooperative effort of the UW and the USGS that links volcano-related activities of the UW Dept. of Earth and Space Sciences and Oceanography departments with related USGS activities.
- **Seismosurfing**: **http://www.ess.washington.edu/seismosurfing.html** is a comprehensive listing of sites worldwide that offer substantive seismology data and information. This page is mirrored at two sites in Europe.
- The **Council of the National Seismic Systems** (CNSS): **http://www.cnss.org** features composite listings and maps of recent U.S. earthquakes, and documentation of the EARTHWORM system.
- **"Tsunami!"** : **http://www.ess.washington.edu/tsunami** offers many pages, including an excellent discussion on the physics of tsunamis, and short movie clips. It was developed by Benjamin Cook under the direction of Dr. Catherine Petroff (UW Civil Engineering).
- **The UW Dept. of Earth and Space Sciences Global Positioning System (GPS)**:
  http://www.ess.washington.edu/GPS/gps.html
  site provides information on geodetic studies of crustal deformation in Washington and Oregon.

EARTHQUAKE DATA - 2001-C

There were 2,029 events digitally recorded and processed at the University of Washington between July 1 and September 30, 2001. Locations in Washington, Oregon, or southernmost British Columbia were determined for 800 of these events; 665 were classified as earthquakes and 135 as known or suspected blasts. The remaining 1,229 processed events include teleseisms (192 events), regional events outside the PNSN (181), and unlocated events within the PNSN. Unlocated events within the PNSN include very small earthquakes and some known blasts. Frequent mining blasts occur near Centralia, Washington and we routinely locate some of them.

Table 3A is a listing of all earthquakes reported to have been felt during this quarter. Table 3B is a listing of earthquakes magnitude 2.5 or greater with reasonably constrained focal mechanisms from P-wave first motions. Table 4, located at the end of this report, is this quarter's catalog of earthquakes M 2.0 or greater, located within the network - between 42-49.5 degrees north latitude and 117-125.3 degrees west longitude.

Fig. 2 shows earthquakes with magnitude greater than or equal to 0.0 ($M_c \geq 0$).
Fig. 3 shows blasts and probable blasts ($M_c \geq 0$).
Fig. 4 shows earthquakes located near Mt. Rainier ($M_c \geq 0$).
Fig. 5 shows earthquakes located at Mt. St. Helens ($M_c \geq 0$).
Fig. 6 shows reasonably well-constrained focal mechanisms for earthquakes with M 2.5 this quarter.
Fig. 7 shows earthquakes near Spokane, Jan.-Sept. 2001.

TABLE 3A - Felt Earthquakes during the 3rd Quarter of 2001

DATE-(UTC)-TIME	LAT(N)	LON(W)	DEPTH	MAG	COMMENTS	CIIM	ShakeMap
01/07/01 05:44:12	47.67	117.41	0.0	2.8	0.4 km W of Spokane, WA		
01/07/01 05:45:43	47.66	117.40	0.5	2.8	0.3 km SSE of Spokane, WA		
01/07/01 06:07:13	47.67	117.40	0.0	2.3	0.5 km NW of Spokane, WA		
01/07/02 17:48:28	47.67	117.42	0.5	0.6	1.5 km WNW of Spokane, WA		
01/07/03 21:20:27	47.67	117.41	0.0	2.2	0.9 km NW of Spokane, WA		
01/07/08 11:16:32	47.68	117.41	0.5	1.5	1.7 km NW of Spokane, WA		
01/07/16 11:37:35	45.11	122.51	13.1	1.9	21.4 km SE of Canby, OR		
01/07/22 15:13:52	47.08	122.68	52.4	4.3	16.3 km ENE of Olympia, WA	x	x
01/07/24 13:31:06	47.49	122.02	16.4	2.2	9.3 km N of Maple Valley, WA		
01/07/29 06:26:53	47.74	117.46	0.6	2.1	8.9 km NNW of Spokane, WA	x	
01/07/29 06:37:58	47.72	117.45	6.2	1.3	7.5 km NNW of Spokane, WA		
01/07/29 07:04:25	47.73	117.46	3.9	1.2	7.9 km NNW of Spokane, WA		
01/07/30 20:35:09	47.73	117.46	0.6	1.8	8.2 km NNW of Spokane, WA		
01/07/31 01:38:11	47.73	117.45	0.4	3.2	8.0 km NNW of Spokane, WA	x	
01/07/31 05:07:32	47.73	117.44	0.6	2.2	7.4 km NNW of Spokane, WA		
01/07/31 05:24:33	47.74	117.45	0.5	1.5	9.2 km NNW of Spokane, WA		
01/07/31 06:48:11	47.71	117.47	0.5	1.8	7.3 km NW of Spokane, WA		
01/07/31 08:51:55	47.72	117.45	2.1	1.6	7.4 km NNW of Spokane, WA		
01/07/31 16:27:43	47.72	117.45	0.6	1.8	7.4 km NNW of Spokane, WA		
01/08/01 14:29:48	47.71	117.44	0.6	2.2	5.9 km NNW of Spokane, WA		
01/08/09 13:31:24	47.73	117.46	0.5	1.5	8.2 km NW of Spokane, WA		
01/08/19 06:17:32	48.25	121.61	1.7	3.0	1.0 km WSW of Darrington, WA		
01/08/25 17:52:34	48.23	121.60	2.7	2.1	2.1 km S of Darrington, WA		
01/08/30 03:47:31	48.23	121.62	4.8	2.7	2.9 km SW of Darrington, WA		
01/09/28 18:34:53	47.68	117.38	1.8	2.8	1.8 km NE of Spokane, WA	x	
01/09/28 18:37:53	47.66	117.37	0.3	1.9	2.3 km ESE of Spokane, WA		
01/09/28 18:38:37	47.67	117.40	0.6	2.6	0.7 km NNW of Spokane, WA		
01/09/28 18:41:40	47.67	117.39	0.0	1.6	0.6 km NE of Spokane, WA		

TABLE 3B - Earthquakes M 2.5 or larger during the 3rd Quarter of 2001
Focal mechanisms noted where computed. Some earthquakes have more than one possible mechanism.

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEP km	MAG	COMMENTS	STRIKE deg.	DIP deg.	RAKE deg.
01/07/01 05/44/12	47.67	117.41	0.0	2.8	0.4 km W of Spokane, WA	345	50	-130
01/07/01 05/45/43	47.67	117.40	0.5	2.8	0.3 km SSE of Spokane, WA	-	-	-
01/07/20 07/38/24	43.53	121.74	8.4	2.6	46.8 km WSW of Newberry Caldera, OR	-	-	-
01/07/22 15/13/52	47.09	122.69	52.4	4.3	16.3 km ENE of Olympia, WA	65	70	140
01/07/31 01/38/11	47.73	117.46	0.4	3.2	8.0 km NNW of Spokane, WA	-	-	-
01/08/19 06/17/32	48.25	121.61	1.7	3.0	1.0 km WSW of Darrington, WA	65	40	100
						115	75	170
01/08/30 03/47/31	48.23	121.63	4.8	2.7	2.9 km SW of Darrington, WA	60	45	120
						170	50	20
01/09/06 21/40/44	45.79	124.54	35.1	2.9	65.7 km NW of Tillamook, OR	-	-	-
01/09/14 11/22/57	45.31	121.73	5.2	2.9	8.0 km SSW of Mt Hood, OR	5	45	-90
01/09/15 12/21/09	45.31	121.73	4.2	2.5	8.1 km SSW of Mt Hood, OR	-	-	-
01/09/28 18/34/53	47.68	117.39	1.8	2.8	1.8 km NE of Spokane, WA	-	-	-
01/09/28 18/38/37	47.68	117.41	0.6	2.6	0.7 km NNW of Spokane, WA	-	-	-

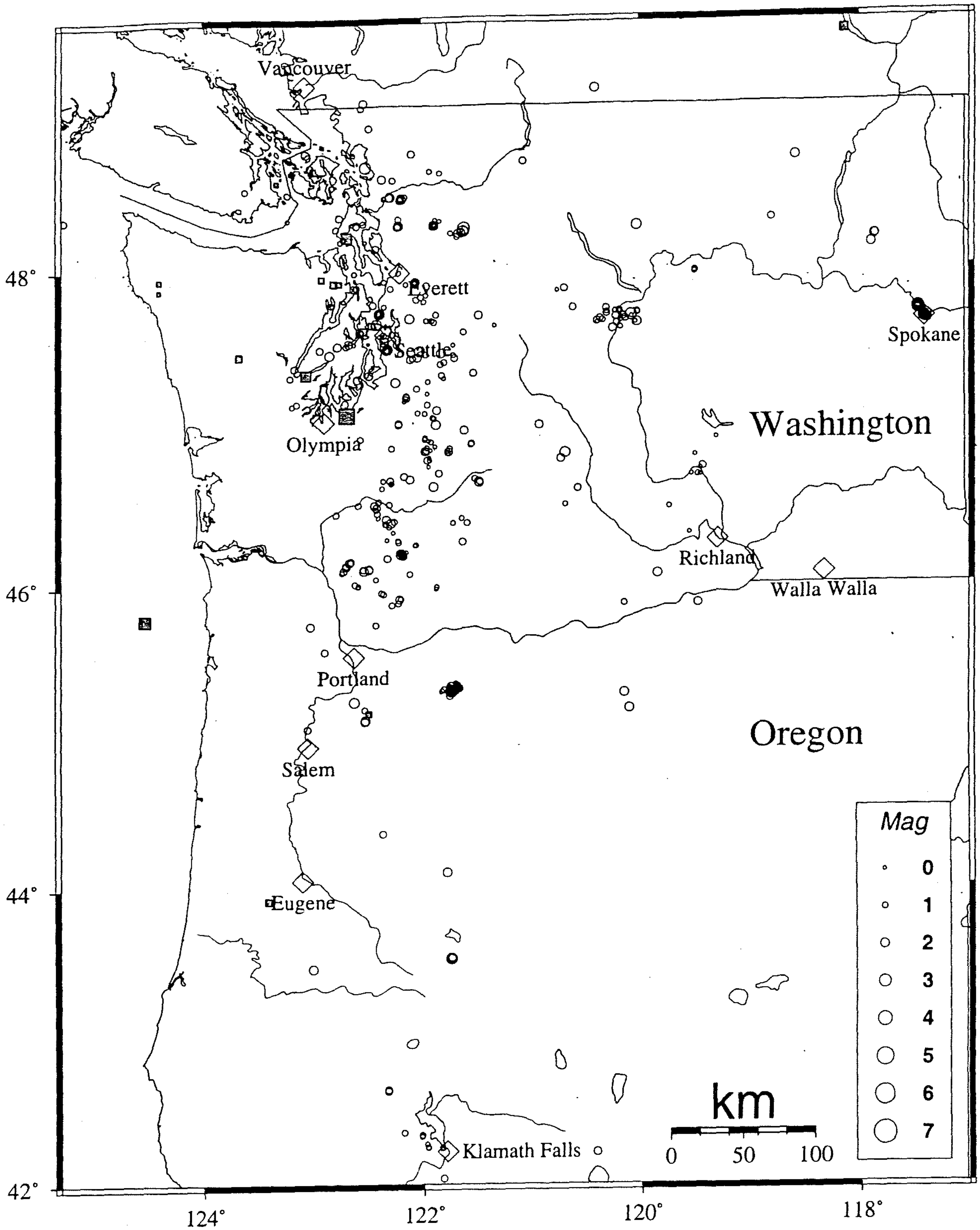

Figure 2. Located earthquakes, magnitude > 0, 3rd quarter, 2001. Filled squares indicate earthquakes with depth greater than 30km. Unfilled diamonds represent cities.

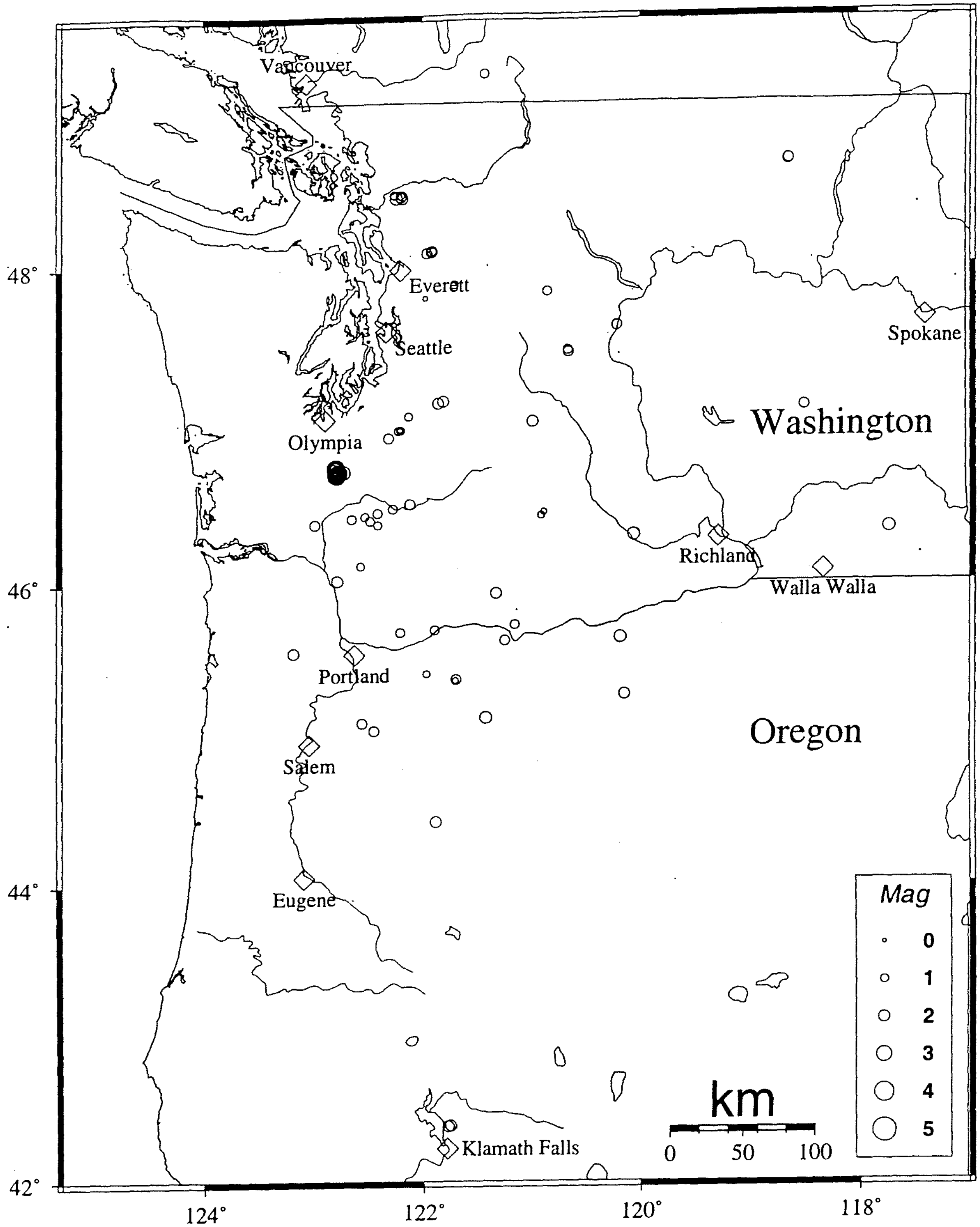

Figure 3. Blasts and probable blasts, 3rd quarter, 2001. Unfilled diamonds represent cities.

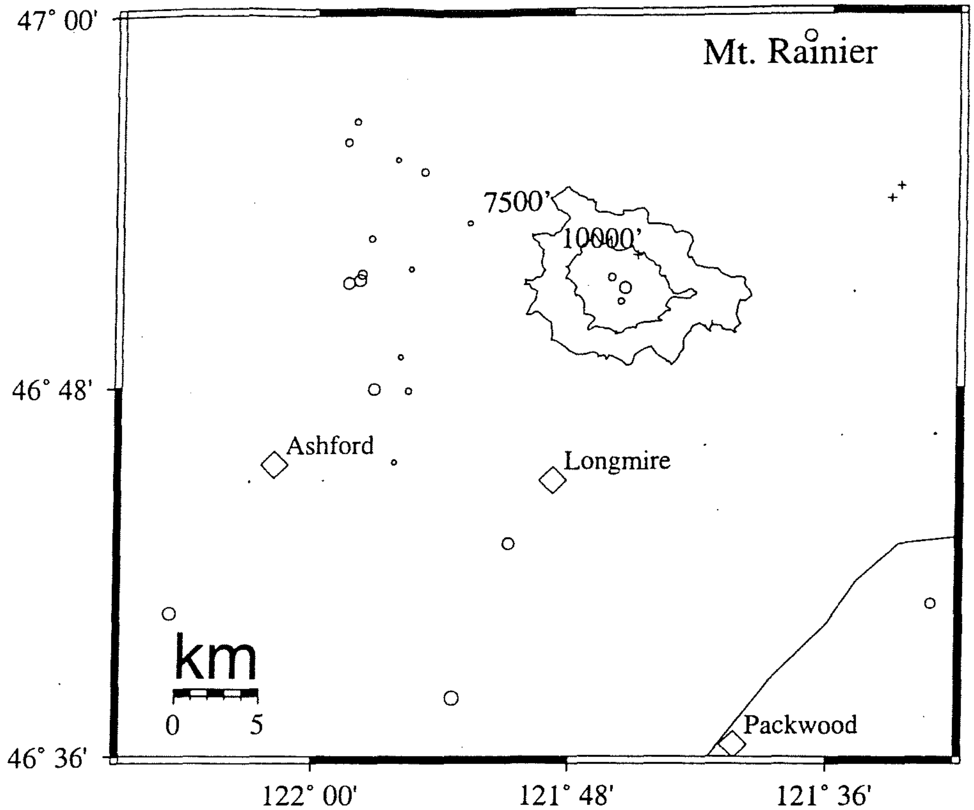

Figure 4. Earthquakes M > 0, 3rd quarter, 2001. 'Plus' symbols indicate depth less than 1 km. Circles indicate depth greater than 1 km. Elevation contours shown in feet.

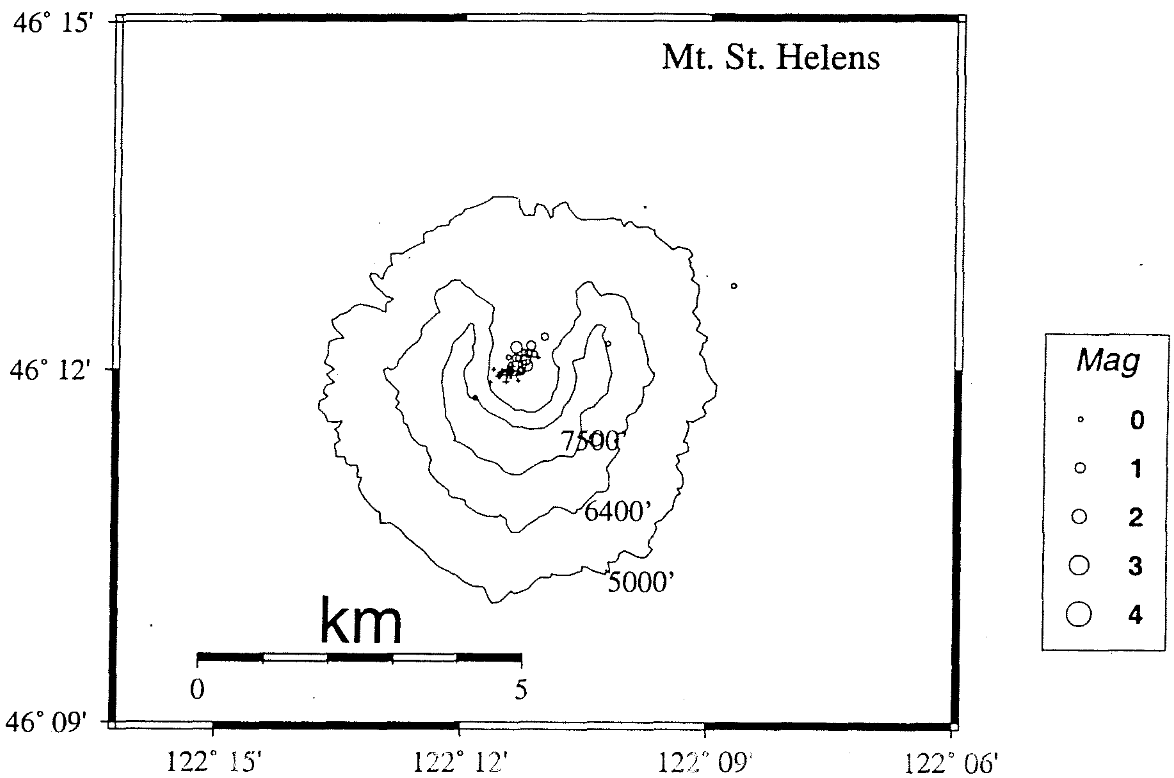

Figure 5. Earthquakes M > 0, 3rd quarter, 2001. 'Plus' symbols indicate depth less than 1 km. Circles indicate depth greater than 1 km. Elevation contours shown in feet.

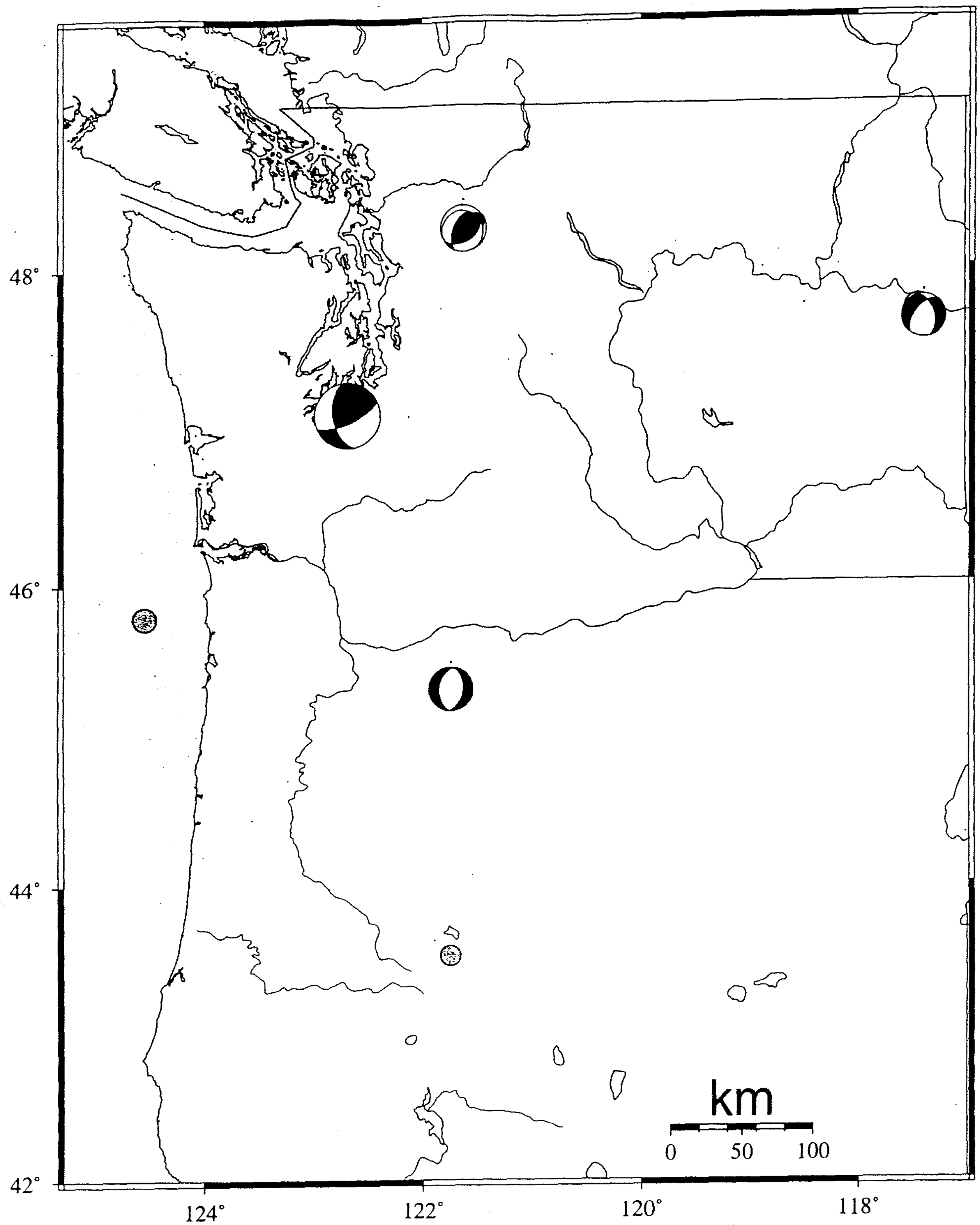

Figure 6. Events and fault plane solutions, 3rd quarter 2001, Magnitude greater than or equal to 2.5.
Focal symbol size reflects earthquake magnitude. Events without fault plane solutions are shown as filled dots.

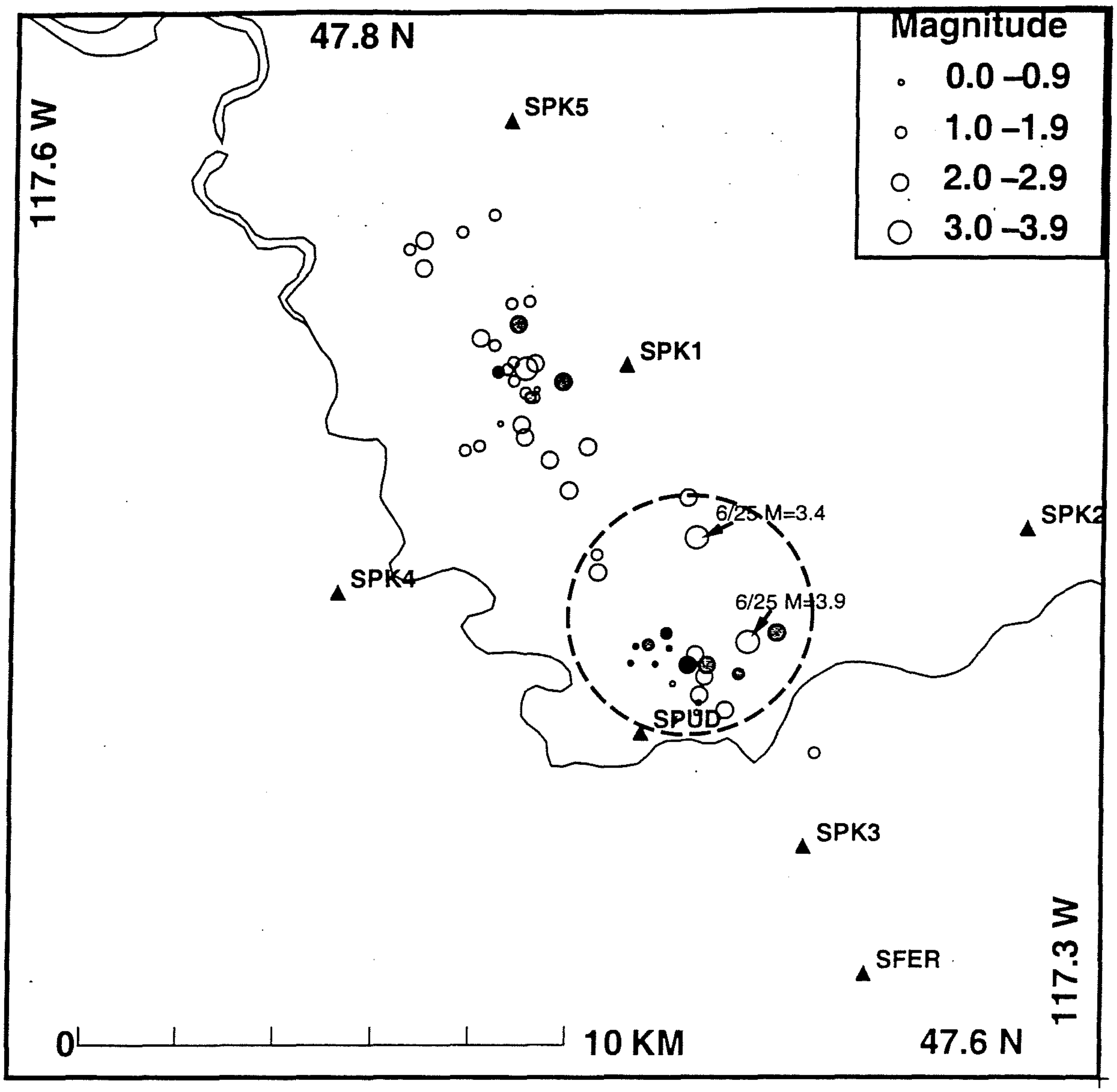

Figure 7. Overview of station locations and earthquakes recorded in the Spokane area Jan. 1– Sept. 30, 2001. Earthquakes are shown as circles. Unfilled circles indicate events with the poorest–quality solutions. Gray shaded circles have solution quailities of CC or better. Black–filled circles represent the best – located events (azimuthal gap <135 degrees, less than 10 km to nearest station, CC or better quality, and read on at least 7 stations). Although the locations shown suggest a northwest–southeast trend, it is more likely that all the events occurred in the area indicated by the dashed circle just northeast of station SPUD. The station distribution varied during the sequence, and the clock at station SPUD may have drifted, making it impossible to obtain correct relative locations for the events of the sequence.

OREGON SEISMICITY

During the third quarter of 2001, a total of 96 earthquakes were located in Oregon between 42.0° and 45.5° north latitude, and between 117° and 125° west longitude. One small (M 1.9; July 16) earthquake in Oregon was reported felt this quarter. The most interesting feature of seismic activity in Oregon this quarter were two swarms of earthquakes near Mt. Hood. A total of 66 shallow (depths <10 km) earthquakes were located near Mt. Hood between 45-45.5 N latitude and 121-122 west longitude during the quarter.

The first swarm, 5 km SSE of Mt. Hood, occurred mainly on August 20, when 9 events (none larger than magnitude 1.3, and mostly at depths <5 km) were located. The second swarm was more vigorous, longer lasting, and slightly deeper (most events 7-9 km deep). It was located in a different area 8 km SSW of Mt Hood, and began on August 21 with very small (M<1) events. Its most intense activity was Sept. 11-16, and included 5 events magnitude 2.0 or larger and 15 events magnitude 1.0 or larger. The largest event was magnitude 2.9 on Sept. 14.

In the Klamath Falls area, 14 earthquakes occurred in the third quarter of 2001. Since 1994, most earthquakes in the Klamath Falls area have been considered aftershocks of a pair of damaging earthquakes in September of 1993. The 1993 earthquakes were followed by a vigorous aftershock sequence which decreased over time.

Elsewhere in Oregon, on Aug. 21 a M 1.9 earthquake at about 5 km depth was located near the Three Sisters volcanic area in Oregon. Earthquakes are uncommon in this area. Another interesting nearby event was a clear rockfall signal noted on seismograms HUO and TCO on Sept. 26. The rockfall was visually confirmed to be on South Sister. Bob Norris and Willie Scott of the USGS estimated the volume of the rockfall based on the signal (Norris) and visual observations (Scott) at between 10,000 and 50,000 cubic meters, large enough to leave a noticeable deposit on the Prouty Glacier. Mt. Rainier has rockfalls this size every few years or so, but they are rarer at South Sister, as it is a much smaller volcano and has only a few cliffs that are steep and tall enough to generate a rockfall of that size.

WESTERN WASHINGTON SEISMICITY

During the third quarter of 2001, 466 earthquakes were located between 45.5° and 49.5° north latitude and between 121° and 125.3° west longitude. Five earthquakes were felt this quarter in western Washington. Details are in Table 3.

The largest felt earthquake in western Washington was a magnitude 4.3 earthquake in the early morning hours of July 22. It was located at 52 km depth about 18 km NE of Olympia; close to the M 6.8 Nisqually earthquake on Feb. 28, 2001. This July 22 earthquake may be a late aftershock of the Nisqually earthquake. It was well recorded by strong motion instruments in the Puget Sound.

http://www.ess.washington.edu/SEIS/EQ_Special/WEBDIR_01072215135p/strong_motion.html

A ShakeMap is available at:

http://spike.ess.washington.edu/shake/0107221513/intensity.html

and a CIIM "felt" map at:

http://pasadena.wr.usgs.gov/shake/pnw/STORE/X7221513/ciim_display.html

The CIIM web site received about 750 "felt" reports from 164 different zip codes around Puget Sound. No damage was reported.

CASCADE VOLCANOS

Mount Rainier Area: Figure 4 shows earthquakes near Mount Rainier. The number of events in close proximity to the cone of Mt. Rainier varies over the course of the year, since the source of much of the shallow activity is presumably ice movement or avalanching at the surface, which is seasonal in nature. Events with very low frequency signals (1-3 Hz) believed to be icequakes are assigned type "L" in the catalog. Emergent, very long duration signals, probably due to rockfalls or avalanches, are assigned type "S" (see Key to Earthquake Catalog). There were no events flagged "L" or "S" were located at Mount Rainier this quarter but 120 "L" or "S" events were recorded, but were too small to locate reliably. Type L and S events are not shown in Fig. 4.

This quarter, on August 14 (PDT), a small volcanic lahar was recorded on three seismometers at Mt. Rainier as it flowed down Van Trump Creek and the Nisqually River. The event lasted for several hours. Seimograms and spectrograms are available on our web site at:

http://www.ess.washington.edu/SEIS/PNSN/WEBICORDER/Rainier/

A total of 50 tectonic events (25 of these were smaller than magnitude 0.0, and thus are not shown in Fig. 4) were located within the region shown in Fig. 4. Of these, 33 were tectonic events located in the "Western Rainier Seismic Zone" (WRSZ), a north-south trending lineation of seismicity approximately 15 km west of the summit of Mt. Rainier (for counting purposes, the western zone is defined as 46.6-47 degrees north latitude and 121.83-122 west longitude). The largest tectonic earthquake located near Mt. Rainier this quarter was the felt magnitude 1.8 earthquake on August 28, located about 27 km south-southwest of the summit at a depth of about 4 km.

This quarter, there were 10 (4 of them smaller than magnitude 0.0 and thus not shown in Fig. 4) higher-frequency tectonic-style earthquakes within 5 km of the summit. The remaining events were scattered around the cone of Rainier as seen in Fig. 4.

Mount St. Helens Area: Figure 5 shows volcano-tectonic earthquakes near Mount St. Helens. Low frequency (L) and avalanche or rockfall events (S) are not shown. This quarter, 142 earthquakes were located at Mount St. Helens in the area shown in Fig. 5. Of these earthquakes, 40 were magnitude 0.0 or larger and 9 were deeper than 4 km. The largest tectonic earthquake at Mount St. Helens this quarter was a magnitude 1.5 event on Sept. 25 located .6 km NNE of Mount St. Helens.

Two type "S" or "L" events were located at Mount St. Helens, and 356 "L" or "S" events too small to locate were recorded.

EASTERN WASHINGTON SEISMICITY

During the second quarter of 2001, 101 earthquakes were located in eastern Washington in the area between 45.5-49.5 degrees north latitude and 117-121 degrees west longitude.

The most unusual activity in eastern Washington this quarter was the continuation of a very unusual sequence of earthquakes in the Spokane urban area.

SPECIAL REPORT - Spokane Earthquake Activity in the Summer of 2001

On the morning of June 25 (at 7:15 and 8:01 AM PDT), two earthquakes, M 3.9 and M 3.4 were widely felt in urban Spokane. Additional smaller events continued through the day. Spokane is an area that historically has been seismically quiet, and is located at the very edge of the seismograph network operated by the Pacific Northwest Seismograph Network (PNSN). The PNSN immediately began continuous recording of the three nearest network stations (64-104 km away).

Because of the ongoing nature of the seismicity and its location in an urban area, on June 26 temporary station SPUD was installed at the Spokane County Public Works building (on W. Broadway between Monroe and Madison) to improve our ability to locate Spokane earthquakes. As the sequence continued, five additional stations were installed in Spokane between June 30 and July 2.

By the end of the third quarter, the PNSN had located a total of 61 events in the Spokane sequence. Another twenty-two events were recorded, but could not be located. Because a variety of seismograph configurations have operated, the accuracy of event locations has varied over the course of the sequence.

The Spokane sequence began with a M 2.0 foreshock on May 24, a month before the larger shocks. This quake was felt by residents, who also reported feeling other shaking around that time, likely due to earthquakes too small to be record by the PNSN. Reports of shaking in May and early June became known to us only after activity intensified in late June. On June 25 the two largest events in the sequence (M 3.9 and M 3.4 on 6/25) occurred, and twenty-three other events were located during the following week. Some of the locations on and after June 26 included readings from the quickly-installed temporary Spokane station SPUD, although SPUD had some telemetry problems and operated only intermittently during the sequence.

Around the beginning of July, when the 5-station temporary array was installed in Spokane, activity dropped off. Between July 2 and July 12 only 16 earthquakes (mostly tiny events with data only from the temporary five-station array) were located. The proximity and number of the stations made these earthquakes the most accurately located of the sequence. All of the earthquakes located with the 5-station array are north and east of the Spokane River, inside the river's bend. This is also near where the two largest shocks on June 25 were located using regional seismograph data, and in the area where residents report feeling continued shaking, between Riverfront Park and Corbin Park. Figure 7 shows location of seismometer stations and earthquakes located near Spokane between January and September, 2001.

The July 2-12 earthquakes appear to be extremely shallow, and residents reported feeling many, but not all, of the recorded earthquakes. Loud explosion-like sounds were often reported along with the shaking. Reports of shaking were also received for times when no activity was recorded, probably due to a heightened sensitivity to typical background vibrations that occur in the urban environment. No earthquakes were recorded between July 13 and July 28.

The temporary 5-station array was removed on July 25, and activity picked up again almost immediately. Fourteen events were located between July 29 and August 1. The largest event in this time period was magnitude 3.2, and at least a dozen events were reported felt between July 29 and August 1, much disturbing residents.

Following August 1, seismicity quieted. SPUD continued to operate and an additional permanent station, SFER at Ferris High School, was installed on August 9. Just one event was located on August 9, but it occurred in the early morning hours before the SFER installation. No further events were located in August or during the first three weeks of September.

SPUD was removed on September 25. It had been borrowed from another project and had to be returned. Seismicity picked up just a few days later, when four events occurred within a ten-minute period on Sept. 28. The largest was a magnitude 2.8 that was noticed by many people in the downtown area, as was the magnitude 2.6 that followed about 4 minutes later.

There is no history of damaging earthquakes in the Spokane area, nor any comparable sequence of small events. While the current sequence continued through the 3rd quarter, it is notable that since June the maximum magnitude and number of earthquakes in each burst of activity has declined and the time lapses between bursts of activity have lengthened.

Spokane Geology and Earthquake History:

Geologists have long suspected that the course of the Spokane River was structurally controlled. It flows east to west toward Spokane, where it abrubtly changes to a northwest direction. Hangman Creek (also called Latah Creek) flows into the Spokane River near the bend along the same NW striking lineament. This lineament is clearly expressed in the topography, paricularly along Hangman Creek, which is quite straight compared to the complex dendritic pattern more commonly displayed by other drainage in this area (see digital elevation map). Bob Durkey of the Washington State Dept. of Natural Resources has mapped the Hangman Creek watershed, and named this structure the Latah Fault. An brief discussion on the possible relation of the Latah Fault to the Spokane earthquakes has been published in Washington Geology (Derkey, R.E., and M.H. Hamilton, 2001, Spokane Earthquake point to Latah Fault?, Washington Geology, V. 29, No 1/2, pg. 42).

However, direct evidence for faulting is skimpy: At Hangman Valley Golf course, flood deposits are uptilted to 35 degrees. Well data from either side of Hangman Creek shows elevation or thickness differences in the Grande Ronde Columbia River Basalt (CRB) flow. However, the flow was deposited onto a Miocene landscape and it is difficult to determine whether differences result from flows interacting with the ancient landscape or from faulting. Likewise exposures of basalt along the Spokane River near "Bowl and Pitcher" in Riverside State Park differ from what is seen at "Five Mile Prairie" across the river. Again it is difficult to pinpoint the cause of this.

Very little is known about the seismic hazard to Spokane, since there is no history of large damaging earthquakes in the area. It is unusual to have any earthquake activity at all in Spokane, and no sequence like this one has been noted in the past. Looking back at Spokane history, minor damage has been caused by events outside the immediate Spokane area (e.g. Hebgen Lake quake of 1959), and there is also a history of a few small quakes felt only locally in Spokane. Events felt only in and around Spokane occurred in 1915, 1920, 1922, 1941, 1942, 1948, 1952, 1961 and 1962. In some instances the shaking was accompanied by explosion-like noises, and in some cases several events close together in time were reported. No other extended sequence like the one in 2001 is known.

Although never previously noted near Spokane, earthquake swarm activity (defined as a cluster of small close-together earthquakes without a distinct, sizable mainshock) has previously been seen in eastern Washington. One notable swarm occurred near Othello and lasted nearly a year. It began in November of 1987 and included about 200 located earthquakes, about 20 of them larger than magnitude 2.0. The largest event in the Othello sequence was magnitude 3.3.

Earthquake locations in the current sequence appear spread out along the trend of the Hangman Creek structure, but this is probably misleading as many of the far-flung locations are not well constrained. The best located earthquakes (using data from the 5-station temporary array) were immediately inside the bend in the river, approximately near the Corbin Park neighborhood.

A close examination of events that appear to be to the northwest indicates that those events either lacked a close-by station or, if the data included station SPUD, occurred after July 28. The internal clock of station SPUD may have drifted, and the drift would increase with time. SPUD waveforms from events apparently to the northwest appear no different than waveforms from events located closer to SPUD. It seems fairly likely that all events in the swarm have been located in a single cluster close to the immediate downtown Spokane area.

Eastern Washington Geology and Earthquake History

Placing Spokane in a wider context; it is important to realize that, although less active than western Washington, eastern Washington does have faults capable of producing damaging earthquakes. Historic damaging earthquakes in eastern Washington include the 1872 earthquake (M 6.8-7.3), near southern Lake Chelan. This earthquake was one of the largest earthquakes known in Washington, and it was widely felt in Washington and British Columbia and followed by many aftershocks. The same area, near Entiat, experienced a M 5.0 earthquake in 1959, and there is a persistent cluster of tiny earthquakes in the area.

An earthquake near Walla Walla in 1936 (M 6.4) caused extensive damage to chimneys and walls, ground cracking, and water level and well flow changes, with numerous aftershocks reported. Since 1936, several earthquakes around magnitude 4.0 have been located in the same area.

Large earthquakes at some distance from eastern Washington are sometimes felt and can even be damaging. For example, the 1959 M 7.5 Hebgen Lake earthquake in Montana was felt as far as Seattle, and caused minor damage in Spokane, as did the 1983 M 7.2 Borah Peak, Idaho earthquake.

Overall, the rate of seismicity in eastern Washington is low, although the seismology lab at the University of Washington locates 200-300 earthquakes per year in eastern Washington and northeastern Oregon. Only a few earthquakes each year are usually large enough to be felt. Earthquakes in eastern Washington are shallow, within the upper 10 miles or so of the Earth's crust. Although we know that damaging earthquakes can occur in eastern Washington, the low rate of seismicity makes evaluating earthquake hazards and identifying dangerous faults difficult. Events like the 1872 and 1936 earthquakes are likely to recur, and other faults may also break. We look for clues in the geology, but the processes that produce faults and deform, fold, and uplift rocks are slow and the traces they leave in the landscape can be difficult to interpret. Active faults may never break the surface, faults exposed at the surface may be inactive, and evidence of faulting can be eroded away or obscured by new deposits.

In eastern Washington the landscape includes older rocks in the Cascade highlands and geologically young (15 million years old) flood basalts covering the Columbia Plateau. The older (100 million years) Mesozoic crystalline rocks of the Cascade highlands contain faults, but the absence of young rocks makes it difficult to determine whether those faults are still active. Earthquakes of magnitude 4.5 - 5.0 have occurred in the Cascade highlands in recent years, and larger earthquakes cannot be ruled out. Complex geologic structures within the older rocks extend beneath the layered flood basalts. Large faults in the eastern Columbia Plateau, near the Spokane area and near Clarkston/Lewiston were active while the basalt flows were occurring, but show little evidence of significant recent activity. In the western part of the Columbia Plateau, numerous faults showing very recent activity distort the flood basalts. The Yakima Fold Belt is a series of east-west trending folded and faulted ridges in the basalts. The most prominent ridges are in the southwestern plateau, and include the Saddle Mountains, Rattlesnake Mountain, Frenchman Hills, and Horse Heaven Hills. Swarms of small earthquakes are common and there are large geologically recent thrust faults that may be capable of producing earthquakes larger than magnitude 7. Yakima Fold Belt structures also extend into the northwestern plateau, and are a feasible source for the 1872 earthquake.

Earthquake Mitigation for low-seismicity areas

Damaging earthquakes sometimes occur even in areas of low seismicity When there is not enough information to estimate the frequency or maximum magnitude of damaging earthquakes, a conservative approach is to plan for the possibility of a damaging earthquake of moderate size (magnitude 5.0). There are many low-cost mitigation measures such as family emergency plans, restraining gas water heaters and tall bookcases, etc. Some mitigation activities, such as bracing or removal of masonry parapets and anchoring of masonry walls can be implemented during other refurbishing projects. The 2001 sequence has demonstrated that there is an active seismogenic source in the Spokane area. Damaging earthquakes near Wenatchee (1872) and Walla Walla (1936), the presence of large geologically recent faults in the Tri-cities area, and the generally young geology of Washington suggest that basic mitigation acitivites should be considered by communities in eastern Washington.

TABLE 3C - Earthquakes located near Spokane during the 3rd Quarter of 2001
(See "Key to Earthquake Catalog in Table 4")

July 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	05:44:12.67	47 40.32	117 24.61	0.02*	2.8	7/07	218	0.32	CD	N3	F
1	05:45:43.24	47 40.15	117 24.19	0.50#	2.8	6/07	234	0.37	CD	N3	F
1	05:46:51.14	47 40.12	117 24.66	2.97	0.9	4/07	231	0.23	BD	N3	
1	05:49:15.01	47 40.45	117 25.05	2.03	0.8	7/07	193	0.28	BD	N3	
1	06:07:13.52	47 40.52	117 24.53	0.02*	2.3	7/07	209	0.33	CD	N3	F
2	08:43:00.21	47 40.91	117 25.22	0.57	-0.2	4/08	132	0.04	AD	N3	
2	17:48:28.97	47 40.67	117 25.36	0.47*	0.6	12/13	92	0.18	BB	N3	F
3	21:20:27.63	47 40.65	117 24.81	0.03*	2.2	16/16	80	0.20	BA	N3	F
5	15:34:15.54	47 40.23	117 24.62	1.65	0.5	8/08	142	0.02	AC	N3	
5	21:53:46.27	47 40.88	117 25.46	1.73	1.2	10/10	136	0.03	AC	N3	
6	02:11:34.19	47 40.84	117 25.11	2.57	0.4	8/08	132	0.02	AB	N3	
8	09:22:45.08	47 40.39	117 24.45	1.41	-0.9	6/06	134	0.04	AC	N3	
8	09:58:48.44	47 41.00	117 25.18	0.58	-0.5	7/07	130	0.12	AB	N3	
8	11:16:32.98	47 41.01	117 25.17	0.51	1.5	14/15	103	0.30	CB	N3	F
8	11:17:13.61	47 40.72	117 25.43	2.43	-0.6	6/06	213	0.02	AD	N3	
9	03:40:11.40	47 40.87	117 25.68	0.58	0.0	8/08	139	0.02	AC	N3	
9	17:11:16.00	47 40.68	117 24.94	0.29	-0.8	6/06	135	0.02	AC	N3	
10	11:55:10.79	47 40.43	117 25.50	2.50	-0.6	7/08	150	0.06	AC	N3	
12	11:21:51.83	47 40.68	117 25.76	0.54	0.5	8/08	146	0.09	AC	N3	
12	11:26:55.44	47 40.39	117 25.82	2.17	-0.6	3/06	156	0.04	AD	N3	
12	11:29:11.47	47 40.43	117 25.78	2.31	-1.6	3/06	154	0.02	AD	N3	
29	06:26:53.84	47 44.49	117 27.68	0.55	2.1	6/07	139	0.22	BC	N3	F
29	06:37:58.49	47 43.72	117 27.55	6.24	1.3	4/05	137	0.01	AD	N3	F
29	07:04:25.52	47 43.85	117 27.75	3.87	1.2	4/05	136	0.09	AD	N3	F
30	20:35:09.62	47 43.98	117 27.85	0.63	1.8	4/07	135	0.16	BD	N3	F
31	01:38:11.76	47 44.00	117 27.55	0.45$	3.2	7/07	138	0.32	DC	N3	F
31	05:07:32.71	47 43.85	117 26.92	0.63	2.2	7/08	144	0.14	AC	N3	F
31	05:24:33.95	47 44.75	117 27.50	0.53	1.5	5/07	141	0.38	CD	N3	F
31	06:48:11.75	47 43.13	117 28.30	0.54$	1.8	11/12	204	0.64	DD	N3	F
31	08:51:55.82	47 43.66	117 27.40	2.13$	1.6	5/09	213	0.33	CD	N3	F
31	16:27:43.30	47 43.66	117 27.46	0.60	1.8	6/07	138	0.22	BC	N3	F
31	16:28:58.63	47 43.75	117 27.36	0.62	0.9	3/05	139	0.41	CD	N3	
31	16:40:39.03	47 43.37	117 27.96	0.54	0.9	3/06	131	0.47	CD	N3	

Aug 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	12:49:20.78	47 44.26	117 28.07	0.63	1.2	4/06	135	0.20	BD	N3	
1	14:29:48.83	47 43.11	117 26.52	0.55	2.2	4/05	147	0.06	AD	N3	F
9	13:31:24.17	47 43.95	117 28.01	0.51	1.5	7/08	134	0.21	BB	N3	F

Sept 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
28	18:34:53.83	47 41.01	117 23.36	1.78*	2.8	6/06	148	0.20	BC	N3	F
28	18:37:53.71	47 39.65	117 22.74	0.31	1.9	4/04	151	0.44	CD	N3	F
28	18:38:37.73	47 40.65	117 24.49	0.58	2.6	6/07	135	0.37	CC	N3	F
28	18:41:40.97	47 40.55	117 23.97	0.02*	1.6	6/06	139	0.20	BC	N3	F

Times, locations, and depths of all felt earthquakes in the PNSN region this quarter are given in Table 3A.

OTHER SOURCES OF EARTHQUAKE INFORMATION

We provide automatic computer-generated alert messages about significant Washington and Oregon earthquakes by e-mail, FAX or via the pager-based RACE system to institutions needing such information, and we regularly exchange phase data via e-mail with other regional seismograph network operators. The "Outreach Activities" section describes how to access PNSN data via e-mail, Internet, and World-Wide-Web. To request additional information by e-mail, contact seis_info@ess.washington.edu.

Earthquake information in the quarterlies has been published in final form by the Washington State Department of Natural Resources as information circulars entitled "Earthquake Hypocenters in Washington and Northern Oregon" covering the period 1970-1989 (see circulars Nos. 53, 56, 64-66, 72, 79, 82-84, and 89). These circulars, plus circular No. 85, "Washington State Earthquake Hazards", are available from Washington Dept. of Natural Resources, Division of Geology and Earth Resources, Post Office Box 47007, Olympia, WA. 98504-7007, or by telephone at (360) 902-1450.

Several excellent maps of Pacific Northwest seismicity are available. A very colorful perspective-view map (18" x 27") entitled "Major Earthquakes of the Pacific Northwest" depicts selected epicenters of strong earthquakes (magnitudes > 5.1) that have occurred in the Pacific Northwest. A more detailed full-color map is called "Earthquakes in Washington and Oregon 1872-1993", by Susan Goter (USGS Open-File Report 94-226A). It is accompanied by a companion pamphlet "Washington and Oregon Earthquake History and Hazards", by Yelin, Tarr, Michael, and Weaver (USGS Open-File Report 94-226B). The pamphlet is also available separately. Maps can be ordered from: "Earthquake Maps", U.S. Geological Survey, Box 25046, Federal Center, MS 967, Denver, CO 80225, phone (303) 273-8477. The price of each map is $12. (including US shipping and handling).

USGS Cascades Volcano Observatory has a video, "Perilous Beauty: The Hidden Dangers of Mount Rainier", about the risk of lahars from Mount Rainier. Copies are available through: North west Interpretive Association (NWIA), 909 First Avenue Suite 630, Seattle WA 98104, Telephon e: (206) 220-4141, Fax: (206) 220-4143.

Other regional agencies provide earthquake information. These include the Geological Survey of Canada (Pacific Geoscience Centre, Sidney, B.C.; (250) 363-6500, FAX (250) 363-6565), which produces monthly summaries of Canadian earthquakes; the US Geological Survey which produces weekly reports called "Seismicity Reports for Northern California" (USGS, attn: Steve Walter, 345 Middlefield Rd, MS-977, Menlo Park, CA, 94025) and "Weekly Earthquake Report for Southern California" (USGS, attn: Dr. Kate Hutton or Dr. Lucy Jones, CalTech, Pasadena, CA.).

Key to Earthquake Catalog in Table 4

TIME Origin time is calculated for each earthquake on the basis of multi-station arrival times. Time is given in **Coordinated Universal Time** (UTC), in hours:minutes:seconds. To convert to Pacific Standard Time (PST) subtract eight hours, or to Pacific Daylight Time subtract seven hours.

LAT North latitude of the epicenter, in degrees and minutes.

LONG West longitude of the epicenter, in degrees and minutes.

DEPTH The depth, given in kilometers, is usually freely calculated from the arrival-time data. In some instances, the depth must be fixed arbitrarily to obtain a convergent solution. Such depths are noted by an asterisk (*) in the column immediately following the depth. A $ or a # following the depth mean that the maximum number of iterations has been exceeded without meeting convergence tests and both the location and depth have been fixed.

MAG Coda-length magnitude M_c, an estimate of local magnitude M_L (Richter, C.F., 1958, Elementary Seismology: W.H. Freeman and Co., 768p), calculated using the coda-length/magnitude relationship determined for Washington (Crosson, R.S., 1972, Bull. Seism. Soc. Am., v. 62, p. 1133-1171). Where blank, data were insufficient for a reliable magnitude determination. Normally, the only earthquakes with undetermined magnitudes are very small ones. Magnitudes may be revised as we improve our analysis procedure.

NS/NP **NS** is the number of station observations, and **NP** the number of P and S phases used to calculate the earthquake location. A minimum of three stations and four phases are required. Generally, more observations improve the quality of the solution.

GAP Azimuthal gap. The largest angle (relative to the epicenter) containing no stations.

RMS The root-mean-square residual (observed arrival time minus predicted arrival time) at all stations used to locate the earthquake. It is only useful as a measure of the quality of the solution when 5 or more well-distributed stations are used in the solution. Good solutions are normally characterized by **RMS** values less than about 0.3 sec.

Q Two **Quality factors** indicate the general reliability of the solution (**A** is best quality, **D** is worst). Similar quality factors are used by the USGS for events located with the computer program HYPO71. The first letter is a measure of the hypocenter quality based on travel-time residuals. For example: **A** quality requires an **RMS** less than 0.15 sec while an **RMS** of 0.5 sec or more is **D** quality (estimates of the uncertainty in hypocenter location also affect this quality parameter). The second letter of the quality code depends on the spatial distribution of stations around the epicenter, i.e. number of stations, their azimuthal distribution, and the minimum distance (**DMIN**) from the epicenter to a station. Quality **A** requires a solution with 8 or more phases, **GAP** $\leq 90^\circ$ and **DMIN** $\leq$ (5 km or depth, whichever is greater). If the number of phases, **NP**, is 5 or fewer or **GAP** $> 180^\circ$ or **DMIN** $>$ 50 km the solution is assigned quality **D.**

MOD The crustal velocity model used in location calculations.

- **P3** - Puget Sound model
- **C3** - Cascade model
- **S3** - Mt. St. Helens model including Elk Lake
- **N3** - northeastern model
- **E3** - southeastern model
- **O0** - Oregon model
- **K3** - Southern Oregon, Klamath Falls area model
- **R0 and J1** - Regional and Offshore models

TYP Events flagged in Table 4 use the following code:

- **F** - earthquake reported to have been felt
- **P** - probable explosion
- **L** - low frequency earthquake (e.g. glacier movement, volcanic activity)
- **H** - handpicked from helicorder records
- **S** - Special event (e.g. rockslide, avalanche, volcanic steam emission, harmonic tremor, sonic boom), not a man-made explosion or tectonic earthquake
- **X** - known explosion

TABLE 4

Tectonic Earthquakes, Magnitude 2.0 or larger, Third Quarter, 2001.

Within an area 42-49.5 degrees north latitude and 117-125.3 degrees west longitude.

July 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	05:44:12.67	47 40.32	117 24.61	0.02*	2.8	7/07	218	0.32	CD	N3	F
1	05:45:43.24	47 40.15	117 24.19	0.50#	2.8	6/07	234	0.37	CD	N3	F
1	06:07:13.52	47 40.52	117 24.53	0.02*	2.3	7/07	209	0.33	CD	N3	F
3	04:37:31.69	48 37.81	122 30.56	16.37	2.5	29/33	96	0.25	BB	P3	
3	21:20:27.63	47 40.65	117 24.81	0.03*	2.2	16/16	80	0.20	BA	N3	F
7	02:03:14.86	47 30.15	122 18.58	24.80	2.3	54/58	32	0.13	AA	P3	
9	21:40:33.06	45 14.37	122 36.92	27.78	2.2	36/37	80	0.27	BA	O0	
20	07:38:24.06	43 31.50	121 44.38	8.36#	2.6	18/19	159	0.25	BD	O0	
22	15:13:52.43	47 05.28	122 41.13	52.41	4.3	87/102	33	0.23	BA	P3	F
24	13:31:06.56	47 29.56	122 01.23	16.44	2.2	50/54	33	0.15	BA	P3	F
24	17:57:02.41	47 39.83	120 01.44	7.13	2.0	28/35	43	0.30	CA	N3	
27	05:02:16.80	47 41.65	122 06.56	1.71	2.0	26/30	51	0.23	BB	P3	
29	06:26:53.84	47 44.49	117 27.68	0.55	2.1	6/07	139	0.22	BC	N3	F
31	01:38:11.76	47 44.00	117 27.55	0.45$	3.2	7/07	138	0.32	DC	N3	F
31	05:07:32.71	47 43.85	117 26.92	0.63	2.2	7/08	144	0.14	AC	N3	F

Aug 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	14:29:48.83	47 43.11	117 26.52	0.55	2.2	4/05	147	0.06	AD	N3	F
2	15:35:23.27	47 43.59	122 23.13	27.05	2.2	56/62	27	0.27	BA	P3	
13	11:47:28.75	48 15.59	120 01.54	7.17	2.3	18/20	245	0.41	CD	N3	
15	00:37:29.52	47 39.64	122 24.90	26.07	2.2	50/58	24	0.16	BA	P3	
19	06:17:32.96	48 15.04	121 36.88	1.69*	3.0	50/51	121	0.33	CC	C3	F
20	06:14:09.32	45 17.46	120 08.61	8.81#	2.1	12/12	245	0.27	BD	O0	
25	17:52:34.65	48 14.07	121 36.37	2.69	2.1	36/41	84	0.40	CC	C3	F
30	03:47:31.88	48 14.01	121 37.63	4.75$	2.7	54/65	81	0.47	CC	C3	F
31	14:39:17.47	47 01.54	121 52.16	17.86*	2.1	54/67	35	0.16	BA	C3	

Sept 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
6	21:40:44.16	45 47.14	124 32.51	35.09	2.9	12/13	225	0.32	CD	P3	
9	04:06:29.07	48 11.85	122 40.85	56.44	2.3	61/63	30	0.22	BA	P3	
10	21:46:58.66	47 20.56	123 03.01	46.15	2.3	58/60	35	0.25	BA	P3	
12	20:38:21.77	45 18.31	121 43.53	2.71	2.0	23/25	59	0.24	BB	O0	
12	21:26:43.19	45 18.22	121 43.53	4.52	2.3	29/30	51	0.21	BB	O0	
14	10:52:14.17	45 18.18	121 43.67	5.14	2.1	18/21	91	0.22	BB	O0	
14	11:22:57.98	45 18.43	121 43.84	5.16	2.9	35/35	70	0.28	BA	O0	
15	12:21:09.64	45 18.34	121 43.75	4.25	2.5	21/23	90	0.28	BB	O0	
15	19:51:03.95	47 42.58	120 04.49	2.92*	2.5	17/18	55	0.12	AB	N3	
21	11:59:04.70	46 50.69	120 41.60	15.97	2.3	28/33	58	0.18	BA	E3	
21	18:54:38.00	48 16.36	122 12.72	6.98$	2.1	25/29	50	0.23	BC	P3	
27	19:28:16.13	48 10.97	117 52.13	1.91	2.0	8/09	179	0.21	BC	N3	
28	18:34:53.83	47 41.01	117 23.36	1.78*	2.8	6/06	148	0.20	BC	N3	F
28	18:38:37.73	47 40.65	117 24.49	0.58	2.6	6/07	135	0.37	CC	N3	F

QUARTERLY NETWORK REPORT 2001-D
on
Seismicity of Washington and Oregon

October 1 through December 31, 2001

Pacific Northwest Seismograph Network
Dept. of Earth and Space Sciences
Box 351310
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Seattle, Washington 98195-1310

This report is prepared as a preliminary description of the seismic activity in Washington State and Oregon. Information contained in this report should be considered preliminary, and not cited for publication without checking directly with network staff. The views and conclusions contained in this document should not be interpreted as necessarily representing the official policies, either express or implied, of the U.S. Government.

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INTRODUCTION

This is the fourth quarterly report of 2001 from the University of Washington Dept. of Earth and Space Sciences *Pacific Northwest Seismograph Network* (PNSN), covering seismicity of Washington and western Oregon.

Comprehensive quarterlies have been produced by the PNSN since the beginning of 1984. Prior to that we published quarterly reports for western Washington in 1983 and for eastern Washington from 1975 to 1983. Annual technical reports covering seismicity in Washington since 1969 are available from the U.W. Dept. of Earth and Space Sciences. Beginning in 1999, the quarterly PNSN catalog listing changed; earthquakes smaller than magnitude 2.0 are no longer listed in the quarterly reports. The complete PNSN catalog is available on-line, both through our web-site and through the CNSS catalog. We will continue to provide special coverage (figures, counts, listings, etc.) of earthquake swarms, aftershock sequences, etc.

This quarterly report discusses network operations, seismicity of the region, unusual events or findings, and our educational and outreach activities. This report is preliminary, and subject to revision. The PNSN routinely records signals from selected stations in adjoining networks. This improves our ability to locate earthquakes at the edges of our network. However, our earthquake locations may be revised if new data become available. Findings mentioned in these quarterly reports should not be cited for publication.

NETWORK OPERATIONS

Figure 1A shows a map view of stations operating during the quarter. Figure 1B is a more detailed view of stations in the Puget Sound area. Figure 1C is a more detailed view of stations near Mt. St. Helens. Figure 1D is a more detailed view of stations in the Spokane area. Table 1 gives approximate periods of time when individual stations were inoperable. Data for Table 1 are compiled from weekly plots of network-wide teleseismic arrivals and automated and manual digital and analog signal checks, plus records of maintenance and repair visits.

Strong Motion Instrumentation and Recording Update

After the PNSN strong-motion team completed the installation of twenty new ANSS strong-motion instruments in the greater Puget Sound Region during the summer and fall, this quarter's activities were more routine. A few stations are being repaired and other communication problems are being worked on. Improved education and outreach pages for the strong-motion web site involving schools and school teachers in the community are also being created.

CREST Instrument Update

CREST (Consolidated Reporting of EarthquakeS and Tsumamis) instrumentation was installed at Forks, Washington in October.

The Bonneville Power Administration (BPA) has provided telemetry for four CREST stations at BPA power substations near the coast (3 along the Oregon coast, and one in southwestern Washington). BPA completed site preparation work at these four sites by the end of September and all four stations were installed in October. We are receiving data for two of the sites, TAKO and TOLO, but not for the other two, MEGW and HEBO. Collaboration with the technicians and Reftek staff should get data flowing at the beginning of 2002.

Temporary Spokane Stations

Seismic activity continued in Spokane throughout the fourth quarter, and temporary instruments were once again installed. Amy Lindemuth, Tom Yelin, and Bob Norris installed two temporary strong-motion instruments in November. The first is SGAR, Garfield Elementary School, which was installed on November 15, 2001. The second is SWES, Westview Elementary School, which was installed on November 16, 2001. Three other strong-motion stations were installed and are operated by Pete Swanson at the National Institute of Occupational Safety and Health in Spokane. Those stations are SNIO, SHLY, and SOPS. We receive SOPS in real-time. Data from SNIO and SHLY has been emailed to us and merged in with data from the other Spokane stations.

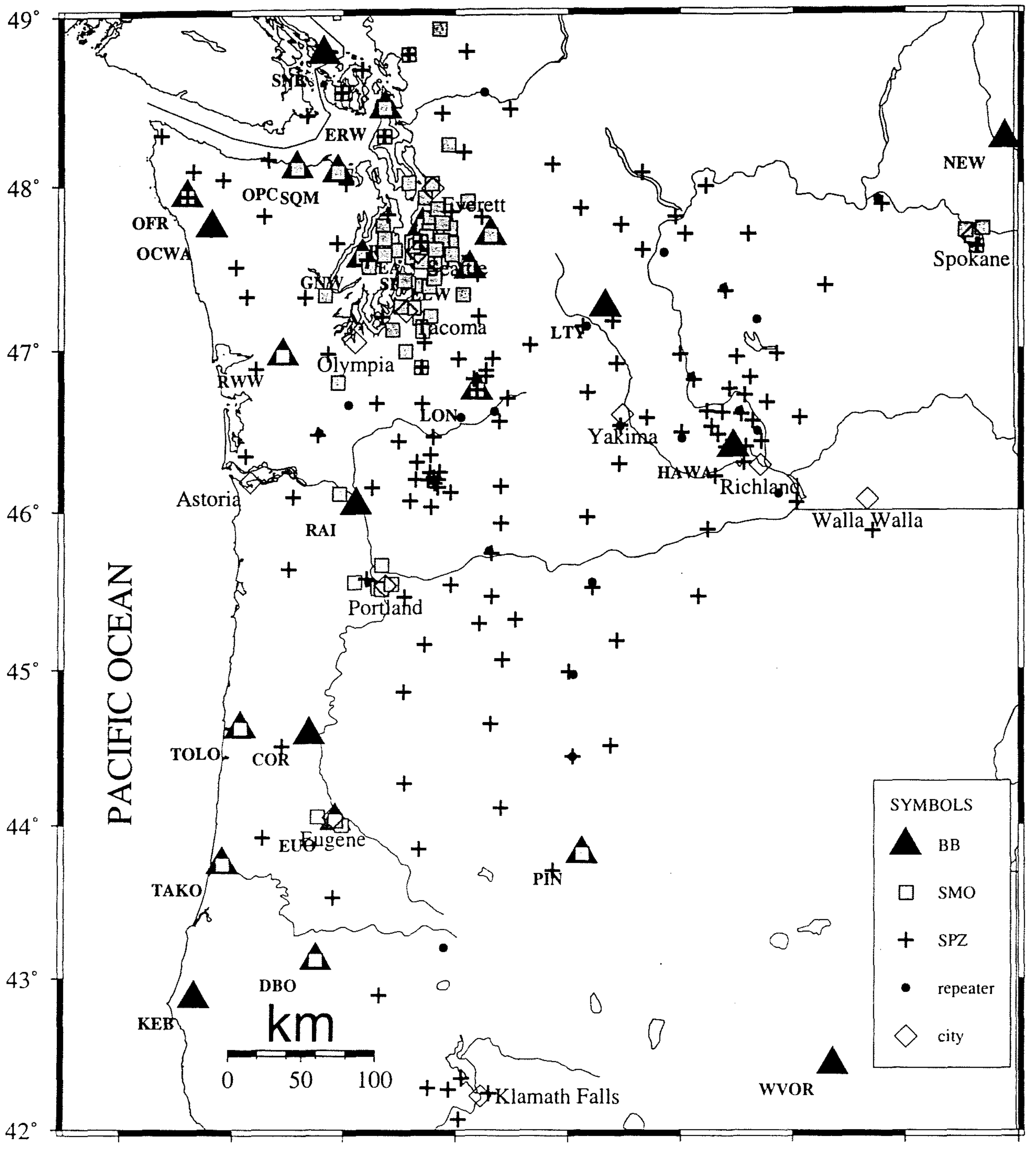

Figure 1A. Stations operating at the end of 4th quarter, 2001. Stations shown are short period vertical (SPZ), 3-component broadband (BB), or strong motion (SMO).

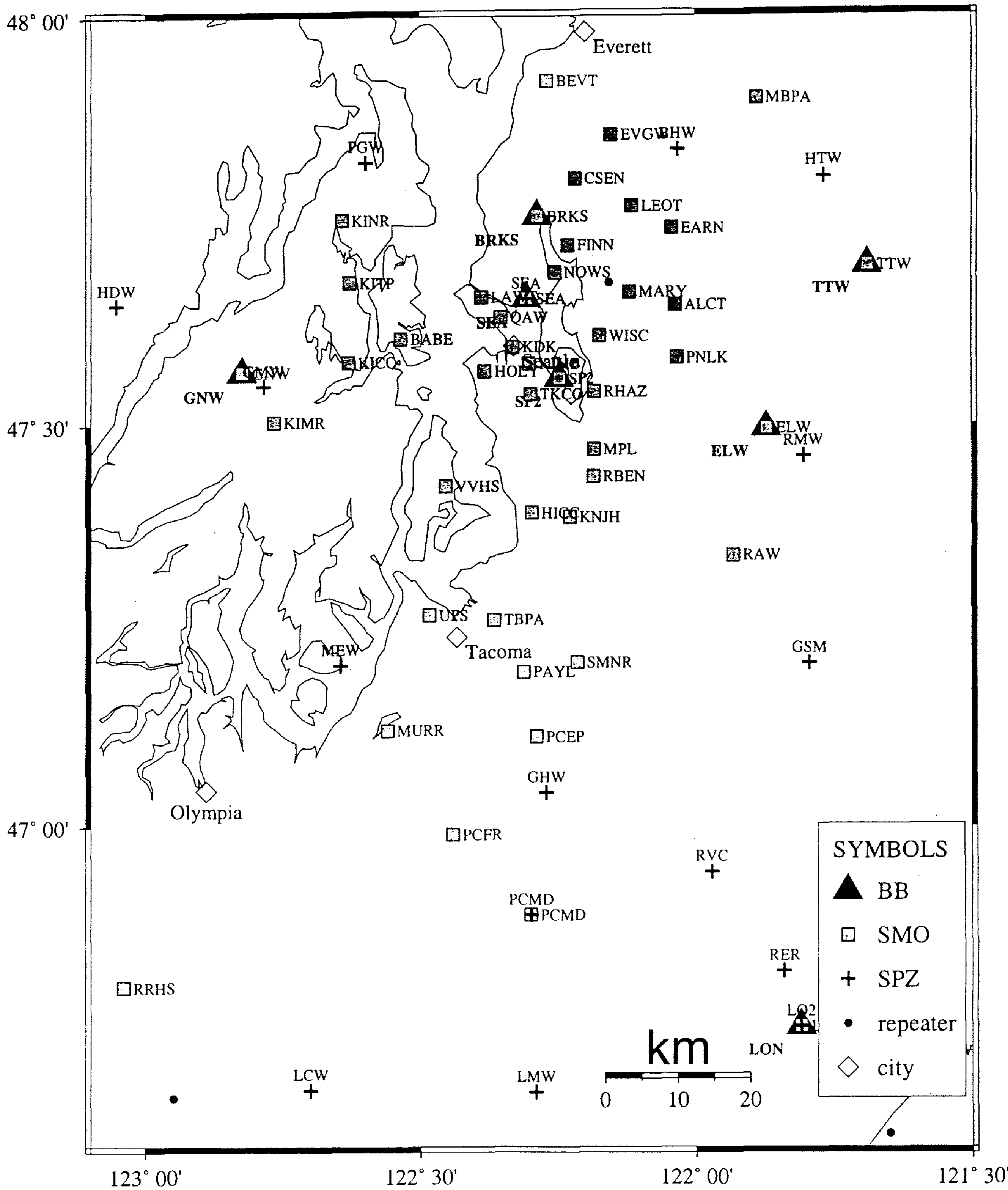

Figure 1B. Stations operating at the end of 4th quarter, 2001. Detail of Figure 1A.

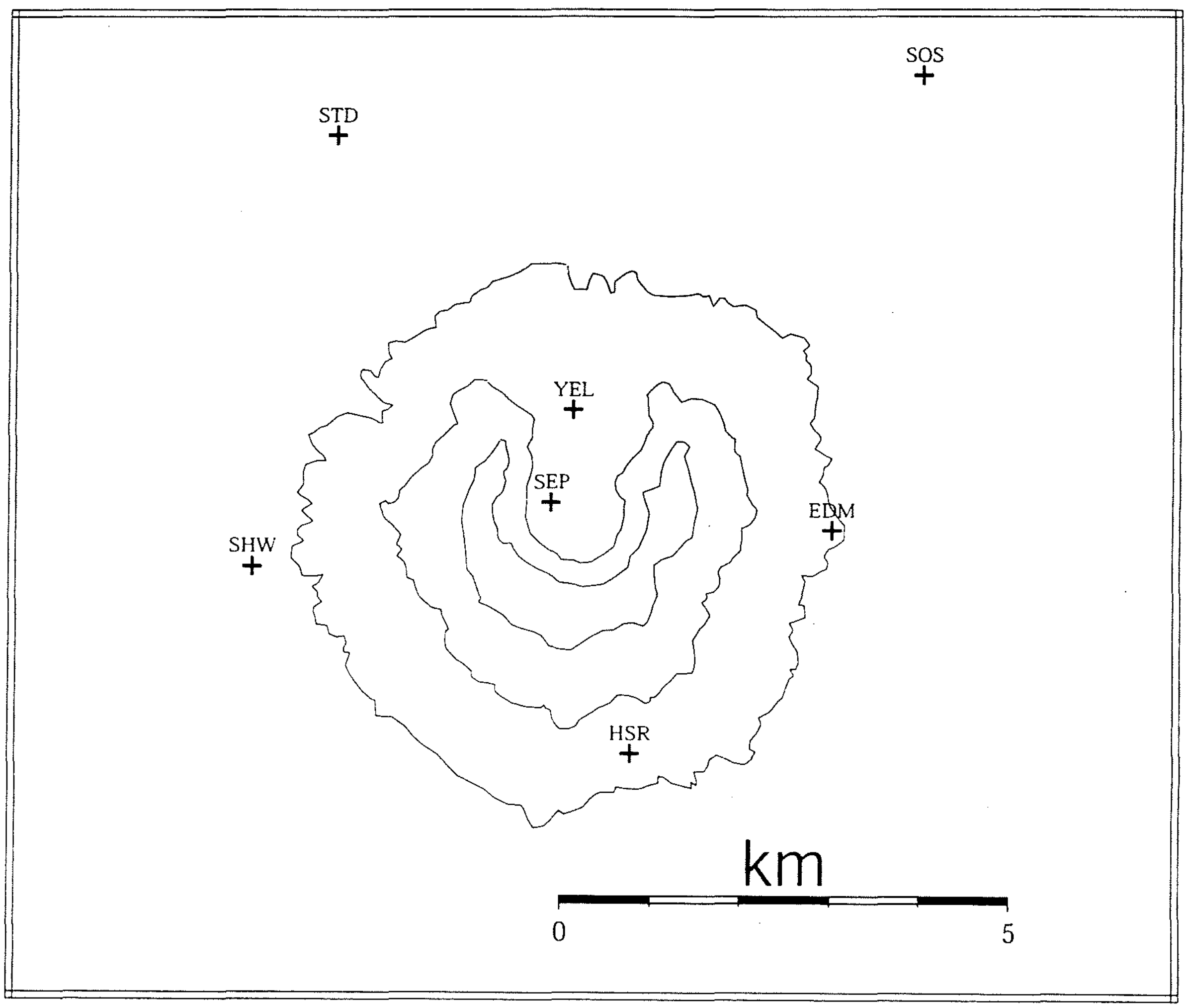

Figure 1C. Stations operating near Mt. St. Helens at the end of 4th quarter, 2001. Detail of Figure 1A. Station symbols as in Fig. 1A.

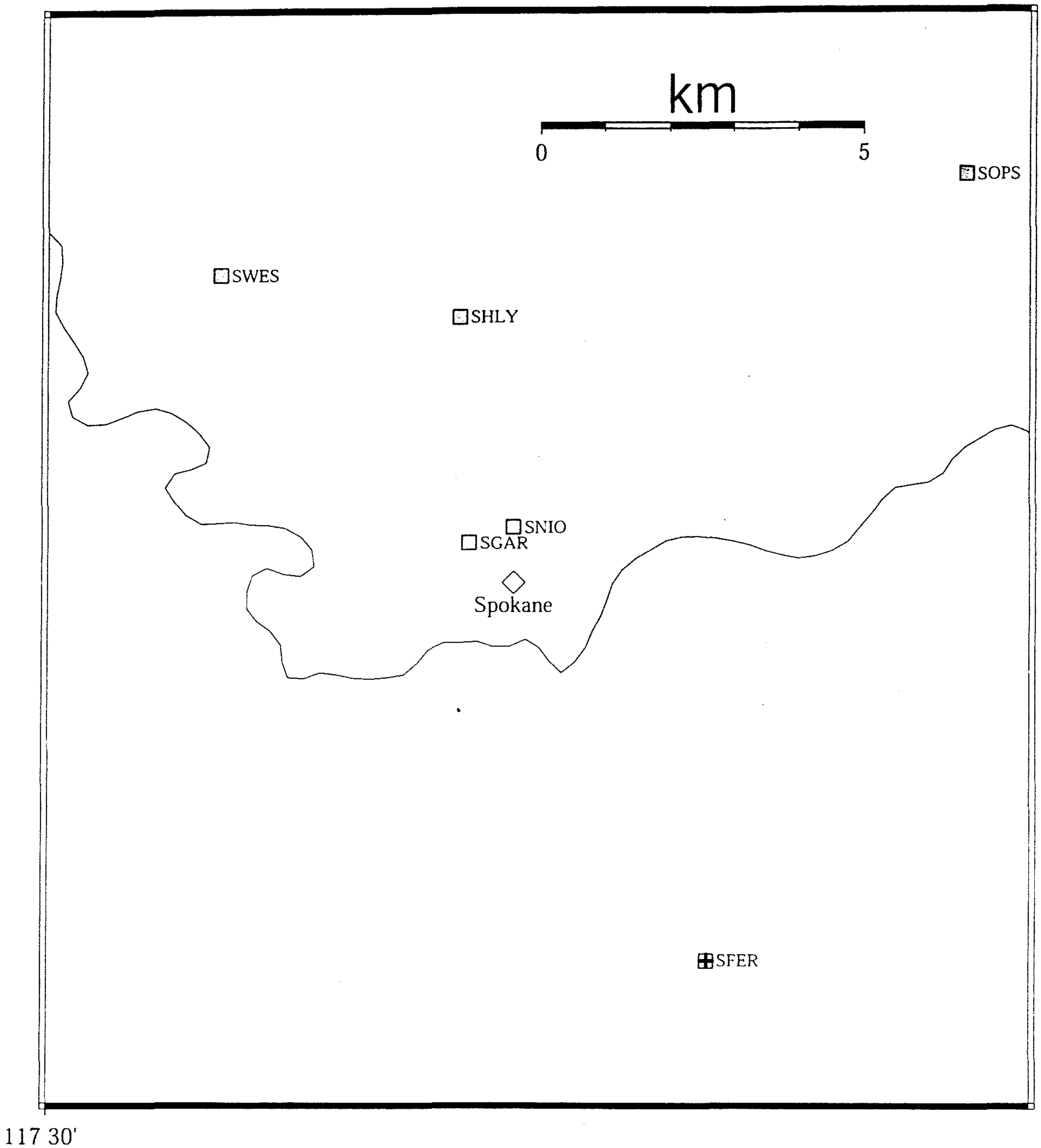

Figure 1D. Stations operating near Spokane at the end of 4th quarter, 2001. Detail of Figure 1A. Stations SGAR, SFER, SWES, and SOPS are telemetered to the PNSN in real-time. Stations SNIO and SHLY are not telemetered, but are recorded on-site. Data retrieved from SNIO and SHLY are e-mailed to the PNSN and merged with the real-time data. Station symbols as in Fig. 1A.

Other Station News

In interesting station news, short period station NLO had its seismometer and VCO changed because of a chewed through seismometer cable! Short period station OHW, Oak Harbor, was removed because a short period component was added to the strong-motion station SVOH, Skagit Valley Community College in Oak Harbor. Strong motion station TBPA, Tacoma BPA, was removed for repair because of flood damage from heavy rainfall.

Data Recording and EARTHWORM Update

This quarter, *scossa* remained our main EARTHWORM computer, with *milli* serving as our primary backup and *verme* as the secondary backup. *Milli* and *verme* still serve as the principal computers for data acquisition for many of the digital stations. We are currently running EARTHWORM-V5.1.

This quarter we completed the wiring for *pigia* our new Intel-based EARTHWORM digitizer running under Windows NT. The rewiring task was quite complex, but *pigia* is now digitizing data. *Pigia* will operate as an EARTHWORM node, exporting digitized data to *milli*. We are currently configuring the files that associate channel numbers with station and component names. Full integration of *pigia* into our data acquisition process is expected in the first quarter of 2002.

TABLE 1
Station Outages, Repairs, and Installations 4th quarter 2001

Station	Outage Dates	Comments
AUG	12/19/01-End	Noisy, not recording events
BOW	12/01/00-End	Dead because air cells have run down
BPO	12/13/01-End	Noisy, not recording events
CDF	12/13/01-End	Dead
EVCC	9/27/01-10/9/01	No power
EVCC	11/13/01	Removed to use in Spokane
EVCC	12/07/01	Installed new K2
GLK	12/19/01-End	Noisy, not recording events
GNW	10/15/01-10/31/01	Qwest replaced hardware
HDW	12/08/01-End	Dead
HEBO	10/01/01	Installed, no telemetry (CREST BB/SMO)
HOG	10/11/01	Replaced VCO
KDK	9/27/01-11/30/01	No GPS or telemetry
KICC	8/30/01-12/4/01	No GPS or telemetry
KITP	12/03/01-End	Removed for repair
KNJH	7/9/01-End	Intermittent telemetry
LCW	12/12/01-End	Dead
MARY	5/10/01-End	No GPS
MEGW	10/21/01	Installed, no telemetry (CREST BB/SMO)
MURR	10/23/01	Removed short period
NCO	11/07/01-End	Noisy, not recording events
NLO	12/1/00-10/01/01	Seismometer and VCO changed (seismometer cable had been chewed through)
OCP	7/01-End	Dead
OFR	10/18/01	Installed (SMO)
OFR	10/18/01-End	Bad timing (no GPS)
OHW	11/08/01	Removed (replaced by SVOH)
OOW	12/10/01-End	Dead
OSD	12/10/01-End	Dead
RCM	8/20/01-End	Seismically dead
RCS	10/11/01-12/21/01	Seismically dead (still intermittent)
RER	12/01/01-12/20/01	Offline possibly due to weather
RRHS	6/20/01-11/13/01	Intermittent telemetry
RRHS.EHZ	11/13/01-End	No telemetry
RVC	12/01/01-12/20/01	Offline possibly due to weather
RVN	12/04/01-12/18/01	Offline possibly due to weather
SFER	08/09/01-11/16/01	Replaced cable on the short period
SGAR	11/15/01	Installed (temporary SMO)
SHLY	11/16/01	Installed (Pete Swanson SMO)
SLF	11/20/01-End	Dead for winter
SNIO	11/16/01	Installed (Pete Swanson SMO)
SOPS	11/15/01	Installed (Pete Swanson SMO)
SSO	9/00-10/10/01	Seismometer and VCO changed
SVOH	11/20/01	Installed L4
SWES	11/16/01	Installed (temporary SMO)
TAKO	10/24/01	Installed (CREST BB/SMO)
TBPA	11/27/01-End	Removed for repair (flood damage)
TOLO	10/23/01	Installed (CREST BB/SMO)
VFP	12/23/01-End	Dead
WPW	5/15/01-End	Dead
WRW	11/20/01-End	Dead for winter

STATIONS USED FOR LOCATION OF EVENTS

Table 2A lists short-period, mostly vertical-component stations used in locating seismic events in Washington and Oregon. The first column in the table gives the 3-letter station designator, followed by a symbol designating the funding agency; stations marked by a percent sign (%) were supported by USGS joint operating agreement 01-HQ-AG-0011. A plus (+) indicates support under Pacific Northwest National Laboratory, Battelle contract 259116-A-B3. Stations designated "#" are USGS-maintained stations recorded at the PNSN. Stations designated by letters are operated by other networks, and telemetered to the PNSN. "M" stations are received from the Montana Bureau of Mines and Geology, "C" stations from the Canadian Pacific Geoscience Center, "U" stations from the US Geological Survey (usually USNSN stations), "N" stations from the USGS Northern California Network, and "H" stations from the Hanford Reservation via the Pacific Northwest National Labs. Other designation indicate support from other sources. Additional columns give station north latitude and west longitude (in degrees, minutes and seconds), station elevation in km, and comments indicating landmarks for which stations were named.

Table 2B lists broad-band stations used in locating seismic events in Washington and Oregon, and Table 2C lists strong-motion stations.

TABLE 2A - Short-period Stations operated by the PNSN during the fourth quarter 2001

STA	F	LAT	LONG	EL	NAME
ASR	%	46 09 09.9	121 36 01.6	1.357	Mt. Adams - Stagman Ridge
AUG	%	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BBO	%	42 53 12.6	122 40 46.6	1.671	Butler Butte, Oregon
BEN	1	46 31 12.0	119 43 18.0	0.335	W PNNL station
BHW	%	47 50 12.6	122 01 55.8	0.198	Bald Hill
BLN	%	48 00 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	%	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
BPO	%	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
BRO	%	44 16 02.5	122 27 07.1	0.135	Big Rock Lookout, Oregon
BRV	+	46 29 07.2	119 59 28.2	0.920	Black Rock Valley
BSMT	M	47 51 04.8	114 47 13.2	1.950	Bassoo Peak, MT
BUO	%	42 16 42.5	122 14 43.1	1.797	Burton Butte, Oregon
BVW	+	46 48 39.5	119 52 56.4	0.670	Beverly
CBS	+	47 48 17.4	120 02 30.0	1.067	Chelan Butte, South
CDF	%	46 07 01.4	122 02 42.1	0.756	Cedar Flats
CHMT	M	46 54 51.0	113 15 07.0	-	Chamberlain Mtn, MT
CMM	%	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.
CMW	%	48 25 25.3	122 07 08.4	1.190	Cultus Mtns.
CPW	%	46 58 25.8	123 08 10.8	0.792	Capitol Peak
CRF		46 49 30.0	119 23 13.2	0.189	Corfu
DPW	+	47 52 14.3	118 12 10.2	0.892	Davenport
DY2	+	47 59 06.6	119 46 16.8	0.890	Dyer Hill 2
EDM	%	46 11 50.4	122 09 00.0	1.609	East Dome, Mt. St. Helens
ELK	%	46 18 20.0	122 20 27.0	1.270	Elk Rock
ELL	+	46 54 34.8	120 33 58.8	0.789	Ellensburg
EPH	+	47 21 22.8	119 35 45.6	0.661	Ephrata
ET3	+	46 34 38.4	118 56 15.0	0.286	Eltopia (replaces ET2)
ETW	+	47 36 15.6	120 19 56.4	1.477	Entiat
FHE	+	46 57 06.9	119 29 49.0	0.455	Frenchman Hills East
FL2	%	46 11 47.0	122 21 01.0	1.378	Flat Top 2
FMW	%	46 56 29.6	121 40 11.3	1.859	Mt. Fremont
GBB	H	46 36 31.8	119 37 40.2	0.185	PNNL Station
GBL	+	46 35 54.0	119 27 35.4	0.330	Gable Mountain
GHW	%	47 02 30.0	122 16 21.0	0.268	Garrison Hill
GL2	+	45 57 35.0	120 49 22.5	1.000	New Goldendale
GLK	%	46 33 27.6	121 36 34.3	1.305	Glacier Lake
GMO	%	44 26 20.8	120 57 22.3	1.689	Grizzly Mountain, Oregon
GMW	%	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GPW	%	48 07 05.0	121 08 12.0	2.354	Glacier Peak
GSM	%	47 12 11.4	121 47 40.2	1.305	Grass Mt.
GUL	%	45 55 27.0	121 35 44.0	1.189	Guler Mt.
H2O	H	46 23 45.0	119 25 22.0	-	Water PNNL Station
HAM	%	42 04 08.3	121 58 16.0	1.999	Hamaker Mt., Oregon
HBO	%	43 50 39.5	122 19 11.9	1.615	Huckleberry Mt., Oregon
HDW	%	47 38 54.6	123 03 15.2	1.006	Hoodsport
HOG	%	42 14 32.7	121 42 20.5	1.887	Hogback Mtn., Oregon
HSO	%	43 31 33.0	123 05 24.0	1.020	Harness Mountain, Oregon
HSR	%	46 10 28.0	122 10 46.0	1.720	South Ridge, Mt. St. Helens
HTW	%	47 48 14.2	121 46 03.5	0.833	Haystack Lookout
HUO	%	44 07 10.9	121 50 53.5	2.037	Husband OR (UO)
JBO	+	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JCW	%	48 11 42.7	121 55 31.1	0.792	Jim Creek
JUN	%	46 08 50.0	122 09 04.4	1.049	June Lake
KMO	%	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	%	46 27 46.7	122 11 41.3	0.610	Kosmos
KTR	N	41 54 31.2	123 22 35.4	1.378	CAL-NET
LAB	%	42 16 03.3	122 03 48.7	1.774	Little Aspen Butte, Oregon
LAM	N	41 36 35.2	122 37 32.1	1.769	CAL-NET
LCCM	M	45 50 16.8	111 52 40.8	1.669	Lewis and Clark Caverns, MT
LCW	%	46 40 14.4	122 42 02.8	0.396	Lucas Creek
LMW	%	46 40 04.8	122 17 28.8	1.195	Ladd Mt.

LNO	+	45 52 18.6	118 17 06.6	0.771	Lincton Mt., Oregon
LO2	%	46 45 00.0	121 48 36.0	0.853	Longmire
LOC	+	46 43 01.2	119 25 51.0	0.210	Locke Island
LVP	%	46 03 59.4	122 24 10.2	1.134	Lakeview Peak
MBW	%	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCMT	M	44 49 39.6	112 50 55.8	2.323	McKenzie Canyon, MT
MCW	%	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MDW	+	46 36 47.4	119 45 39.6	0.330	Midway
MEW	%	47 12 07.0	122 38 45.0	0.097	McNeil Island
MJ2	+	46 33 27.0	119 21 32.4	0.146	May Junction 2
MOX	+	46 34 38.4	120 17 53.4	0.501	Moxie City
MPO	%	44 30 17.4	123 33 00.6	1.249	Mary's Peak, Oregon
MTM	%	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
NAC	+	46 43 59.4	120 49 25.2	0.728	Naches
NCO	%	43 42 14.4	121 08 18.0	1.908	Newberry Crater, Oregon
NEL	+	48 04 12.6	120 20 24.6	1.500	Nelson Butte
NLO	%	46 05 21.9	123 27 01.8	0.826	Nicolai Mt., Oregon
OBC	%	48 02 07.1	124 04 39.0	0.938	Olympics - Bonidu Creek
OBH	%	47 19 34.5	123 51 57.0	0.383	Olympics - Burnt Hill
OCP	%	48 17 53.5	124 37 30.0	0.487	Olympics - Cheeka Peak
OD2	+	47 23 15.6	118 42 34.8	0.553	Odessa site 2
OFR	%	47 56 00.0	124 23 41.0	0.152	Olympics - Forest Resource Cen
OHW	%	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ON2	%	46 52 50.8	123 46 51.8	0.257	Olympics - North River
OOW	%	47 44 03.6	124 11 10.2	0.561	Octopus West
OSD	%	47 48 59.2	123 42 13.7	2.008	Olympics - Snow Dome
OSR	%	47 30 20.3	123 57 42.0	0.815	Olympics Salmon Ridge
OT3	+	46 40 08.4	119 13 58.8	0.322	New Othello (replaces OT2 8/26
OTR	%	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PAT	+	45 52 55.2	119 45 08.4	0.262	Paterson
PCMD	%	46 53 20.9	122 18 00.9	0.239	PC Mountain Detachment ANSS-SM
PGO	%	45 27 42.6	122 27 11.5	0.253	Gresham, Oregon
PGW	%	47 49 18.8	122 35 57.7	0.122	Port Gamble
PRO	+	46 12 45.6	119 41 08.4	0.553	Prosser
RCM	%	46 50 08.9	121 43 54.4	3.085	Mt. Rainier, Camp Muir
RCS	%	46 52 15.6	121 43 52.0	2.877	Mt. Rainier, Camp Schurman
RED	H	46 17 51.0	119 26 15.6	0.330	Red Mountain PNNL Station
RER	%	46 49 09.2	121 50 27.3	1.756	Mt. Rainier, Emerald Ridge
RMW	%	47 27 35.0	121 48 19.2	1.024	Rattlesnake Mt. (West)
RNO	%	43 54 58.9	123 43 25.5	0.850	Roman Nose, Oregon
RPW	%	48 26 54.0	121 30 49.0	0.850	Rockport
RRHS	%	46 47 58.6	123 02 25.4	0.047	Rochester HS ANSS-SMO
RSW	+	46 23 40.2	119 35 28.8	1.045	Rattlesnake Mt. (East)
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
RVN	%	47 01 38.6	121 20 11.9	1.885	Raven Roost (former NEHRP temp
RVW	%	46 08 53.2	122 44 32.1	0.460	Rose Valley
SAW	+	47 42 06.0	119 24 01.8	0.701	St. Andrews
SBES	%	48 46 05.9	122 24 54.2	0.119	Silver Beach ES SMO
SEA	%	47 39 15.8	122 18 29.3	0.030	UW, Seattle (Wood Anderson BB
SEP	#	46 12 00.7	122 11 28.1	2.116	September lobe, Mt. St. Helens
SFER	%	47 37 10.4	117 21 55.7	-	Spokane Schools, Ferris High S
SHW	%	46 11 37.1	122 14 06.5	1.425	Mt. St. Helens
SLF	%	47 45 32.0	120 31 40.0	1.750	Sugar Loaf
SMW	%	47 19 10.7	123 20 35.4	0.877	South Mtn.
SNI	H	46 27 80.0	119 39 50.0	-	PNNL station
SOS	%	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
SSO	%	44 51 21.6	122 27 37.8	1.242	Sweet Springs, Oregon
STD	%	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	%	48 09 03.1	123 40 11.1	0.308	Striped Peak
SVOH	%	48 17 21.8	122 37 54.8	0.010	Skagit Valley CC ANSS-SMO
TBM	+	47 10 12.0	120 35 52.8	1.006	Table Mt.
TCO	%	44 06 27.6	121 36 02.1	1.975	Three Creek Meadows, Oregon.
TDH	%	45 17 23.4	121 47 25.2	1.541	Tom,Dick,Harry Mt., Oregon
TDL	%	46 21 03.0	122 12 57.0	1.400	Tradedollar Lake
TRW	+	46 17 32.0	120 32 31.0	0.723	Toppenish Ridge
TWW	+	47 08 17.4	120 52 06.0	1.027	Teanaway
UWFH	%	48 32 46.0	123 00 43.0	0.010	UW Friday Harbor ANSS-SMO
VBE	%	45 03 37.2	121 35 12.6	1.544	Beaver Butte, Oregon
VCR	%	44 58 58.2	120 59 17.4	1.015	Criterion Ridge, Oregon
VDB	C	49 01 34.0	122 06 10.1	0.404	Canada
VFP	%	45 19 05.0	121 27 54.3	1.716	Flag Point, Oregon
VG2	%	45 09 20.0	122 16 15.0	0.823	Goat Mt., Oregon
VGB	+	45 30 56.4	120 46 39.0	0.729	Gordon Butte, Oregon
VGZ	C	48 24 50.0	123 19 27.8	0.067	Canada
VIP	%	44 30 29.4	120 37 07.8	1.731	Ingram Pt., Oregon
VLL	%	45 27 48.0	121 40 45.0	1.195	Laurance Lk., Oregon
VLM	%	45 32 18.6	122 02 21.0	1.150	Little Larch, Oregon
VSP	%	42 20 30.0	121 57 00.0	1.539	Spence Mtn, Oregon
VT2	+	46 58 02.4	119 59 57.0	1.270	Vantage2
VTH	%	45 10 52.2	120 33 40.8	0.773	The Trough, Oregon
WA2	+	46 45 19.2	119 33 56.4	0.244	Wahluke Slope
WAT	+	47 41 55.2	119 57 14.4	0.821	Waterville
WIB	%	46 20 34.8	123 52 30.6	0.503	Willapa Bay
WIW	+	46 25 45.6	119 17 15.6	0.128	Wooded Island
WPO	%	45 34 24.0	122 47 22.4	0.334	West Portland, Oregon
WPW	%	46 41 55.7	121 32 10.1	1.280	White Pass
WRD	+	46 58 12.0	119 08 41.4	0.375	Warden
WRW	%	47 51 26.0	120 52 52.0	1.189	Wenatchee Ridge
YA2	+	46 31 36.0	120 31 48.0	0.652	Yakima
YEL	#	46 12 35.0	122 11 16.0	1.750	Yellow Rock, Mt. St Helens
YPT	+	46 02 55.8	118 57 44.0	0.325	Yellepit

TABLE 2B

Broad-band three-component stations operating at the end of the fourth quarter 2001. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME
BRKS	%	47 45 19.1	122 17 17.9	0.020	Brookside ANSS-SMO
COR	U	44 35 08.5	123 18 11.5	0.121	Corvallis, Oregon (OSU BB)
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon (UO CREST
ELW	%	47 29 39.4	121 52 17.2	0.267	EchoLakeBPA BB-SMO-IDS20
ERW	%	48 27 14.4	122 37 30.2	0.389	Mt. Erie SMO-IDS24 BB
EUO	%	44 01 45.7	123 04 08.2	0.160	Eugene,OR U0 CREST BB SMO
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mt CREST BB SMO
HAWA	U	46 23 32.3	119 31 57.2	0.367	Hanford Nike USNSN BB
HLID	U	43 33 45.0	114 24 49.3	1.772	Hailey, ID USNSN BB
KSXB	N	41 49 51.0	123 52 33.0	-	Camp Six, OR CREST BB
KEB	N	42 52 20.0	124 20 03.0	0.818	Edson Butte, OR CREST BB
KRMB	N	41 31 23.0	123 54 29.0	1.265	Red Mtn, OR CREST BB
LON	%	46 45 00.0	121 48 36.0	0.853	Longmire CREST BB LONLZ SMO
LTY	%	47 15 21.2	120 39 53.3	0.970	Liberty (BB)
NEW	U	48 15 50.0	117 07 13.0	0.760	Newport Observatory USNSN BB
OCWA	U	47 44 56.0	124 10 41.2	0.671	Octopus Mtn. USNSN BB
OFR	%	47 56 00.0	124 23 41.0	0.152	Olympics - Forest Resource Cen
OPC	%	48 06 01.0	123 24 41.8	0.090	Olympic Penn College CREST BB
PIN	%	43 48 40.0	120 52 19.0	1.865	Piñe Mt., Oregon (U0 CREST, B
PNT	C	49 18 57.6	119 36 57.6	0.550	Canada, BB
RAI		46 02 25.1	122 53 06.4	1.520	Trojan Plant, Oregon (OSU BB)
RWW	%	46 57 53.7	123 32 31.7	0.015	Ranney Well CREST BB SMO
SEA	%	47 39 15.8	122 18 29.3	0.030	UW, Seattle (Wood Anderson BB
SNB	C	48 46 33.6	123 10 16.3	0.408	Canada BB
SP2	%	47 33 23.3	122 14 52.8	0.030	Seward Park, Seattle SMO-IDS24
SQM	%	48 04 39.0	123 02 44.0	0.030	Sequim, WA (CREST BB SMO)
TAKO	%	43 44 36.0	124 04 56.0	0.100	Tahkenitch, OR CREST BB SMO
TOLO	%	44 37 19.0	123 55 21.0	0.100	Toledo BPA, OR CREST BB SMO
TTW	%	47 41 40.7	121 41 20.0	0.542	Tolt Res, WA CREST BB SMO
WVOR	U	42 26 02.0	118 38 13.0	1.344	Wildhorse Valley, Oregon (USNS

OUTREACH ACTIVITIES

The PNSN Seismology Lab staff provides an educational outreach program to better inform the public, educators, businesses, policy makers, and the emergency management community about seismicity and natural hazards. Our outreach includes lab tours, lectures, classes and workshops, press conferences, TV and radio news programs and talk shows, field trips, and participation in regional earthquake planning efforts. We provide basic information through information sheets, an audio library, and the Internet on the World-Wide-Web (WWW):

http://www.ess.washington.edu/SEIS/PNSN

Telephone, Mail, and On-line outreach

The PNSN audio library system received about 325 calls this quarter. Our audio library provides several recordings. frequently updated message on current seismic activity. In addition we have a tape describing the seismic hazards in Washington and Oregon, and another on earthquake prediction. Callers often request our one-page information and resource sheet on seismic hazards in Washington and Oregon. Thousands of these have been mailed out or distributed, and we encourage others to reproduce and further distribute this sheet. Our information sheet discussing earthquake prediction is also frequently requested. Callers to the audio library can also choose to be transferred to the Seismology Lab, where additional information is available. This quarter we responded in person to: ~20 calls from emergency managers and government, ~50 calls from the media, ~15 calls from educators ~20 calls from the business community, and about 66 calls from the general public.

Internet outreach

The PNSN web-site offers many web pages, including maps and lists of the most recent PNW earthquakes, general information on earthquakes and PNW earthquake hazards, information on past damaging PNW earthquakes, and catalogs of earthquake summary cards. Web-pages on seismicity of Cascade Volcanos, and Quarterly summaries of seismicity are also included. The PNSN recent earthquake list is available through the World-Wide-Web (WWW) at:

http://www.ess.washington.edu/SEIS/PNSN

"Webicorder" pages show continuous data from PNSN seismographic stations:

http://www.ess.washington.edu/SEIS/PNSN/WEBICORDER/

ShakeMap shows maps of instrumentally measured shaking. Table 3A indicates which events this quarter generated ShakeMaps.

Shake Maps: **http://www.ess.washington.edu/shake/index.html**

Table 2C lists strong-motion, three-component stations operating in Washington and Oregon that provide data in real or near-real time to the PNSN.. Several of these stations also have broad-band instruments, as noted. The "SENSOR" field designates what type of seismic sensor is used;

- A = Terra-Tech SSA-320 SLN triaxial accelerometer/Terra-Tech IDS24
- A20 = Terra-Tech SSA-320 triaxial accelerometer/Terra-Tech IDS20 recording system,
- FBA23 = Kinemetrics FBA23 accelerometers and Reftek recording system,
- EPI = Kinemetrics Episensor accelerometers and Reftek recording system.
- BB = Guralp CMG-40T 3-D broadband velocity sensor.
- BB3 = Guralp CMG3T 3-D broadband velocity sensor.
- BBZ = Broad Band sensor, PMD 2024, vertical component only.
- K2 = Kinemetrics Episensor accelerometers and K2 Recording System

The "TELEMETRY" field indicates the type of telemetry used to recover the data.

- D = dial-up,
- E = continuously telemetered via Internet from a remote EARTHWORM system
- I = continuously telemetered via Internet,
- L = continuously telemetered via dedicated lease-line telephone lines,
- L-PPP = continuously telemetered via dedicated lease-line telephone lines using PPP protocol
- M = continuously telemetered via BPA microwave
- R = continuously telemetered via spread-spectrum radio

TABLE 2C

Strong-motion three-component stations operating at the end of the fourth quarter 2001. Symbols are as in Table 2A.

STA	F	LAT	LONG	EL	NAME	SENSORS	TELEMETRY
ALCT	%	47 38 48.8	122 2 15.7	0.055	Alcott Elementary	K2	I
ALST	%	46 6 32.3	123 1 58.5	0.198	Alston	A20	E,M
ALVY	%	43 59 53.2	123 0 57.0	0.155	Alvey	K2	E,M
ATES	%	48 14 10.9	122 3 33.0	0.010	Trafton Elementary	K2	I
BABE	%	47 36 21.0	122 32 7.0	0.010	Blakely Elementary	K2	I
BEVT	%	47 55 12.0	122 16 12.0	0.170	Boeing Plant Everett	K2	I
BRKS	%	47 45 19.1	122 17 17.9	0.020	Brookside Elementary	K2,BBZ	I
CSEN	%	47 48 4.5	122 13 6.5	0.055	Crystal Springs Elementary	K2	I
CSO	#	45 31 1.0	122 41 22.5	0.036	Canyon	FBA23	D
DBO	%	43 7 9.0	123 14 34.0	0.984	Dodson Butte (CREST)	EPI,BB3	E,L-PPP
EARN	%	47 44 27.2	122 2 37.7	0.159	East Ridge Elementary	K2	I
EGRN	%	47 4 24.0	122 58 41.0	0.010	Evergreen State College	K2	None
ELW	%	47 29 39.4	121 52 17.2	0.267	Echo Lake	A,BB	D,M,L
ERW	%	48 27 14.4	122 37 30.2	0.389	Mount Erie	A,BB	D,L,M
EUO	%	44 1 45.7	123 4 8.2	0.160	Eugene Golf Course (CREST)	EPI,BB	E,L-PPP
EVCC	%	48 0 27.0	122 12 15.3	0.000	Everett Community College	K2	None
EVGW	%	47 51 15.8	122 9 12.2	0.010	Gateway Middle School	K2	I
FINN	%	47 43 10.2	122 13 55.9	0.121	Finn Hill Junior High	K2	I
GNW	%	47 33 51.8	122 49 31.0	0.165	Green Mountain (CREST)	EPI,BB3	L-PPP
HAO	#	45 30 33.1	122 39 24.0	0.018	Harrison	FBA23	D
HICC	%	47 23 24.4	122 17 52.4	0.115	Highline Community College	K2	I
HOLY	%	47 33 55.4	122 23 1.0	0.106	Holy Rosary School	K2	I
KDK	%	47 35 42.7	122 19 56.0	0.004	King Dome	K2	None
KEEL	%	45 33 0.8	122 53 42.4	0.067	Keeler	A20	D,E,M
KICC	%	47 34 37.9	122 37 52.4	0.010	Kitsap County Central Communications	K2	None
KIMB	%	47 34 29.3	122 18 10.1	0.069	Kimball Elementary	K2	I
KIMR	%	47 30 11.0	122 46 2.0	0.123	Moderate Risk Waste Collection Facility	K2	I
KINR	%	47 45 6.0	122 38 35.0	0.010	North Road Shed	K2	I
KITP	%	47 40 30.0	122 37 47.0	0.076	Wastewater Treatment Plant	K2	I
KNJH	%	47 23 5.0	122 13 42.0	0.010	Kent Junior High	K2	None
LANE	%	44 3 6.5	123 13 54.8	0.120	Lane	K2	E,M
LAWT	%	47 39 23.4	122 23 21.9	0.050	Lawton Elementary	A20	I
LEOT	%	47 46 4.4	122 6 56.2	0.115	Leota Junior High	K2	I
LON	%	46 45 0.0	121 48 36.0	0.853	Longmire Springs (CREST)	EPI,BB3	L-PPP
LTY	%	47 15 21.2	120 39 53.4	0.970	Liberty Heights Mine (CREST)	BB3	I
MARY	%	47 39 45.7	122 7 11.6	0.011	Marymoor Park	K2	I
MBKE	%	48 55 2.0	122 8 29.0	1.010	Kendall Elementary	K2	I
MBPA	%	47 53 54.7	121 53 20.2	0.186	Monroe	A20	D,M,L
MPL	%	47 28 7.0	122 11 4.5	0.122	Maple Valley	A	D,M,L
MURR	%	47 7 12.0	122 33 36.0	0.100	Camp Murray	K2	None
NOWS	%	47 41 12.0	122 15 21.2	0.002	NOAA Sand Point	A20	I
OHC	%	47 20 2.0	123 9 29.0	0.010	Hood Canal Junior High	K2	I
OPC	%	48 6 1.0	123 24 41.8	0.090	Peninsula College (CREST)	EPI,BB	I
PAYL	%	47 11 34.0	122 18 46.0	0.010	Aylen Junior High	K2	I
PCEP	%	47 6 41.8	122 17 24.0	0.160	Puyallup East Sheriff Precinct	K2	I
PCFR	%	46 59 23.3	122 26 27.4	0.137	Roy Training Center	K2	I
PCMD	%	46 53 20.9	122 18 0.9	0.239	Mountain Detachment	K2	I
PIN	%	43 48 40.0	120 52 19.0	1.865	Pine Mtn. (CREST)	EPI,BB3	E,L-PPP
PNLK	%	47 34 54.5	122 2 1.0	0.128	Pine Lake Middle School	K2	I
QAW	%	47 37 54.3	122 21 15.5	0.140	Queen Anne	A20	L
RAW	%	47 20 14.0	121 55 53.2	0.208	Raver	A20	M,L
RBEN	%	47 26 6.7	122 11 10.0	0.152	Benson Hill Elementary	K2	I
RBO	#	45 32 27.0	122 33 51.5	0.158	Rocky Butte	FBA23	D
RHAZ	%	47 32 24.7	122 11 1.3	0.108	Hazelwood Elementary	A20	I
ROSS	%	45 39 43.0	122 39 25.0	0.061	Ross	A20	E
RRHS	%	46 47 58.6	123 2 25.4	0.047	Rochester High School	K2	I
RWW	%	46 57 53.7	123 32 31.7	0.015	Ranney Well (CREST)	EPI,BB3	L-PPP
SBES	%	48 46 5.9	122 24 54.2	0.119	Silver Beach Elementary School	K2	I
SEA	%	47 39 15.8	122 18 29.3	0.030	University of Washington	A20,PMD2023	L
SFER	%	47 37 10.4	117 21 55.7	0.000	Ferris High School	K2	I
SGAR	%	47 40 37.8	117 24 50.3	0.579	Garfield Elementary	K2	I
SMNR	%	47 12 16.6	122 12 53.4	0.010	Sumner High School	K2	I
SP2	%	47 33 23.3	122 14 52.8	0.030	Seward Park	A,BB	L
SQM	%	48 4 39.0	123 2 44.0	0.030	Sequim Battelle Properties (CREST)	EPI,BB	I,R
SVOH	%	48 17 21.8	122 37 54.8	0.010	Skagit Valley College Oak Harbor	K2	I
SWES	%	47 42 51.0	117 27 53.2	0.623	Westview Elementary	K2	I
SWID	%	48 0 31.0	122 24 42.0	0.010	South Whidbey Primary School	K2	I
TAKO	%	43 44 36.0	124 4 56.0	0.100	Tahkenitch (CREST)	EPI,BB	Microwave,E
TBPA	%	47 15 29.0	122 22 1.0	0.002	Tacoma	A20	M,L,D
TKCO	%	47 32 12.7	122 18 1.5	0.005	King County Airport	A20	I
TOLO	%	44 37 19.0	123 55 21.0	0.100	Toledo (CREST)	EPI,BB	Microwave,E
TTW	%	47 41 40.7	121 41 20.0	0.542	Tolt Reservoir (CREST)	EPI,BB3	I
UPS	%	47 15 50.2	122 29 1.1	0.113	University of Puget Sound	K2	I
UWFH	%	48 32 46.0	123 0 43.0	0.010	Friday Harbor Laboratories	K2	I
VVHS	%	47 25 25.1	122 27 13.1	0.095	Vashon High School	K2	I
WISC	%	47 36 32.0	122 10 27.8	0.056	Wilburton Instructional Services Center	K2	I

Table 3A also indicates the felt events this quarter that generated Community Internet Intensity Maps (CIIM). CIIM maps are made using Internet reports. For a well-felt event hundreds (or thousands) of people fill out an on-line form describing their experiences during the earthquake. These "felt" reports are converted into numeric intensity values, and the CIIM map shows the average intensity by zip code.

CIIM Maps: **http://pasadena.wr.usgs.gov/shake/pnw/**

In addition to the PNSN web site, the UW Dept. of Earth and Space Sciences and the PNSN host several other earthquake-related web sites:

- **Volcano Systems Center**: **http://www.vsc.washington.edu** is a cooperative effort of the UW and the USGS that links volcano-related activities of the UW Dept. of Earth and Space Sciences and Oceanography departments with related USGS activities.
- **Seismosurfing**: **http://www.ess.washington.edu/seismosurfing.html** is a comprehensive listing of sites worldwide that offer substantive seismology data and information. This page is mirrored at two sites in Europe.
- The **Council of the National Seismic Systems** (CNSS): **http://www.cnss.org** features composite listings and maps of recent U.S. earthquakes, and documentation of the EARTHWORM system.
- **"Tsunami!"** : **http://www.ess.washington.edu/tsunami** offers many pages, including an excellent discussion on the physics of tsunamis, and short movie clips. It was developed by Benjamin Cook under the direction of Dr. Catherine Petroff (UW Civil Engineering).
- **The UW Dept. of Earth and Space Sciences Global Positioning System (GPS):**
  http://www.ess.washington.edu/GPS/gps.html
  site provides information on geodetic studies of crustal deformation in Washington and Oregon.

Events, Meetings, and Presentations

PNSN staff continued to provide information to the public and to work with organizations whose goals and objectives are in line with the PNSN mission. Below is a summary of activities.

Scientific:

- Steve Malone gave an invited lecture at the Geological Survey of Canada in Vancouver, BC entitled "Magma recharge at Cascade Volcanos".
- Steve Malone participated in a one-day review meeting at CVO on the volcanic situation at Three-Sisters Volcano.
- At the AGU meetings this year, Steve Malone participated in a number of "sub-meetings" on the ANSS, IRIS Board of Directors and on the formation of a "Consortium of US Volcano Observatories" (CUSVO)

Mitigation and Emergency Management:

- Tony Qamar and Bill Steele attended a meeting of Washington State Seismic Safety Committee. Dr. Qamar chairs the Information and Technology Subcommittee, one of four working groups.
- Steve Malone and Tony Qamar met with the Washington State Emergency Management officials to discuss state participation in and support of earthquake information services of the PNSN.
- Bill Steele participated in numerous CREW Executive board meetings developing a scope of work for 2002 and in preparation of "The Business of Earthquakes" conference.
- Bill Steele gave talks to the Boeing Management Association at Boeing Field, the Washington Insurance Council at Safeco Plaza, and at two locations for Seattle Public Utilities.

Education:

- PNSN staff provided 12 Seismology Lab tours and presentations for k-12 students and teachers serving ~300 people.
- Amy Lindemuth continued to work with a team (four) of local educators on content for an upcoming web area dedicated to seismology related educational material. In addition, Amy has established an e-mail distribution list for educators intended to provide updates on local seismicity, new educational resources available from the PNSN website, and UW seismology lab activities. The list currently reaches over 40 educators throughout Washington State. Two reports were sent to the list in the fourth quarter explaining the recent seismic events in the Spokane area.
- PNSN Seismic Analyst Amy Wright and other PNSN staff responded to over 250 e-mail messages from the public seeking information on a variety of topics.
- Bill Steele was a guest lecturer for a UW Technical Communications Science Writing Class.

Events

- Ruth Ludwin staffed a booth at the Seattle Project Impact sponsored "Disaster Saturday" community event.
- Bill Steele provided two workshops on Regional Earthquake Hazards for Seattle Public Utilities employees and engineers.
- Steve Malone gave a talk on earthquake hazards to Emerald Heights Retirement Center.
- Bill Steele was the guest of the 30-minute television program on Earthquake Hazards and the Nisqually Quake for "Current Affairs" broadcast on KTBW television at their studios in Federal Way.
- Ruth Ludwin discussed the Spoakane earthquake sequence on National Public Radio's "All Things Considered".
- Ruth Ludwin presented her research on Native American stories related to Cascadia Subduction Zone Earthquakes to the Oregon Archeological Society at the Oregon Museum of Science and Industry in Portland. The same talk was given to the staff at The Oregon Dept. of Geology and Mineral Industries. Ruth also met with DOGAMI Staff to discuss the expansion in Oregon of the PNSN Urban Strong Motion Network.
- The PNSN Staffed an information booth at the two-day CREW Conference entitled "The Business of Earthquakes" at the Westin Hotel in Seattle. Bill Steele managed media relations for the meeting.
- Ruth Ludwin and Bill Steele continued to work with exhibits coordinators from the Burke Museum developing content for a touring exhibit that will be shown at locations throughout the region in 2002.

EARTHQUAKE DATA - 2001-D

There were 1,138 events digitally recorded and processed at the University of Washington between October 1 and December 31, 2001. Locations in Washington, Oregon, or southernmost British Columbia were determined for 575 of these events; 502 were classified as earthquakes and 73 as known or suspected blasts. The remaining 563 processed events include teleseisms (138 events), regional events outside the PNSN (62), and unlocated events within the PNSN. Unlocated events within the PNSN include very small earthquakes and some known blasts. Frequent mining blasts occur near Centralia, Washington and we routinely locate some of them.

Table 3A is a listing of all earthquakes reported to have been felt during this quarter, events for which ShakeMaps or Community Internet Intensity Maps (CIIM) are noted.

ShakeMap shows instrumentally measured shaking.

Shake Maps: **http://www.ess.washington.edu/shake/index.html**

CIIM maps are made using "felt" reports relayed via Internet. These "felt" reports are converted into numeric intensity values, and the CIIM map shows the average intensity by zip code.

CIIM Maps: **http://pasadena.wr.usgs.gov/shake/pnw/**

Table 3B is a listing of earthquakes magnitude 2.5 or greater with reasonably constrained focal mechanisms from P-wave first motions. Table 4, located at the end of this report, is this quarter's catalog of earthquakes M 2.0 or greater, located within the network - between 42-49.5 degrees north latitude and 117-125.3 degrees west longitude.

Fig. 2 shows earthquakes with magnitude greater than or equal to 0.0 ($M_c \geq 0$).
Fig. 3 shows blasts and probable blasts ($M_c \geq 0$).
Fig. 4 shows earthquakes located near Mt. Rainier ($M_c \geq 0$).
Fig. 5 shows earthquakes located at Mt. St. Helens ($M_c \geq 0$).
Fig. 6 Map view of earthquakes located near Spokane in 2001.
Fig. 7 Spokane Earthquake sequence, 2001 - Earthquake activity vs. Time

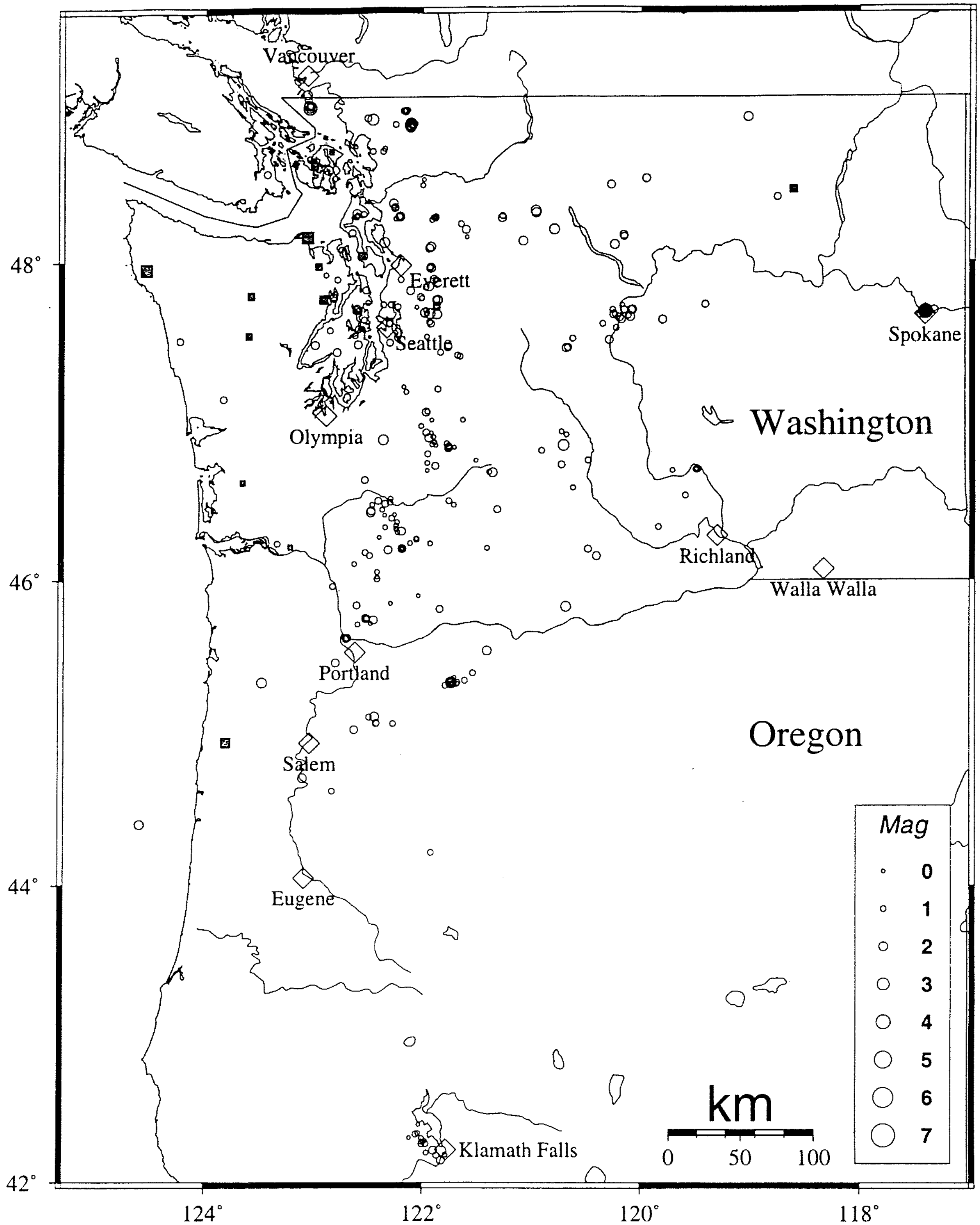

Figure 2. Located earthquakes, magnitude > 0, 4th quarter, 2001. Filled squares indicate earthquakes with depth greater than 30km. Unfilled diamonds represent cities.

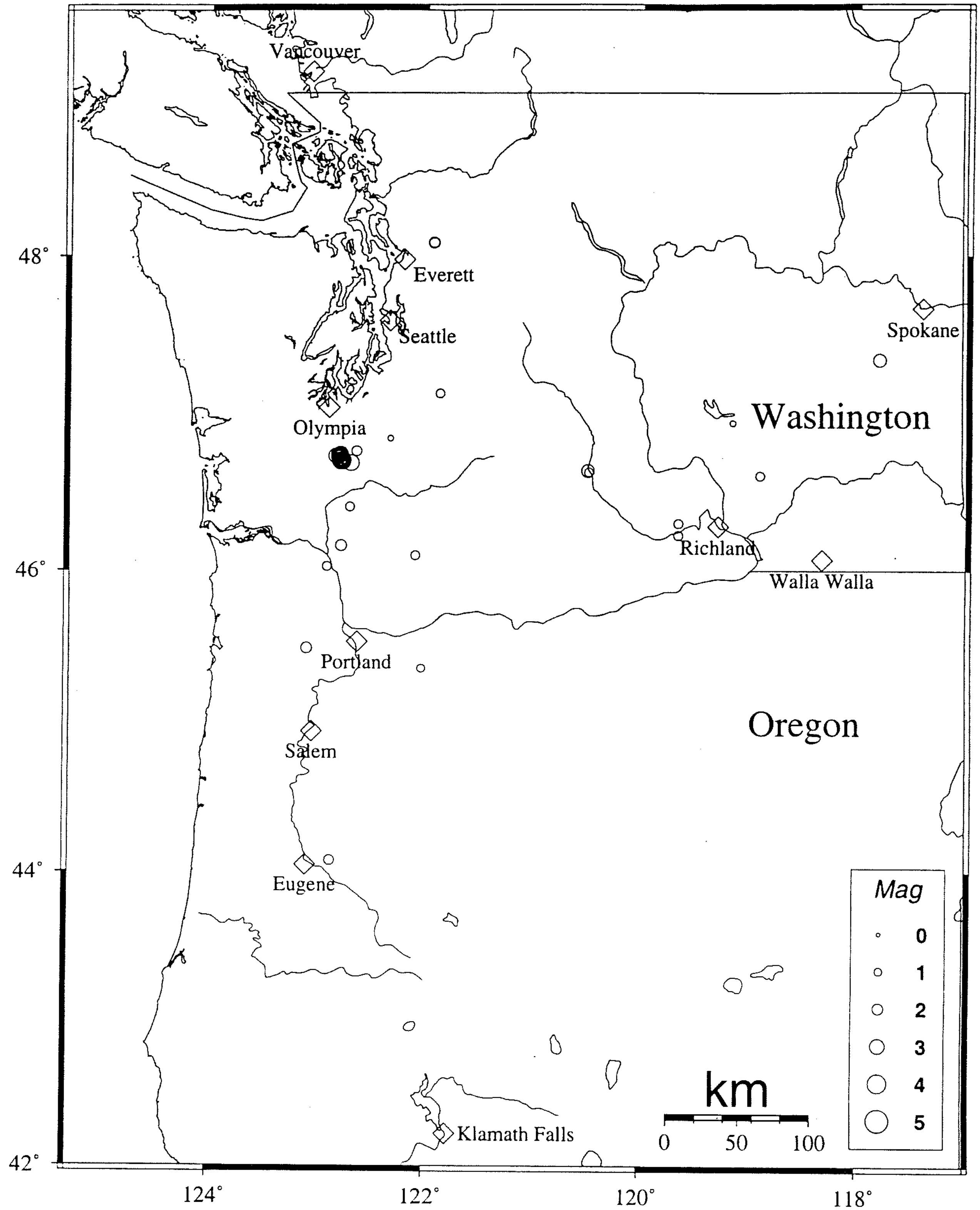

Figure 3. Blasts and probable blasts, 4th quarter, 2001. Unfilled diamonds represent cities.

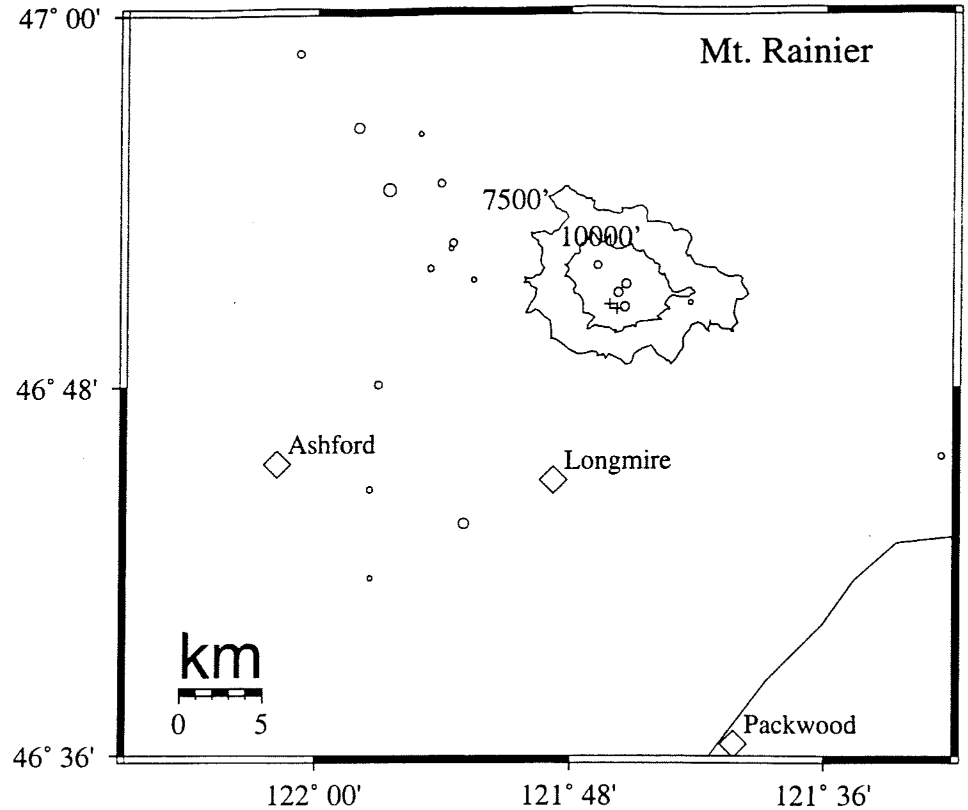

Figure 4. Earthquakes M > 0, 4th quarter, 2001. 'Plus' symbols indicate depth less than 1 km. Circles indicate depth greater than 1 km. Elevation contours shown in feet.

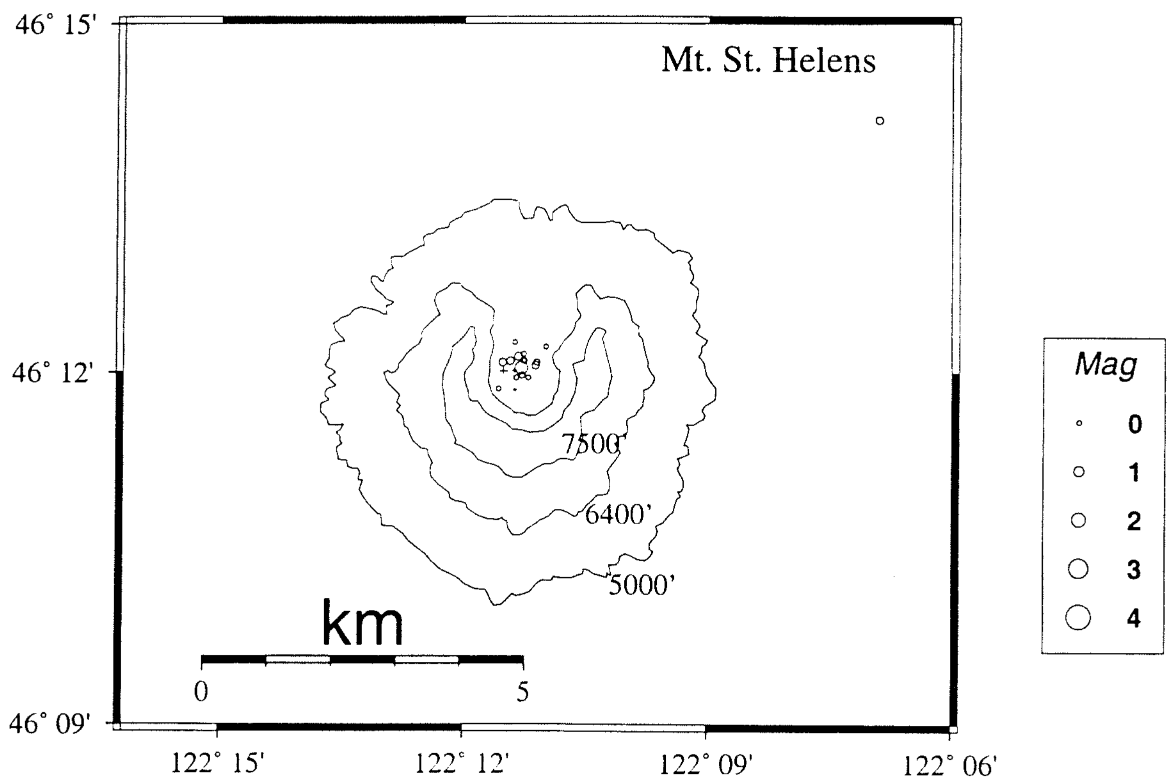

Figure 5. Earthquakes M > 0, 4th quarter, 2001. 'Plus' symbols indicate depth less than 1 km. Circles indicate depth greater than 1 km. Elevation contours shown in feet.

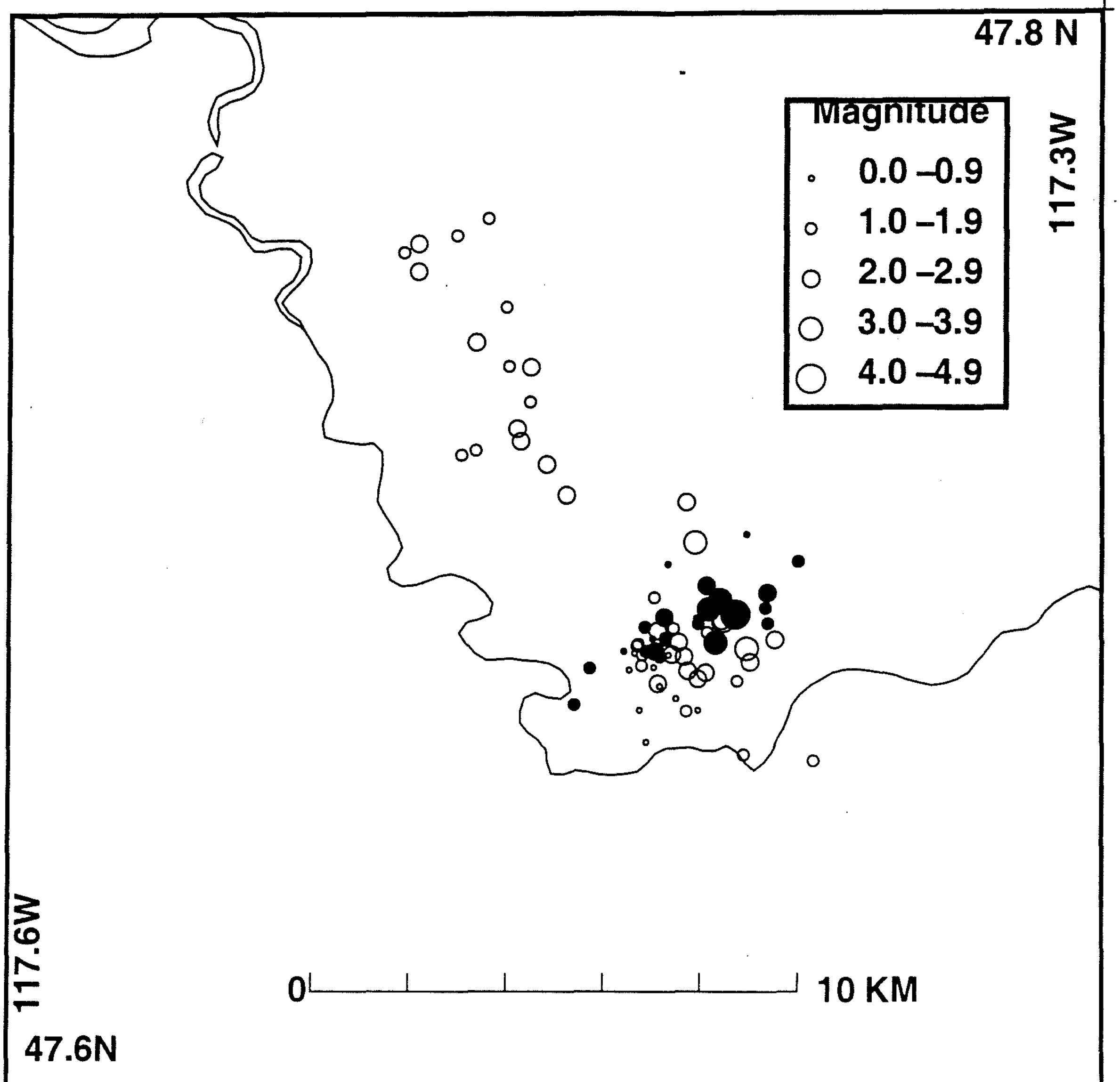

Figure 6. Spokane area earthquakes, 2001. Earthquakes in the fourth quarter (Oct. – Dec.) are filled. S–P times from SPUD, a statiion not synchronized to Universal time, were used to improve locations of some events. All well–constrained events locate within an area of radius ~2km. Locations to the northwest of the central cluster are poorly constrained and are believed to be mislocated.

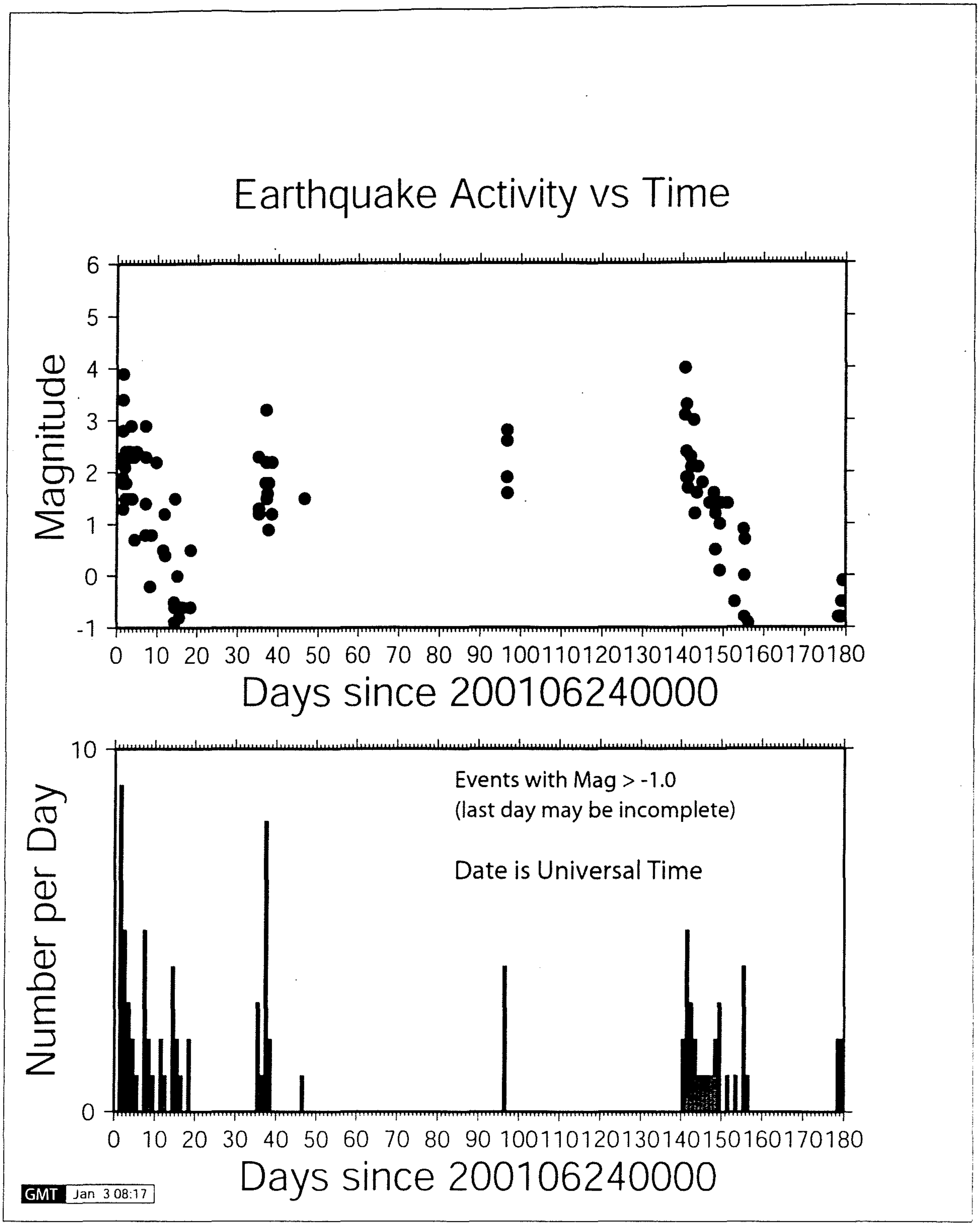

Figure 7. Plots showing Spokane sequence earthquake magnitudes (top) and number of events per day (bottom). Station coverage varied, and our detection capability for events of magnitude 1.0 or less was poor except between July 2 and 24, and after Nov. 12.

TABLE 3A - Felt Earthquakes during the 4th Quarter of 2001

DATE-(UTC)-TIME	LAT(N)	LON(W)	DEPTH	MAG	COMMENTS	CIIM	ShakeMap
01/10/05 02:26:41	48.82N	122.11W	12.1	3.0	7.6 km E of Deming, WA	x	
01/10/06 10:52:09	48.83N	122.10W	13.2	3.0	8.2 km E of Deming, WA		
01/10/15 04:57:01	48.15N	123.06W	44.4	2.9	28.6 km E of Port Angeles, WA		
01/11/10 18:30:59	48.93N	123.04W	15.4	3.4	21.7 km S of Vancouver,BC	x	
01/11/11 16:00:29	47.68N	117.40W	4.7	4.0	1.9 km N of Spokane, WA	x	
01/11/11 17:21:33	47.68N	117.40W	0.6	3.1	1.3 km N of Spokane, WA		
01/11/12 03:03:02	47.68N	117.40W	0.6	3.3	2.0 km N of Spokane, WA	x	
01/11/12 03:07:40	47.68N	117.41W	0.6	1.9	1.7 km NNW of Spokane, WA		
01/11/12 03:11:15	47.68N	117.41W	0.6	2.4	2.1 km NNW of Spokane, WA		
01/11/12 11:44:18	47.68N	117.39W	0.6	1.7	2.2 km NNE of Spokane, WA		
01/11/12 13:25:59	47.68N	117.40W	0.5	1.9	2.0 km N of Spokane, WA		
01/11/13 05:41:45	47.69N	117.40W	0.6	2.3	2.5 km N of Spokane, WA		
01/11/13 07:39:05	47.68N	117.42W	0.6	2.1	1.7 km NW of Spokane, WA		
01/11/13 10:14:01	48.86N	122.46W	22.0	2.5	11.7 km N of Bellingham, WA		
01/11/13 20:26:26	47.69N	117.40W	0.6	3.0	2.1 km N of Spokane, WA	x	
01/11/14 01:50:51	47.69N	117.38W	0.6	1.2	3.4 km NNE of Spokane, WA		
01/11/14 16:41:20	47.69N	117.32W	0.6	1.6	6.9 km ENE of Spokane, WA		
01/11/15 00:11:46	47.69N	117.39W	0.0	2.1	2.5 km NNE of Spokane, WA		
01/11/16 01:42:29	47.68N	117.39W	0.5	1.8	2.0 km NNE of Spokane, WA		
01/11/17 16:18:49	47.68N	117.42W	0.4	1.4	2.2 km NW of Spokane, WA		
01/11/18 19:51:12	47.68N	117.42W	0.8	1.6	1.8 km NW of Spokane, WA		
01/11/19 04:47:06	47.68N	117.41W	2.2	1.2	1.7 km NW of Spokane, WA		
01/11/19 04:47:52	47.69N	117.41W	1.2	0.5	3.1 km NNW of Spokane, WA		
01/11/20 06:03:56	47.67N	117.44W	2.6	1.0	2.8 km WNW of Spokane, WA		
01/11/20 12:14:42	47.67N	117.44W	0.0	1.4	3.0 km W of Spokane, WA		
01/11/22 04:43:01	47.68N	117.42W	2.5	1.4	1.6 km NW of Spokane, WA		
01/11/24 00:32:10	47.67N	117.43W	2.1	-0.5	2.1 km WNW of Spokane, WA		
01/11/26 04:13:15	47.68N	117.42W	2.2	0.9	1.9 km NW of Spokane, WA		
01/11/26 09:41:37	47.69N	117.40W	0.0	-0.8	3.0 km N of Spokane, WA		
01/11/26 09:41:53	47.68N	117.43W	2.1	0.0	2.2 km WNW of Spokane, WA		
01/11/26 09:59:53	47.68N	117.38W	4.7	-1.6	2.0 km NE of Spokane, WA		
01/11/26 10:12:11	47.68N	117.40W	2.3	-1.6	1.7 km N of Spokane, WA		
01/11/26 11:56:07	47.68N	117.41W	2.2	0.7	1.8 km NNW of Spokane, WA		
01/11/27 08:26:58	47.65N	117.44W	0.5	-0.9	3.8 km WSW of Spokane, WA		
01/12/06 23:24:08	46.89N	122.36W	20.4	2.4	8.1 km WNW of Eatonville, WA		
01/12/19 06:39:26	47.69N	117.38W	0.0	-0.8	2.8 km NNE of Spokane, WA		
01/12/19 21:32:17	47.67N	117.44W	2.0	-0.8	2.7 km W of Spokane, WA		
01/12/20 03:03:20	47.67N	117.44W	2.0	-0.5	2.8 km W of Spokane, WA		
01/12/20 08:30:43	47.67N	117.43W	1.8	-0.1	2.6 km W of Spokane, WA		
01/12/25 03:58:53	47.68N	117.42W	0.2	-0.7	2.0 km WNW of Spokane, WA		
01/12/27 22:11:20	47.66N	117.43W	0.0	-0.5	2.4 km W of Spokane, WA		
01/12/29 11:57:27	47.67N	117.43W	0.0	-0.8	2.5 km W of Spokane, WA		

TABLE 3B - Earthquakes M 2.5 or larger during the 4th Quarter of 2001

Focal mechanisms noted where computed. Some earthquakes have more than one possible mechanism.

DATE-(UTC)-TIME yy/mm/dd hh:mm:ss	LAT(N) deg.	LON(W) deg.	DEP km	MAG	COMMENTS	STRIKE deg.	DIP deg.	RAKE deg.
01/10/05 02:26:41	48.83	122.11	12.1	3.0	7.6 km E of Deming, WA	25	60	-10
01/10/06 10:52:09	48.84	122.11	13.2	3.0	8.2 km E of Deming, WA	20	90	-10
01/10/15 04:57:01	48.15	123.06	44.4	2.9	28.6 km E of Port Angeles, WA	40	65	170
01/11/10 18:30:59	48.94	123.04	15.4	3.4	21.7 km S of Vancouver,BC	60	70	60
01/11/11 16:00:29	47.69	117.40	4.7	4.0	1.9 km N of Spokane, WA	40	40	10
01/11/11 17:21:33	47.68	117.41	0.6	3.1	1.3 km N of Spokane, WA	-	-	-
01/11/12 03:02:62	47.69	117.41	0.6	3.3	2.0 km N of Spokane, WA	275	90	10
01/11/13 10:14:01	48.87	122.47	22.0	2.5	11.7 km N of Bellingham, WA	50	30	100
01/11/13 20:25:86	47.69	117.40	0.6	3.0	2.1 km N of Spokane, WA	-	-	-
01/11/17 03:12:64	46.86	120.71	2.1	2.6	20.6 km SW of Ellensburg, WA	-	-	-
01/12/03 07:19:55	45.33	121.73	5.3	2.6	5.4 km SSW of Mt Hood, OR	25	45	-70

OREGON SEISMICITY

During the fourth quarter of 2001, a total of 46 earthquakes were located in Oregon between 42.0° and 45.5° north latitude, and between 117° and 125° west longitude. The largest earthquakes in Oregon this quarter were magnitude 2.4 and 2.6 earthquakes on December 2nd and 3rd UTC, respectively. Both were located about 5 km southwest of Mt. Hood.

A detailed study of Mt. Hood seismicity is underway and will be reported on in a later quarterly.

In the Klamath Falls area, 15 earthquakes occurred in the fourth quarter of 2001. Since 1994, most earthquakes in the Klamath Falls area have been considered aftershocks or earthquake activity related to a pair of damaging earthquakes in September, 1993. The 1993 earthquakes were followed by a vigorous aftershock sequence which decreased over time.

WESTERN WASHINGTON SEISMICITY

During the fourth quarter of 2001, 368 earthquakes were located between 45.5° and 49.5° north latitude and between 121° and 125.3° west longitude. Six earthquakes were felt this quarter in western Washington. Details are in Table 3A.

The largest felt earthquake in western Washington was a magnitude 3.4 earthquake near Point Roberts on November 10. Point Roberts, although in the United States, is isolated from the US mainland and located at the southern tip of a peninsula that originates in Canada. It is closer to Vancouver, B.C. than to Bellingham.

CASCADE VOLCANOS

Mount Rainier Area: Figure 4 shows earthquakes near Mount Rainier. The number of events in close proximity to the cone of Mt. Rainier varies over the course of the year, since the source of much of the shallow activity is presumably ice movement or avalanching at the surface, which is seasonal in nature. Events with very low frequency signals (1-3 Hz) believed to be icequakes are assigned type "L" in the catalog. Emergent, very long duration signals, probably due to rockfalls or avalanches, are assigned type "S" (see Key to Earthquake Catalog). There were no events flagged "L" or "S" located at Mount Rainier this quarter but 20 "L" or "S" events were recorded, but were too small to locate reliably. Type L and S events are not shown in Fig. 4.

A total of 40 tectonic events (19 of these were smaller than magnitude 0.0, and thus are not shown in Fig. 4) were located within the region shown in Fig. 4. The largest tectonic earthquake located near Mt. Rainier this quarter was a magnitude 1.6 earthquake on November 16 UTC, located about 15 km west-north-west of the summit at a depth of about 12 km. This quarter, 23 of the tectonic earthquakes were located in the "Western Rainier Seismic Zone" (WRSZ), a north-south trending lineation of seismicity approximately 15 km west of the summit of Mt. Rainier (for counting purposes, the western zone is defined as 46.6-47 degrees north latitude and 121.83-122 west longitude). Within 5 km of the summit, there were 13 (7 of them smaller than magnitude 0.0 and thus not shown in Fig. 4) higher-frequency tectonic-style earthquakes, and the remaining events were scattered around the cone of Rainier as seen in Fig. 4.

Mount St. Helens Area: Figure 5 shows volcano-tectonic earthquakes near Mount St. Helens. Low frequency (L) and avalanche or rockfall events (S) are not shown.

Beginning on November 3, 2001 a vigorous sequence of very small earthquakes was recorded on stations on Mount St. Helens. An information statement:

http://vulcan.wr.usgs.gov/Volcanoes/Cascades/CurrentActivity/2001/current_updates_20011103.html

was issued by the USGS Cascades Volcano Observatory. These events were located inside the crater of Mt. St. Helens within the dome of hardened lava that has been extruded since the catastrophic eruption of May 18, 1980. Station SEP is located on the dome (see Fig. 1C), and recorded about 3,800 tiny events during the first week of November. However almost all of the events in this swarm were very small. Their signals were not well recorded outside the crater, and precise locations were impossible. A web page with links to webicorder records, spectrograms, and other information is at:

http://spike.ess.washington.edu/SEIS/PNSN/WEBICORDER/HELENS/

This quarter, 126 earthquakes were located at Mount St. Helens in the area shown in Fig. 5. Of these earthquakes, 18 were magnitude 0.0 or larger and 4 were deeper than 4 km. The largest tectonic earthquake at Mount St. Helens this quarter was a magnitude 1.7 event on Oct. 26 UTC located .4 km NE of Mount St. Helens.

One type "S" or "L" events was located at Mount St. Helens, and 52 "L" or "S" events too small to locate were recorded.

EASTERN WASHINGTON SEISMICITY

During the fourth quarter of 2001, 88 earthquakes were located in eastern Washington in the area between 45.5-49.5 degrees north latitude and 117-121 degrees west longitude.

The most interesting activity in eastern Washington this quarter was the continuation of a very unusual sequence of earthquakes in the Spokane urban area.

UPDATE - Spokane Earthquake Activity in 2001

Spokane is an area that historically has been seismically quiet, and is located at the very edge of the seismograph network operated by the Pacific Northwest Seismograph Network (PNSN). The extended, intermittent sequence of 2001 is unprecedented in the 150 year written history of the area. This very shallow crustal sequence is occurring immediately beneath urban Spokane, a city with many unreinforced masonry buildings. In addition, incredibly tiny earthquakes (magnitudes as small as -1.7) are being reported felt and/or heard. This appears to be due to the extreme shallowness of the events and the high population density. Figure 6 shows a map view of earthquakes in 2001 located near Spokane. Fourth-quarter earthquakes are shown as filled symbols. Figure 7 shows the magnitude distribution vs time (top), and the number of events per day vs time (bottom).

On the morning of June 25 (at 7:15 and 8:01 AM PDT), two earthquakes, M 3.9 and M 3.4 were widely felt in urban Spokane. Additional smaller events continued and twenty-three other events were located during the following week. A foreshock on May 24 of M 2.0 was also felt. At the beginning of July activity dropped off for several weeks.

Another spurt of activity began in late July. Fourteen events were located between July 29 and August 1. The largest event in this time period was magnitude 3.2. Following August 1, seismicity quieted for about 8 weeks,

In late September seismicity picked up again when four events occurred within a ten-minute period on Sept. 28. The largest was a magnitude 2.8 that was noticed by many people in the downtown area, as was the magnitude 2.6 that followed about 4 minutes later. The September events were followed by a quiet period lasting about 6 weeks.

On November 11, activity resumed with a magnitude 4.0 earthquake, the largest in the sequence so far. Additional earthquakes followed, and a total of 36 earthquakes were located in Spokane during the fourth quarter. Out of the total of 36, 35 were reported felt, including events as small as -1.6.

During the fits and starts of activity in the Spokane sequence, various seismic recording equipment was operated:

- A temporary array of five stations was operated during the first three weeks of July, and detected and provided accurate locations for low-magnitude events. However, this array operated during a period of low seismicity.
- Another temporary station, SPUD, operated without external time from June 26 to Sept. 25. The clock drifted more and more as time went on. Because of the importance of this data, we adapted our location program to use "S minus P" times as a location constraint. Immediately after SPUD was removed in September another spurt of activity occurred.
- A permanent station, SFER, was installed in August.
- Five additional stations were added after the magnitude 4.0 shock of Nov. 11 (see Fig. 1D). Although these stations are considered "temporary" we plan to operate them for some time.

Times, locations, and depths of all felt earthquakes in the PNSN region this quarter are given in Table 3A.

OTHER SOURCES OF EARTHQUAKE INFORMATION

We provide automatic computer-generated alert messages about significant Washington and Oregon earthquakes by e-mail, FAX or via the pager-based RACE system to institutions needing such information, and we regularly exchange phase data via e-mail with other regional seismograph network operators. The "Outreach Activities" section describes how to access PNSN data via e-mail, Internet, and World-Wide-Web. To request additional information by e-mail, contact seis_info@ess.washington.edu.

Earthquake information in the quarterlies has been published in final form by the Washington State Department of Natural Resources as information circulars entitled "Earthquake Hypocenters in Washington and Northern Oregon" covering the period 1970-1989 (see circulars Nos. 53, 56, 64-66, 72, 79, 82-84, and 89). These circulars, plus circular No. 85, "Washington State Earthquake Hazards", are available from Washington Dept. of Natural Resources, Division of Geology and Earth Resources, Post Office Box 47007, Olympia, WA. 98504-7007, or by telephone at (360) 902-1450.

Several excellent maps of Pacific Northwest seismicity are available. A very colorful perspective-view map (18" x 27") entitled "Major Earthquakes of the Pacific Northwest" depicts selected epicenters of strong earthquakes (magnitudes > 5.1) that have occurred in the Pacific Northwest. A more detailed full-color map is called "Earthquakes in Washington and Oregon 1872-1993", by Susan Goter (USGS Open-File Report 94-226A). It is accompanied by a companion pamphlet "Washington and Oregon Earthquake History and Hazards", by Yelin, Tarr, Michael, and Weaver (USGS Open-File Report 94-226B). The pamphlet is also available separately. Maps can be ordered from: "Earthquake Maps", U.S. Geological Survey, Box 25046, Federal Center, MS 967, Denver, CO 80225, phone (303) 273-8477. The price of each map is $12. (including US shipping and handling).

USGS Cascades Volcano Observatory has a video, "Perilous Beauty: The Hidden Dangers of Mount Rainier", about the risk of lahars from Mount Rainier. Copies are available through: North west Interpretive Association (NWIA), 909 First Avenue Suite 630, Seattle WA 98104, Telephon e: (206) 220-4141, Fax: (206) 220-4143.

Other regional agencies provide earthquake information. These include the Geological Survey of Canada (Pacific Geoscience Centre, Sidney, B.C.; (250) 363-6500, FAX (250) 363-6565), which produces monthly summaries of Canadian earthquakes; the US Geological Survey which produces weekly reports called "Seismicity Reports for Northern California" (USGS, attn: Steve Walter, 345 Middlefield Rd, MS-977, Menlo Park, CA, 94025) and "Weekly Earthquake Report for Southern California" (USGS, attn: Dr. Kate Hutton or Dr. Lucy Jones, CalTech, Pasadena, CA.).

Key to Earthquake Catalog in Table 4

TIME Origin time is calculated for each earthquake on the basis of multi-station arrival times. Time is given in **Coordinated Universal Time** (UTC), in hours:minutes:seconds. To convert to Pacific Standard Time (PST) subtract eight hours, or to Pacific Daylight Time subtract seven hours.

LAT North latitude of the epicenter, in degrees and minutes.

LONG West longitude of the epicenter, in degrees and minutes.

DEPTH The depth, given in kilometers, is usually freely calculated from the arrival-time data. In some instances, the depth must be fixed arbitrarily to obtain a convergent solution. Such depths are noted by an asterisk (*) in the column immediately following the depth. A $ or a # following the depth mean that the maximum number of iterations has been exceeded without meeting convergence tests and both the location and depth have been fixed.

MAG Coda-length magnitude M_c, an estimate of local magnitude M_L (Richter, C.F., 1958, Elementary Seismology: W.H. Freeman and Co., 768p), calculated using the coda-length/magnitude relationship determined for Washington (Crosson, R.S., 1972, Bull. Seism. Soc. Am., v. 62, p. 1133-1171). Where blank, data were insufficient for a reliable magnitude determination. Normally, the only earthquakes with undetermined magnitudes are very small ones. Magnitudes may be revised as we improve our analysis procedure.

NS/NP NS is the number of station observations, and **NP** the number of P and S phases used to calculate the earthquake location. A minimum of three stations and four phases are required. Generally, more observations improve the quality of the solution.

GAP Azimuthal gap. The largest angle (relative to the epicenter) containing no stations.

RMS The root-mean-square residual (observed arrival time minus predicted arrival time) at all stations used to locate the earthquake. It is only useful as a measure of the quality of the solution when 5 or more well-distributed stations are used in the solution. Good solutions are normally characterized by **RMS** values less than about 0.3 sec.

Q Two **Quality factors** indicate the general reliability of the solution (**A** is best quality, **D** is worst). Similar quality factors are used by the USGS for events located with the computer program HYPO71. The first letter is a measure of the hypocenter quality based on travel-time residuals. For example: **A** quality requires an **RMS** less than 0.15 sec while an **RMS** of 0.5 sec or more is **D** quality (estimates of the uncertainty in hypocenter location also affect this quality parameter). The second letter of the quality code depends on the spatial distribution of stations around the epicenter, i.e. number of stations, their azimuthal distribution, and the minimum distance (**DMIN**) from the epicenter to a station. Quality **A** requires a solution with 8 or more phases, **GAP** $\leq 90^\circ$ and **DMIN** $\leq$ (5 km or depth, whichever is greater). If the number of phases, **NP**, is 5 or fewer or **GAP** $> 180^\circ$ or **DMIN** > 50 km the solution is assigned quality **D.**

MOD The crustal velocity model used in location calculations (Ludwin, R.S., et al., 1994, Earthquake hypocenters in Washington and northern Oregon, 1987-1989, and Operation of the Washington Regional Seismograph Network, Information Circular 89, Washington State Dept. of Natural Resources).

- **P3** - Puget Sound model
- **C3** - Cascade model
- **S3** - Mt. St. Helens model including Elk Lake
- **N3** - northeastern model
- **E3** - southeastern model
- **O0** - Oregon model
- **K3** - Southern Oregon, Klamath Falls area model
- **R0 and J1** - Regional and Offshore models

TYP Events flagged in Table 4 use the following code:

- **F** - earthquake reported to have been felt
- **P** - probable explosion
- **L** - low frequency earthquake (e.g. glacier movement, volcanic activity)
- **H** - handpicked from helicorder records
- **S** - Special event (e.g. rockslide, avalanche, volcanic steam emission, harmonic tremor, sonic boom), not a man-made explosion or tectonic earthquake
- **X** - known explosion

TABLE 4

Tectonic Earthquakes, Magnitude 2.0 or larger, Fourth Quarter, 2001.
Within an area 42-49.5 degrees north latitude and 117-125.3 degrees west longitude.

Oct 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
4	00:42:14.93	45 20.22	123 28.37	23.88	2.3	6/008	279	0.05	AD	O0	
5	02:26:41.21	48 49.79	122 06.80	12.09$	3.0	28/032	105	0.27	BB	P3	F
5	12:23:58.65	48 49.41	122 06.69	12.42	2.5	19/025	104	0.29	BB	P3	
6	10:52:09.98	48 50.34	122 06.43	13.21	3.0	37/041	110	0.30	CB	P3	F
6	11:03:22.79	48 50.15	122 05.69	13.82	2.1	17/018	113	0.28	BB	P3	
7	14:52:07.73	45 49.63	120 41.29	11.34	2.4	24/027	129	0.26	BB	E3	
15	04:57:01.89	48 09.13	123 03.78	44.36	2.9	38/043	31	0.16	BA	P3	F
18	08:48:14.96	46 41.07	121 21.58	5.40	2.1	43/051	72	0.27	BC	C3	
18	13:32:41.77	48 18.76	120 58.30	9.14	2.2	20/023	164	0.25	BC	C3	
19	13:49:52.29	45 32.69	121 24.49	4.69	2.0	36/040	57	0.38	CC	C3	
25	11:59:44.59	44 56.56	123 48.52	43.05$	2.2	14/017	220	0.19	BD	O0	
26	18:30:03.47	47 41.23	121 58.87	1.22*	2.1	24/027	72	0.14	AB	P3	
28	09:26:59.69	47 40.97	121 56.07	25.28	2.3	50/053	30	0.18	BA	P3	

Nov 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
7	12:54:40.54	46 26.10	122 28.80	18.89	2.1	41/051	45	0.18	BA	S3	
10	18:30:59.73	48 56.10	123 02.46	15.45	3.4	36/038	192	0.33	CD	P3	F
11	16:00:29.66	47 41.29	117 24.01	4.69	4.0	7/007	143	0.19	BC	N3	F
11	17:21:33.50	47 40.99	117 24.33	0.61	3.1	7/007	138	0.23	BC	N3	F
12	03:03:02.95	47 41.36	117 24.45	0.59	3.3	7/007	139	0.21	BC	N3	F
12	03:11:15.68	47 41.26	117 25.18	0.55	2.4	7/008	132	0.23	BB	N3	F
13	05:41:45.77	47 41.62	117 24.48	0.60	2.3	6/007	139	0.24	BC	N3	F
13	07:39:05.11	47 40.88	117 25.33	0.56	2.1	5/007	128	0.48	CD	N3	F
13	10:14:01.12	48 52.08	122 27.94	21.99	2.5	32/034	157	0.23	BC	P3	F
13	20:26:26.67	47 41.46	117 24.26	0.60	3.0	6/006	141	0.23	BC	N3	F
15	00:11:46.52	47 41.54	117 23.49	0.02*	2.1	6/007	148	0.39	CC	N3	F
17	03:13:04.88	46 51.32	120 42.66	2.11	2.6	31/032	61	0.25	BC	C3	

Dec 2001

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
2	14:10:05.38	45 20.08	121 44.12	2.38	2.4	33/033	41	0.35	CB	O0	
3	00:54:26.95	45 20.14	121 44.12	2.11	2.1	22/022	57	0.33	CB	O0	
3	07:19:55.33	45 20.09	121 44.06	5.30	2.6	29/029	47	0.32	CB	O0	
4	04:33:10.98	48 17.82	122 36.63	22.53	2.1	18/019	44	0.19	BA	P3	
6	23:24:08.62	46 53.60	122 21.88	20.43	2.4	51/056	43	0.16	BA	P3	F
10	09:53:34.72	48 33.72	122 52.37	10.99	2.0	15/018	57	0.16	BA	P3	
15	10:28:53.54	48 11.94	120 47.99	5.49	2.2	18/021	158	0.45	CC	C3	
20	21:26:53.06	48 07.31	122 21.32	21.99	2.4	37/041	44	0.23	BA	P3	
25	17:18:32.55	48 21.48	122 16.17	16.46S	2.0	37/040	36	0.54	DA	P3	
29	21:03:11.70	47 57.14	124 32.79	36.94	2.8	26/028	197	0.29	BD	P3	

APPENDIX 2
Publications supported fully or partially under this operating agreement

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APPENDIX 3

Reprint of:
Preliminary Report on the Mw=6.8 Nisqually, Washington Earthquake of 28, February 2001
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Preliminary Report on the M_w = 6.8 Nisqually, Washington Earthquake of 28 February 2001

Staff of the Pacific Northwest Seismograph Network

Department of Earth and Space Sciences, University of Washington, Seattle
U.S. Geological Survey, Seattle Office

INTRODUCTION

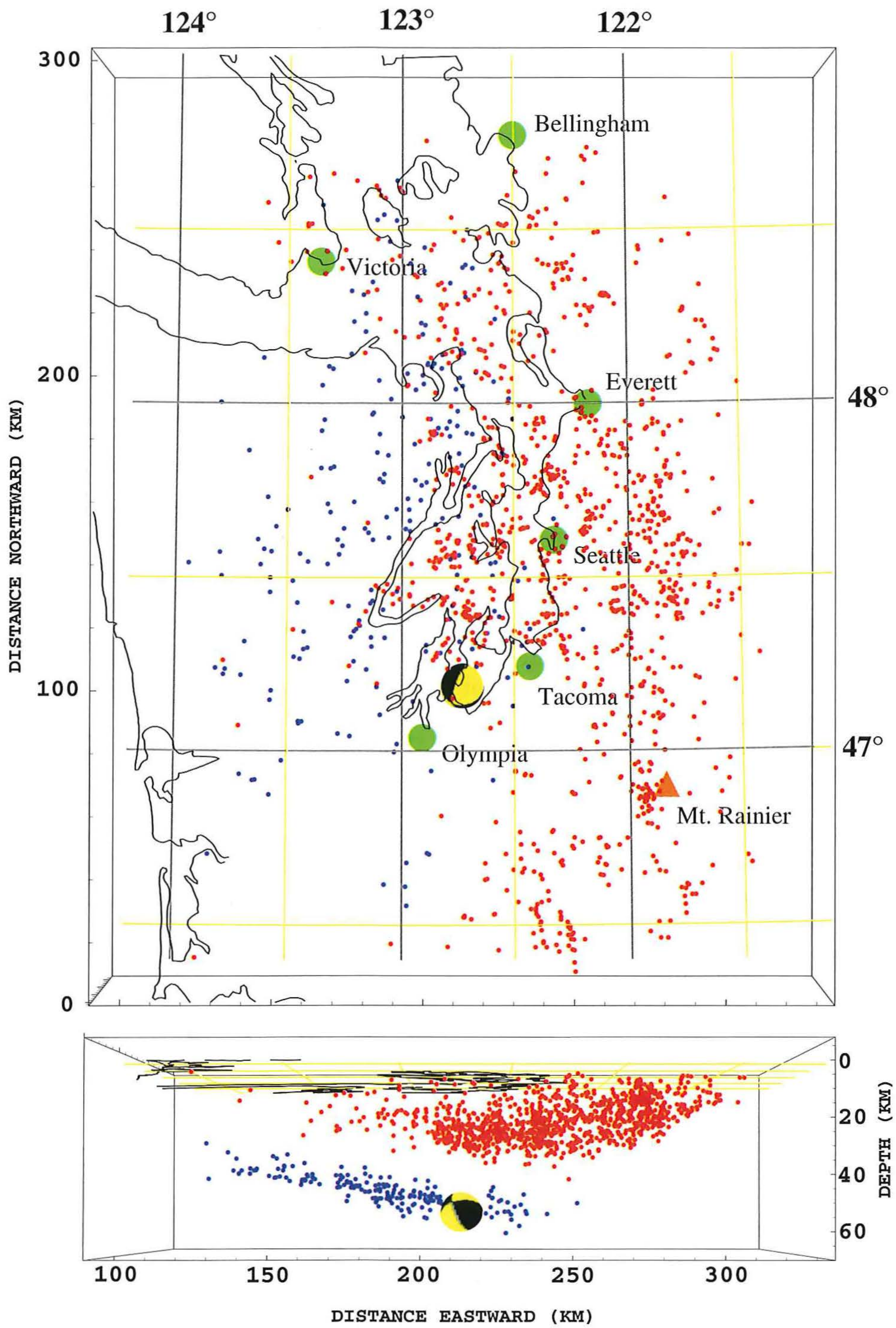
On Wednesday, 28 February 2001 at 10:54 PST (1854 UT) the Puget Sound region of western Washington State was shaken by a magnitude (M_w) 6.8 earthquake. Its epicenter was 47.159°N, 122.733°W and hypocenter was 51 km beneath the Nisqually River delta area, approximately 18 km northeast of Olympia, Washington. Damage from this earthquake had many similarities to damage noted for earthquakes in 1949 (M = 7.1) and in 1965 (M = 6.5). Damage included partial collapse of walls in unreinforced masonry buildings, particularly those on soft soil, lateral spreading and liquefaction in susceptible locations, and damage to unreinforced masonry chimneys. Because of the installation of modern digital strong-motion seismographs over the past few years the suite of strong-motion records for this event is extensive. Upgrades in the Pacific Northwest Seismograph Network's (PNSN) data acquisition and processing capabilities allowed for the rapid location and characterization of this earthquake and dissemination of information to the public in the minutes to hours following the event. The PANGA geodetic network detected coseismic permanent displacements at several sites that are consistent with the mechanism determined by both first-motion polarities and far-field moment-tensor solutions. The following is a preliminary report on seismic observations and geologic reconnaissance conducted during the first two weeks following the event.

TECTONIC SETTING

Three general source zones are recognized in the Cascadia forearc region: (1) the plate interface zone, which is the site of an inferred megathrust earthquake approximately 300 years ago; (2) the intraslab (Wadati-Benioff) zone, which is a zone of eastward-dipping hypocenters at a depth of approximately 40 to 60 km beneath the central Puget basin: earthquakes occurring within the subducting Juan de Fuca Plate; and (3) the crustal zone, which could produce large shallow earthquakes such as an event inferred to have occurred approximately 1,100 years ago on the Seattle Fault. Although no significant earthquakes have been unequivocally identified with modern instrumentation as rupturing the plate interface, the second and third zones are quite active down to the threshold of detection capability of modern instruments deployed in the PNSN.

The Nisqually earthquake occurred in the eastward-dipping Wadati-Benioff intraslab zone (Figure 1), the site of most of the largest historically documented and recorded earthquakes in the region. Other historical earthquakes that have caused damage in Washington State bear similarities to the Nisqually event. A magnitude 6.2 event in 1939 and a magnitude 6.4 event in 1946 had epicentral locations within approximately 60 km of the Nisqually earthquake's epicenter, and both are believed to have been deep events within the Juan de Fuca Plate. The M 7.1 Olympia earthquake of 1949 occurred within 20 km of the Nisqually earthquake (Baker and Langston, 1987) and could have ruptured the same fault. The 1965 magnitude 6.5 Seattle earthquake occurred about 40 km northeast of the Nisqually earthquake. In 1999, a M_w 5.8 earthquake occurred near Satsop, Washington within the subducting Juan de Fuca Plate about 60 km to the west of the Nisqually earthquake.

Focal mechanisms of the 1949, 1965, 1976, and 1999 events are generally consistent with downdip extension in the subducted slab, with T axes trending eastward to east-southeastward. The regional network focal mechanism exhibits significant variation from the preliminary CMT solutions (*e.g.*, Harvard and NEIC) for the Nisqually earthquake. This variation appears to be real and may result from changes in the mechanism during rupture. The regional net focal mechanism is remarkably similar to the focal mechanism derived by Baker and Langston (1987) for the 1949 event, although the location preferred by Baker and Langston (1987) lies approximately 20 km to the west of the Nisqually epicenter. The U.S. Coast and Geodetic Survey catalog epicenter for the 1949 earthquake is virtually identical to the Nisqually earthquake epicenter, suggesting that the 1949 and 2001 events may have ruptured the same fault. The larger slab earthquakes in this region occur near the downdip extent of regional seismicity (Figure 1). Recent tomography studies (Crosson *et al.*, 2000) and earthquake locations (Ludwin *et al.*, 1991) suggest that the slab deforms to steeper dip in this vicinity, although the slab seismicity diminishes dramatically to the east and provides weaker evidence for this deformation.



▲ **Figure 1.** Map (top) and cross-sectional (bottom) views of three-dimensional rectangular space containing the Nisqually earthquake hypocenter (yellow and black "beach ball") and high-quality hypocenters for 1,358 earthquakes used in 3D structure inversion in the greater Puget Sound vicinity. The edges of the 3D box are shown in perspective views with scaling in kilometers along edges and latitude/longitude lines in the map view. The preliminary Nisqually earthquake focal mechanism is shown as a true focal "ball" (convex) in correct 3D perspective views from above and looking from the south toward the north in the cross-sectional view at bottom. Hypocenters of events in the PNSN regional catalog, relocated with a 3D *P* velocity structural model derived from earthquake and SHIPS experiment observations, are shown with blue for intraslab events and with red for events in the continental crust. The focal mechanism of the Nisqually earthquake derived from regional network *P* polarity observations is well constrained and generally consistent with the CMT mechanisms derived from global observations in showing down-dip slab tension; however, the T axis of the regional net mechanism is rotated approximately 20° clockwise relative to the CMT mechanisms.

This figure can be viewed interactively in 3D using a Java-enabled browser. Please visit our Web site at http:/www.geophys.washington.edu/SEIS/EQ_Special/WEBDIR_01022818543p/.

GEOLOGY

The near-surface geology of the Puget Lowland strongly influenced the pattern of ground motion and the distribution of damage caused by the Nisqually earthquake. Basement to the Puget Lowland is a complex patchwork of Eocene basalt of the Coast Range province, andesitic volcanic rocks and fluvial sedimentary rocks of the Challis province, and older metamorphic rocks overlain by Oligocene marine and Miocene fluvial strata of the Cascade forearc basin (Blunt *et al.*, 1987). Miocene and younger north-south shortening has formed large bedrock uplifts and basins as deep as 7 km (the Seattle basin). Tertiary bedrock is overlain by a complex, alternating, and incomplete sequence of glacial and nonglacial deposits. The present thickness of these deposits varies from zero to more than 1,000 m.

The current lowland landscape is largely a result of fluvial infilling and subsequent dissection, largely by subglacial meltwater, during the last glaciation (Booth, 1994). The large north-south troughs that confine Puget Sound, Hood Canal, Lake Washington, and the like were formed by subglacial erosion between about 18,000 and 15,000 years ago. Postglacial modification of the landscape has generally been minor, with the exception of fluvial deposition in some of the subglacial troughs. Such deposition has been most extensive along valleys that drain volcanoes of the Cascade Range. From an earthquake-hazards perspective, primary consequences of this history are (1) low-elevation (100–200 m) uplands of the Puget Lowland are largely overconsolidated by burial beneath as much as a kilometer of ice; (2) near-sea-level valley floors, such as Nisqually, Puyallup, and Duwamish, are underlain by thick, normally consolidated Holocene fluvial deposits; and (3) steep slopes along the margins of subglacial troughs, including most of the prime view properties in the region, are commonly underlain by a coarsening-upward clay-to-sand glacial advance outwash stratigraphy that creates a significant landslide potential.

Development of the ports of Seattle and Tacoma during the last 125 years was accompanied by extensive filling of tidal flats. Much of the Port of Seattle and industrial south Seattle lies on unengineered hydraulic fill that overlies poorly consolidated young estuarine sediments.

GEOLOGIC EFFECTS

The damage produced by the Nisqually earthquake was strongly influenced by geological and geotechnical factors. Early reconnaissance efforts provided useful information on liquefaction and lateral spreading, landslides, and the performance of earth structures (Figure 2). In a manner consistent with liquefaction observations from past earthquakes, principally those of 1949 and 1965, liquefaction was most commonly observed in low-lying alluvial valleys, river deltas, and poorly compacted man-made fills. Overall, however, instances of liquefaction appeared to be considerably fewer than in 1965 and 1949 (Figure 2).

Extensive liquefaction was observed in several localized areas. At the King County Airport (Boeing Field), which lies within the Duwamish River corridor south of downtown Seattle, extensive liquefaction was seen along the eastern runway, where zones of ejecta covered areas some 300 ft. long (Figure 3A). Numerous liquefaction features were also observed in the industrial area along the Duwamish River south of downtown Seattle. Lateral spreading was observed at a number of sites in the Olympia/Tumwater area. Several lateral spreads were observed along the banks of Capitol Lake south of downtown Olympia in patterns similar to what occurred in the 1949 and 1965 earthquakes.

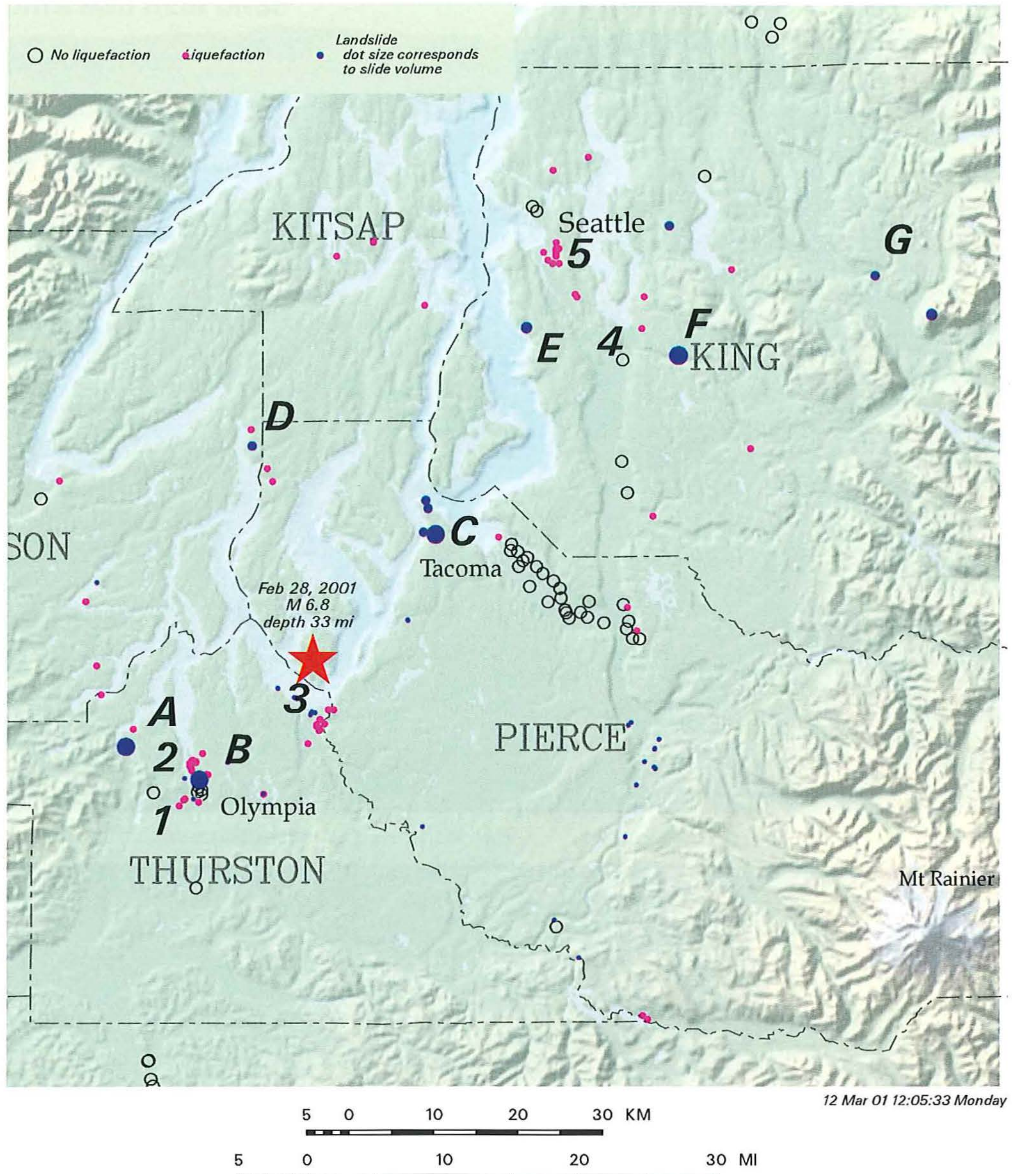
Landslides occurred in the colluvial soils that mantle the slopes of many hills in the Puget Sound Basin. The frequency of occurrence of these slides was no doubt tempered by the extended period of unseasonably dry weather that preceded the earthquake. A significant landslide temporarily dammed the Cedar River in Renton; nearby construction equipment was quickly mobilized to breach the dam and divert the river from nearby homes.

DAMAGE TO STRUCTURES

Damage to buildings, bridges, and lifelines varied across the region and was usually correlated with local soil conditions. The damage to buildings was almost exclusively nonstructural, with the majority occurring in unreinforced masonry buildings (Figure 3B). Damage patterns in this earthquake were similar to those in prior deep intraslab events. Specific locales that suffered damage both in this event and previous quakes included the Magnolia Bridge, Harbor Island, the Aqua Theater area near Greenlake, and Spokane Street bridges/onramps, all in Seattle. In Olympia numerous buildings on the Washington State Capitol campus, several primarily unreinforced buildings, and the 4th Avenue Bridge were damaged.

Harborview Hospital in Seattle, the premier emergency care center for Washington, suffered some nonstructural damage but remained open. Harborview provided treatment for twenty-seven severe casualties, which included head injuries and crushing from falling bricks and collapsing chimneys. Fortunately, only one fatality (from heart attack) was reported. The official number of injuries was reported to be 396. Limited areas lost power, and there was some disruption of phone service due mainly to overload. Water and sewer service continued without major problems, although some of the overflow sewers in south Seattle are currently dry and may have problems that are not yet apparent.

The control tower at SeaTac Airport lost all its windows, closing SeaTac for several hours. Boeing Field, the closest back-up airport, is built on fill and was closed due to ground failure on the runways. Nonstructural (mainly) damage was noted at Boeing, Microsoft, the Starbucks building, the Port of Seattle, Amazon headquarters, UW campuses in Seattle and Tacoma, the King County Courthouse, and many other facilities throughout the area. Broken pipes exacerbated damage in some cases.



▲ **Figure 2.** Letters and numbers on the shaded relief topographic map are keyed to the descriptions of geological effects listed below. Landslides are indicated as blue symbols; liquefaction features are shown as magenta symbols. The size is proportional to the volume of material.

(A) 6 miles west of Olympia, part of the roadbed of four-lane US 101 liquefied and slid down a ravine, with the toe of the slide coming to rest on a frontage road. The slide volume was about 15,000 cubic meters.

(B) In Olympia, the east shore of Capitol Lake failed in a large landslide/lateral spread. There was no damage to structures.

(C) At Salmon Beach (west Tacoma), a steep bluff failed and destroyed two homes. Six more homes are red-tagged (may not be occupied) because they are threatened by the remaining unstable slide mass. Total slide volume is about 15,000 cubic meters.

(D) Near Victor, 15 miles west of Tacoma, about 1,500 cubic meters of artificial fill beneath Hwy 302 failed. The road remains closed.

(E) In Burien (southwest Seattle), a pre-existing slide moved about a foot and has affected six homes.

(F) In Maple Valley (southeast of Seattle), a rapidly moving 2,000 cubic meter debris flow smashed a house. The occupant ran out of the house—because of earthquake shaking—just before the slide hit. A nearby 5,000–10,000 cubic meter slide temporarily dammed the Cedar River and has apparently improved fish habitat.

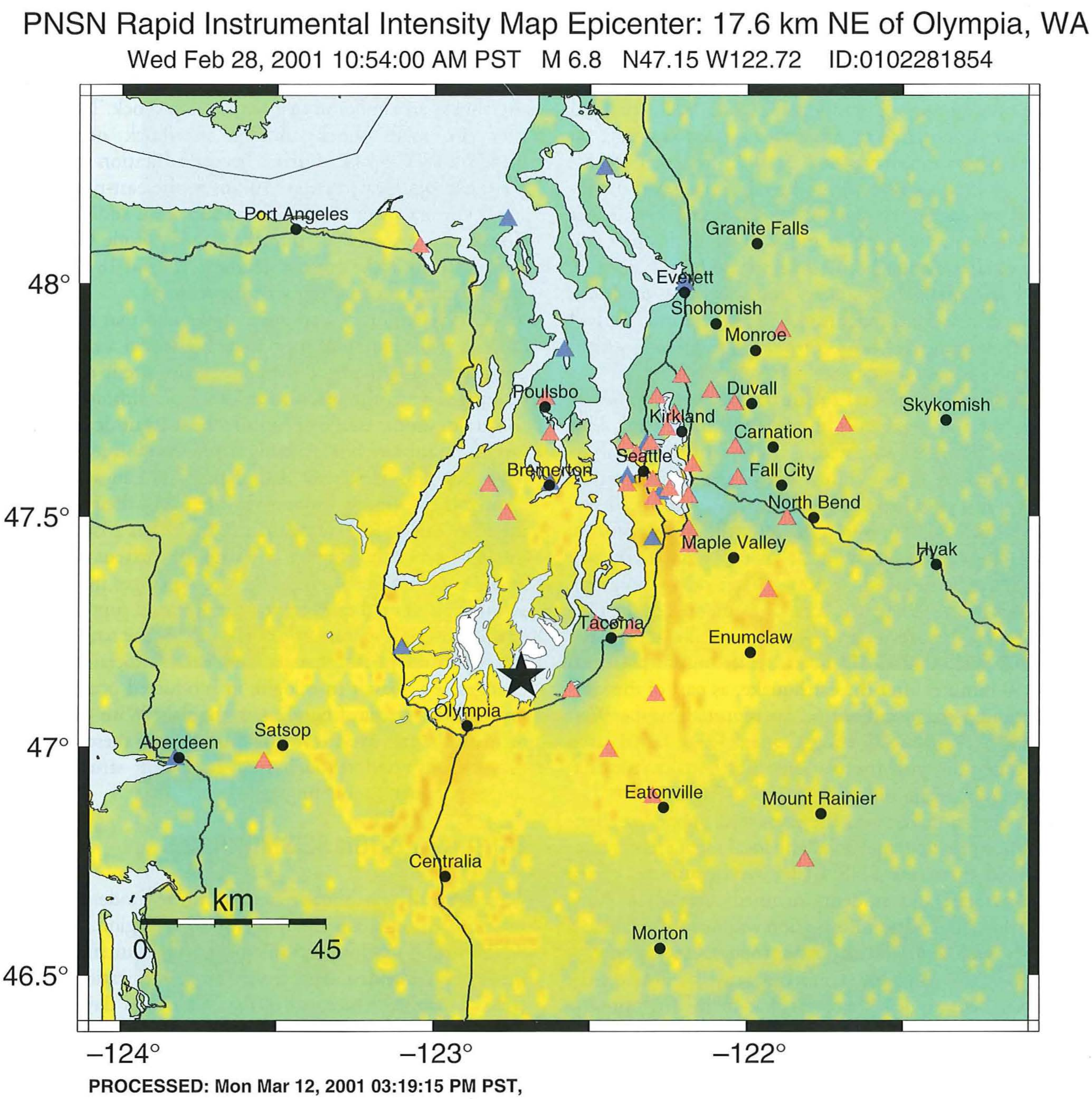
(G) Twenty miles east of Seattle, reactivation of a pre-existing slide closed Hwy 202 between North Bend and Fall City.

(1) In Olympia, extensive liquefaction along the west shore of Capitol Lake and elsewhere damaged roads, walkways, and a mobile-home park.

(2) Ten miles east of Olympia, extensive liquefaction at the Nisqually delta caused little damage. Much of the delta is wildlife refuge.

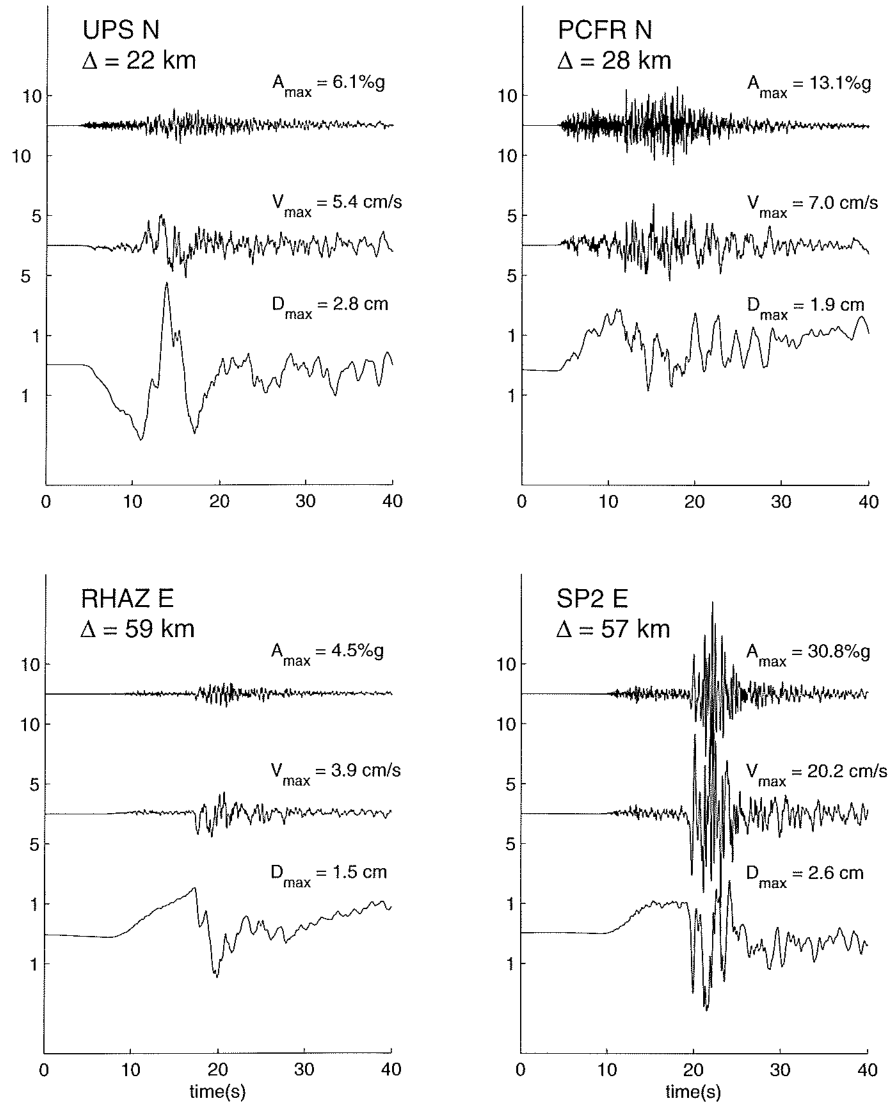
(3) Liquefaction and shaking damage have closed one of the buildings at Boeing's Renton plant, on the Cedar River delta southeast of Seattle.

(4) In south Seattle there was extensive liquefaction of artificial fill and natural deposits along the Duwamish River. The affected area comprises industrial, commercial, and residential properties; much of the Port of Seattle; railroad switching yards; and the King County Airport (Boeing Field). The north half of the airport runway is unusable because of liquefaction damage.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	***<.17***	***.17-1.4***	***1.4-3.9***	***3.9-9.2***	***9.2-18***	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	***16-31***	***31-60***	***60-116***	***>116***
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

▲ **Figure 4.** Instrumental intensity map produced by ShakeMap as recently imported from TriNet using forty-nine strong-motion stations from the PNSN (red triangles) and NSMP (blue triangles). This version of ShakeMap is preliminary since the attenuation relationship for a deep earthquake such as the Nisqually event is not properly handled and many site corrections for individual stations have not yet been confirmed and may be in error.

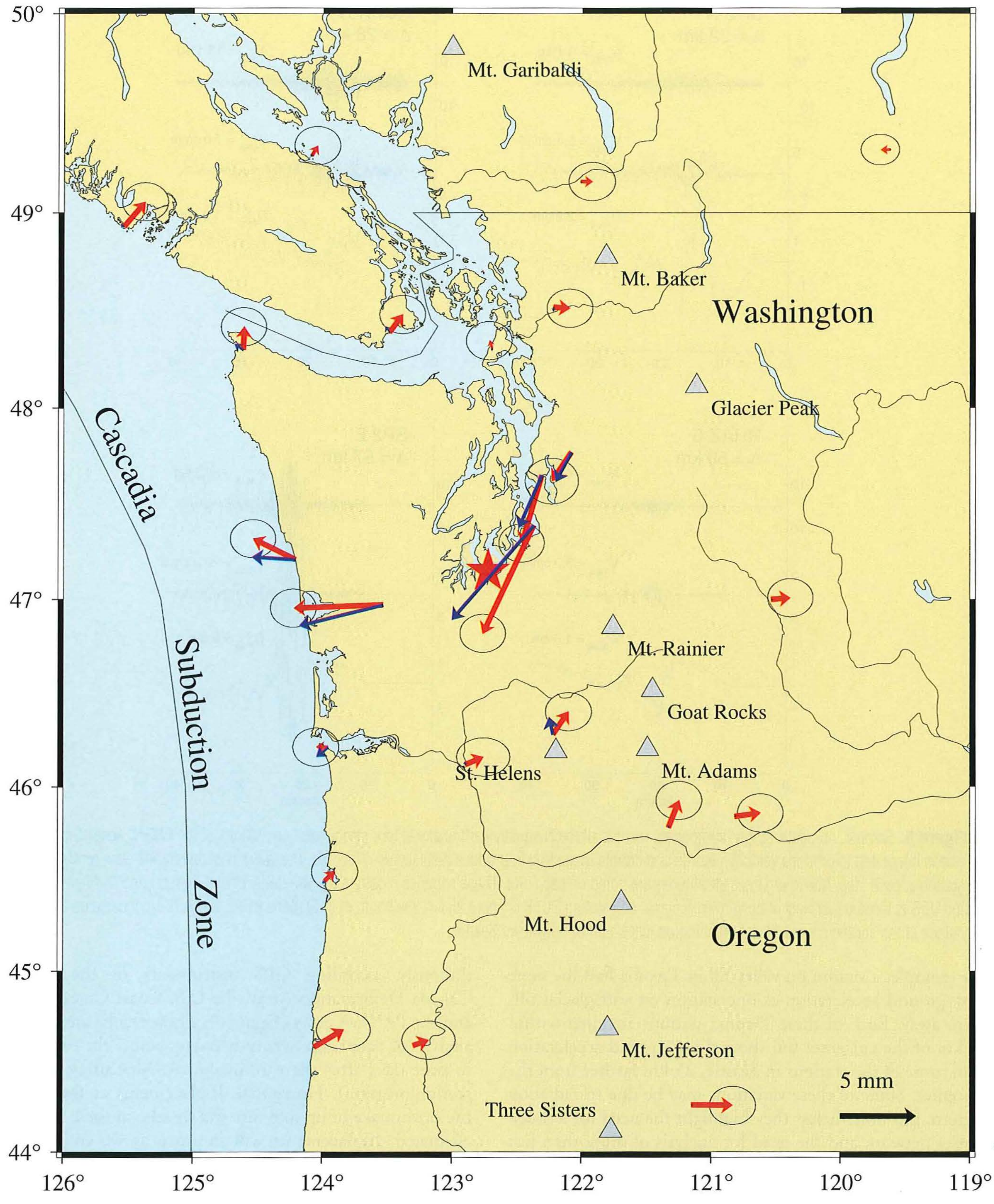


▲ **Figure 5.** Sample, on-scale, single-component records of the Nisqually earthquake at four strong-motion stations of the PNSN. Acceleration records have been integrated to produce velocity records and double integrated to produce displacement records. Pre-event baseline trends were removed prior to integration at each step. Maximum trace amplitudes are noted on each plot. These samples illustrate the variability of motion recorded at different stations. Station UPS is located just west of downtown Tacoma, and station PCFR is about 25 km due south of it. Stations RHAZ and SP2 are located on the east and west sides of the southern end of Lake Washington just south of downtown Seattle.

For example, a station on valley fill in Tacoma had the same peak ground acceleration as one station on stiff glacial tills 9 km away. Both of these Tacoma stations are sited within 35 km of the epicenter but showed less ground acceleration than some of the stations in Seattle, 25 km farther from the epicenter. Some of these variations may be due to radiation pattern, but nonetheless they highlight the need for a much denser network and the need for analysis of more than just the peak ground acceleration before general conclusions can be drawn (Figure 5).

GEODESY

The Nisqually earthquake also produced measurable geodetic changes at the Earth's surface as determined using continuously recording GPS instruments in the Western Canada Deformation Array, the U.S. Coast Guard CORS, and the PANGA array (Figure 6). These results are based on analysis of data from twenty-two days before the earthquake to nine days after the earthquake (R. McCaffrey, personal communication). Horizontal displacements at the time of the earthquake of up to 8 mm can be seen at these sites. The estimated displacements will improve as we collect more "postseismic" GPS data. Figure 6 shows general agreement between the observations and displacements expected from a simple dislocation model of the earthquake based on the Harvard CMT solution for the focal mechanism. Currently, the geodetic data do not distinguish between two possible fault planes, and the moment of the earthquake adjusted to the observed displacements is about 8.4×10^{18} N-m, about



▲ **Figure 6.** Observed displacements (heavy arrows) and predicted displacements (thin arrows) as a result of the deep-focus Nisqually earthquake at continuously recording GPS stations. 2.5 sigma ellipses are also shown. The predicted displacements are consistent with an earthquake moment of 8.4×10^{18} N-m, centroid depth of 53 km, strike of 3°, dip of 72° easterly, rake of 270°, down-dip width of 10 km, along-strike fault length of 30 km, and slip of 0.73 meters. Rigidity is taken to be 40 GPa.

half the Harvard CMT value. There are also many campaign-style GPS sites in the epicentral region, and some of these were reoccupied in the first few days after the earthquake in a cooperative effort by the U.S. Geological Survey, Central Washington University, and the University of Washington. The full set of geodetic data may ultimately help to refine the source parameters for the Nisqually earthquake.

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